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Exploring the Spatial Configuration of Places Related to Homicide Events

Final Report

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As always any errors in the document are the sole responsibility of the authors.

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Chapter 1

Mobility and Homicide

Introduction

This research provides a comprehensive exploration of the spatial etiology of homicides in Washington, D.C. Three basic elements of convergence (victim's home, offender's home, and homicide location) and three associated measures—the relative distances between the locations—are analyzed. All six elements are explored both individually and jointly to increase our understanding of homicides. The initial analysis focuses on the patterns of the three locations separately and then examines the distances between locations. The second phase analyzes the spatial interactions among victims and offenders through the application of both traditional and distance spatial typologies. Finally, the third phase is a comprehensive exploration of techniques for visualizing the distributions and associated relationships.[1] In sum, this research fills a gap in the criminological literature by (1) disaggregating homicides by motive to provide a more exact analysis of movement for each particular type; (2) exploring the distances to homicide for victims and offenders; (3) describing the relationships between victims, offenders, and places through a comparison of two mobility triangle typologies; and (4) applying various cartographic methods for representing the interactions between victim, offender, and place.

The remainder of this chapter is a review of literature that influenced our analysis, including discussions on the theoretical basis, victim/offender journey to crimes, and mobility triangles. Chapter 2 describes our data and analytical approach. The third chapter provides basic analysis on the distances between homicide location, victim's home address, and offender's home address. Our findings indicate, for example, that travel distances for victims and offenders differ significantly depending on the motives for the homicide. Related to the joint movements of victims and offenders, we describe mobility triangles in Chapter 4 to capture another dimension of the homicide event that has been relatively unexplored. The final chapters are

[1] This portion of the research is contained in a separate document called *Visualizations of Spatial Relationships in Mobility Research: A Primer* (Groff & McEwen, 2005a).

dedicated to an in-depth discussion of the results and their application to law enforcement policy and practice.

Literature Review

Theoretical Grounding

A variety of approaches have been undertaken to understand why crime occurs where it does. Some researchers (Boggs, 1965; Dunn, 1976b; Dunn, 1976a; Herbert, 1982; Schmid, 1960b; Schmid, 1960a) have focused on the spatial distribution of *crimes*, while others (Shaw & McKay, 1942) have focused on the spatial distribution of *criminals*. The results of these studies suggest that the differential opportunity structures existing across a city encourage the production of criminals and criminal acts. Other researchers have attempted to combine the spatial analyses of crimes and arrest locations (Schmid, 1960b; Schmid, 1960a). Another avenue of research looked to the offender's behavior in space for clues "to the urban system as a crime opportunity structure" (Capone & Nichols, 1976). Still other researchers have explored the offender's journey to crime but far fewer have examined the victim's journey to crime.

Two more recent theories that have proven beneficial in developing a better understanding of spatial behavior and its relationship to crime events are environmental criminology and routine activity theory. Environmental criminology is concerned with the place at which a victim, an offender, and a law intersect to produce a crime (Brantingham & Brantingham, 1981a). Most particularly, the theory emphasizes the factors that bring offenders and victims together at a specific place and how victims and offenders are distributed throughout space. In their seminal work *Environmental Criminology,* the Brantinghams (1981a; 1981b) advanced two major theoretical views. First, they stated that criminal events occur during the course of normal human activity, both for offenders and victims. Second, they noted that offenders are constantly aware of environmental cues related to the relative risk and opportunity levels present at a particular place. These environmental cues vary depending on the type of crime the offender wants to commit. For instance, a burglar might look for signs that reveal work schedules (e.g., an empty garage every afternoon), while someone interested in committing commercial robbery might notice when stores had fewer customers to minimize the possibility of interference during a robbery. In sum, environmental criminologists view offenders as highly

motivated individuals constantly on the lookout for criminal opportunities (Brantingham & Brantingham, 1981a).

In developing their theories, environmental criminologists drew heavily on studies describing the activity patterns of urban residents. *Action space* was a term introduced by Horton and Reynolds (1971) to describe the areas of the urban environment with which residents were familiar. The size and shape of action spaces vary depending on home location (city vs. suburb), sex, socio-economic class, and age (Chapin & Brail, 1969; Harries, 1999; Horton & Reynolds, 1971). Women and children tend to have more constrained activity spaces; men and young adults have larger activity spaces. The Brantinghams (1984; 1981a) built on this knowledge and put forward the idea that offenders develop activity spaces just like law-abiding members of society.[2] The areas where the activity spaces of the two groups overlap are where crimes are more likely to occur.

Routine activity theory (Cohen & Felson, 1979) emphasizes spatial convergence but focuses on three necessary elements—a motivated offender, a suitable target, and the absence of capable guardians. In later work, Felson (1986, 1987) added place and intimate handlers as necessary elements. As in environmental criminology, routine activity theory holds that all three elements must be present for a crime to occur. Cohen and Felson (1979) note that changes in the routine activities of offenders or targets result in either greater or fewer opportunities for crime because they change the frequency with which offenders and victims converge in space and time. Both environmental criminology and routine activity theory assume motivated offenders and emphasize convergence of offenders, victims, and guardians at a place.

Empirical research on both victims and offenders, although not able to directly measure routine activities, provides some general information regarding travel patterns. The frequency with which individuals come in contact with one another is often due to proximity of residence or to type of relationship (Block, Galary, & Brice, 2004). Neighbors tend to see each other more

[2] The Brantinghams (1981b) developed drawings of paths and nodes under different assumptions (e.g., uniform distribution of targets, one criminal, one node) to describe a wide range of situations in which criminal travel behavior may be modeled. Earlier work by Lynch (1960) in which he described the routine activities of people in terms of several elements (i.e., edges, paths, nodes, districts, and landmarks) provided the basis for the Brantinghams' notions of nodes and pathways used in their diagrams. Most important to this discussion is Lynch's formulation of nodes (i.e., home, work, recreation, etc.) and paths (i.e., roads, bus routes, etc.) to describe the physical environment in which movement occurs.

often because they live close to one another. In general, intimates and friends have more contact than acquaintances or strangers.

Given the important role of activity patterns in theory, it is surprising that travel patterns of offenders have been extensively examined while victims have received relatively little attention. One contributing factor to the disparity may be the relative difficulty of obtaining automated data on home addresses of victims from police agencies. In the case of Washington, D.C., addresses of victims are not routinely collected even for serious crimes; homicide is an important exception.

Distance Decay and Its Effect on Criminal Behavior

In order to better understand the confluence of victim, offender, and place, some researchers have attempted to understand the "spatial interaction" of people in space through models (Rengert, Piquero, & Jones, 1999). One of the most frequently applied functions to model travel behavior is the distance decay function (Harries, 1999; Harries, 1990; Katzman, 1981; Rossmo, 2000; van Koppen & de Keijser, 1997). The distance decay function has its roots in physical sciences and originally referred to the diminishing attraction between two bodies as distance between them increased (Levine, 2005). In the study of human behavior, it describes travel patterns. Specifically, distance decay states that when individuals are deciding where to purchase an item, for example, they will choose a location that is closer (Brantingham & Brantingham, 1984). The importance of intervening opportunities has been well researched in the literature (Levine, 2005). The "principle of least effort" (Harries, 1999) is closely related to the distance decay function and suggests that human nature is to minimize the effort required for any task.

Research on travel and shopping behavior has shown that people tend to choose close-by locations of frequently visited stores and only travel farther for larger or infrequent purchases (Levine, 2005). This same pattern can be seen in criminal behavior. For victims and offenders, it is the cost in time and transportation that increases with distance. Additionally, people tend to be more familiar with shops close to their homes or work places, and less familiar with shops farther away. On the other hand, criminals must balance lower cost and greater familiarity against the increased risk of recognition that comes with committing crimes in their everyday activity space (Brantingham & Brantingham, 1981a).

Given the risk of recognition near home, some criminologists have postulated that the area immediately surrounding an offender's home address is subject to a "doughnut effect" (Brantingham & Brantingham, 1981a; Ratcliffe, 2001; Rengert et al., 1999; Turner, 1969). Offenders do not want to travel too far from known areas because they are less familiar with their surroundings, have a greater chance of standing out, have potentially more time at risk, and might have a harder time getting away (Brantingham & Brantingham, 1981a; Ratcliffe, 2001). Conversely, they do not want to live too close to their targets because of the fear of recognition. The tension between these two factors produces a "buffer zone" around an offender's residence.

However, there has not been consistent support for the existence of such a zone (Block et al., 2004). One homicide study identified a buffer zone for body locations but not for victim abduction locations (Godwin 1996). On the other hand, a burglary study by Ratcliffe (2001) and a study of serial rapists by Warren et al. (1998) discovered a distance decay effect outside a buffer zone. Finally, an early study by Turner (1969) established a buffer zone within one block for index crimes committed by juveniles. These findings indicate the existence of such a zone might be tied to crime type and characteristics of the individuals involved.

Offender Journey to Crime

Interest in the offender's journey to crime centers on the belief that "knowledge of the types and variations in criminal activity can help local police administrators to more accurately target their resources" (McIver, 1981). Our knowledge of offender behavior has progressed steadily from describing behavior to explaining behavior. LeBeau (1987) notes that what started as a descriptive exercise has progressed into efforts to test hypotheses (Rhodes & Conly, 1981) and has become integral to environmental criminology's explanation of offender behavior

Several studies have analyzed the distances that offenders travel to commit their crimes. Harries (1980) offers an early review of what is most commonly called "journey to crime" research conducted in the mid-1970s, and Wiles and Costello (2000) provide a more recent review of literature specifically related to property crime. While the overwhelming majority of these studies have focused exclusively on the offender's journey to crime, a few have included the victim's journey (Block et al., 2004; Bullock, 1955; Wiles & Costello, 2000). Since the late 1980s, much of the work on offender travel behavior has been focused on *geographic profiling*. In general, geographic profiling attempts to identify an offender's residence from a series of

related crime event locations.[3] Rossmo (2000) offers a comprehensive overview of this research. Results of geographic profiling research can inform our understanding of the offender journey to crime. Exhibit 1-1 offers an overview of selected findings regarding offender journey to crime.

The literature on offender journey to crime generally supports several conclusions about the distance that offenders travel to commit crimes (Capone & Nichols, 1976; Harries, 1980; LeBeau, 1986; LeBeau, 1987; Toolkits, 2001; Turner, 1969; Wiles & Costello, 2000). Foremost is the conclusion that most offenders' distances to crime are short. This phenomenon has been explained as a preference to commit crimes in areas with which the offender has personal knowledge (Brantingham & Brantingham, 1981a; Capone & Nichols, 1976). It has implications for determining the crime potential for each neighborhood as a function of the number of criminals living nearby (Katzman, 1981) and for the application of surfaces to represent the probability of offender residence (Gore, 2001). If, as suggested by the literature, crime journeys are short, then the crime potential of a particular block rises with the numbers of criminals that reside nearby.

[3] For a good introduction to the area of geographic profiling and journey to crime, see Chapter 8 in Levine (2005). Dr. James LeBeau was one of the first researchers to use geographic profiling; two of the leading researchers in geographic profiling today are Dr. Kim Rossmo and Dr. David Canter.

Exhibit 1-1: Overview of Journey to Crime Research Findings

Crime Type	Journey to Crime	Measurement Type	Location / Time Period	Source
All Offences	1.93 miles (Euclidean)	Average (assume mean)	Sheffield, 1995	Wiles and Costello (2000)
	1.16 miles (Euclidean) 1.62 miles (Street route) 1.49 miles (Manhattan)	Average (assume mean)	London Borough of Harrow	Chainey, Austin and Holland (2001)
Violent Offences	.77 miles (Euclidean) 1.09 miles (Street route) .99 miles (Manhattan)	Average (assume mean)	London Borough of Harrow	Chainey, Austin and Holland (2001)
Homicide	40% within 1 city block 74% within 2 miles 32.8% lived < 1 mile from one another	Mean	Houston, Texas, 1945-1949	Bullock (1955)
	2.73 miles (All victims) 2.86 miles (Males) 1.80 miles (Females)	Mean	Washington, D.C., 1990-2000	Groff and Wartell (2001)
Rape	1.15 miles (Street distance)	Mean	Washington, D.C., 1974	Rhodes and Conly (1981)
	1.52 miles (not stated)	Mean	Indianapolis, Indiana	White (1932)
	3.14 miles(Euclidean)	Mean	Varied	Warrant et al. (1998)
Sexual Assault	.07 miles (all incidents) .93 miles (excluding zero distances) (Manhattan)	Median	Chicago, Illinois, 1998	Block, Galary and Brice (2002
	.81 miles (Euclidean) 1.06 miles (Street route) .97 miles (Manhattan)	Average (assume mean)	London Borough of Harrow	Chainey, Austin and Holland (2001)
Robbery	33% (<1 mile) (Euclidean) 50% (< 2 miles) (Euclidean)	Mean	Miami, Florida	Capone and Nichols (1976)
(Not in a building)	36% (<1 mile) (Euclidean) 60% (< 2 miles) (Euclidean)	Mean	Miami, Florida	Capone and Nichols (1976)
	1.47 miles (Euclidean) 1.94 miles (Street route) 1.89 miles (Manhattan)	Average (assume mean)	London Borough of Harrow	Chainey, Austin and Holland (2001)
(Non-commercial)	.80 miles (all incidents) miles (excluding zero distances) (Manahttan)	Median	Chicago Illinois, 1998	Block, Galary and Brice (2002)
(Commercial)	1.77 miles (all incidents) 1.78 miles (excluding zero distances) (Manhattan)	Median	Chicago Illinois, 1998	Block, Galary and Brice (2002)
	2.10 miles (Street distance)	Mean	Washington, D.C., 1974	Rhodes and Conly (1981)
	11.9 miles (Euclidean)	Mean	Netherlands	van Koppen and Jansen (1998)

Exhibit 1-1: Overview of Journey to Crime Research Findings (Continued)

Crime Type	Journey to Crime	Measurement Type	Location / Time Period	Source
Aggravated Assault	.11 miles (all incidents) .57 miles (excluding zero distances) (Manhattan)	Median	Chicago Illinois, 1998	Block, Galary and Brice (2002)
	1.49 miles (Euclidean)	Average (assume mean)	Sheffield, 1995	Wiles and Costello (2000)
Burglary (Residential)	1.62 miles (Street Distance)	Mean	Washington, D.C., 1974	Rhodes and Conly (1981)
	3.11 miles (1/3 traveled less than .93 miles) (not stated)	Average (assume mean)	Australian Capital Territory / 1999-2000	Ratcliffe (2001)
	1.21 miles (Euclidean) 1.85 miles (Street route) 1.56 miles (Manhattan)	Average (assume mean)	London Borough of Harrow	Chainey, Austin and Holland (2001)
	1.88 miles (Euclidean)	Average (assume mean)	Sheffield, United Kingdom, 1995	Wiles and Costello (2000)
Burglary (Non-Residential)	1.83 miles (Euclidean)	Average (assume mean)	Sheffield, United Kingdom, 1995	Wiles and Costello (2000)
	3.11 miles (< 50% traveled more than 1.86 miles) (not stated)	Average (assume mean)		Ratcliffe (2001)
Vehicle Theft	1.48 miles (Euclidean) 2.05 miles (Street route) 1.80 miles (Manhattan)	Average (assume mean)	London Borough of Harrow	Chainey, Austin and Holland (2001)
	2.36 miles (Euclidean)	Average (assume mean)	Sheffield, United Kingdom, 1995	Wiles and Costello (2000)
Theft From Vehicle	1.97 miles (Euclidean)	Average (assume mean)	Sheffield, United Kingdom, 1995	Wiles and Costello (2000)
Arson	2/3 of offenders lived less than .47 miles from the target (not stated)	Not stated	Cleveland, UK	Wood (2001)
Shoplifting	1.68 miles (Euclidean) 2.18 miles (Street route) 2.18 miles (Manhattan)	Average (assume mean)	London Borough of Harrow	Chainey, Austin and Holland (2001)
	2.52 miles (Euclidean)	Average (assume mean)	Sheffield, United Kingdom, 1995	Wiles and Costello (2000)

A preference among offenders for shorter trips seems to be a consistent result, even over different transportation types. A study of transit crime in New York City found that 56 percent of all crime trips were within the same borough. Of trips to another borough, the most were from another borough into Manhattan (29 percent) (Belanger, 1997).

The distance traveled depends on the type of crime committed (Chainey, Austin, & Holland, 2001). In general, crime trips related to property crimes tend to have longer travel distances than those related to violent crimes (Capone & Nichols, 1976; Reppetto, 1974; Smith, 1976; Wiles & Costello, 2000). One crime, robbery, is an anomaly because it combines instrumental elements typically associated with property crimes and expressive elements more commonly linked with violent crimes. In research done by Chainey et al. (2001), only shoplifters and car thieves traveled farther than robbers. One additional finding related to property crime is that the economic payback from longer trips is higher than shorter trips (Pyle, 1976; Reppetto, 1974). Several other studies have examined offenders' journeys to commit violent crimes (i.e., homicide, sexual assault, robbery, and assault). Bullock's (1955) study of homicide in Houston, Texas, found very short journey to crime distances for homicide offenders—40 percent were within one block and 67 percent lived within one mile. Exhibit 1-1 shows that for sexual assault, the average offender journey to crime is about one mile. Robbery journeys tend to be longer than those for sexual assault. Finally, similar to homicide, assaults tend to have short journeys to crime.

In general, research shows that the travel distances of offenders increase with age (Chainey et al., 2001; Warren et al., 1998; Wiles & Costello, 2000). Studies on property crime (Chainey et al., 2001; Wiles & Costello, 2000) found that distance traveled tended to increase with offender age (i.e., juveniles traveled the shortest distances). However, Chainey et al. (2001) noted an exception for shoplifters whose average distance traveled tended to increase until the age of 18 years old, then decreased until around the age of 55 years old, then increased before decreasing again. In their Sheffield study, Wiles and Costello (2000) found change in travel behavior over time. Comparing 1966 to 1995, they found that younger offenders were traveling longer distances and older offenders shorter distances, than in the past.

Other studies have shown that distances vary by sex and race. African-American offenders travel significantly shorter distances than white offenders (Chainey et al., 2001;

Warren et al., 1998; Wiles & Costello, 2000), and female offenders have shorter travel distances than male offenders (Rengert, 1975).

One finding that needs further explanation is why, even within the same crime type, there is variation in the distances traveled by offenders to reach the location of the crime. For example, different researchers studying robbery found average offender travel distances that varied from less than a mile to almost two miles. There are three probable sources of this variation: offender characteristics, specific type of crime, and type of distance measurement. The relationship of specific offender characteristics to distance traveled was detailed previously. Another source of variation may be differences among types of robbery (e.g. street robbery vs. commercial robbery). Commercial robbery involves targets that are fixed requiring travel by robbers from their homes to the target location. Street robbery, on the other hand, involves mobile targets and can take place anywhere.

Some of the variation in travel distance for a given crime may also be a function of using different methods for measuring distance. Continuing the robbery example, one researcher calculated Euclidean distance, another calculated Manhattan distance, and another calculated street distance in their studies. Chainey et al. (2001) calculated all three measures—Euclidean, Manhattan and street distance—and compared them for the same set of incidents. Euclidean distance measures "as the crow flies" distance between two places and thus gives a good measurement of the shortest possible distance. Manhattan distance calculates a right angle measure as if following a grid and street distance measures the shortest path along a road network. Chainey et al. (2001) found consistent relationships among the three measures. Euclidean distance was always the shortest, then Manhattan distance, with street distance producing the longest distances. On the relationship between street routing and straight line distance, they found that straight line distances were .72 of street network distance (Chainey et al., 2001). The findings for street and Euclidean distance were replicated by Groff and McEwen (2005b) with homicide data from Washington, D.C.

Victim Journey to Crime

We could find only four studies that have examined the distance that victims are from their homes (Block et al., 2004; Bullock, 1955; Normandeau, 1968; Wiles & Costello, 2000). The earliest study (Bullock, 1955) found that homicide victims lived very close to the homicide

location—61 percent lived within a half a mile and about 75 percent lived within a mile.[4] The median travel distance for victims was .40 miles as compared to offenders at .45 miles. Although his study predates more recent efforts by more than 45 years, the findings are remarkably consistent. Another early study (Normandeau, 1968) on robbery victims found the median distance from the home address of victims to robbery location was 1.88 miles (mean of 2.31 miles) exceeding both the median distance of offenders to robbery location, and the median distance between the homes of victims and offenders.

Rather than measuring victim travel by type of crime, Wiles and Costello (2000) took a different approach and focused on aggregate victim travel distances from eight areas of one city. Using Euclidean distance they found victim travel distances ranging from a low of .23 miles in one area of Sheffield to a high of 2.01 miles in another area. The average distance traveled across all eight areas was .87 miles. Offenders traveled farther (range of .81 to 3.96 with a mean of 2.32 miles) than victims from the same areas. Wiles and Costello (2000) looked at the proportion of victims who experienced their victimization within their home area or outside of it. The lowest in-area victimization was 52.2 percent and the highest was 89 percent. By examining the journeys of victims and offenders to crime locations, they suggested that it is possible to identify appropriate crime prevention strategies. For example, in areas where the home-area offender population is high and the in-home area victim population is high, neighborhood watch would be less effective because almost everyone involved is a resident.

Block, Galary and Brice (2004) determined Manhattan distance to examine the violent crimes of rape, non-commercial robbery and aggravated assault in Chicago. As with research on journeys of offenders, they found that the average distance traveled by victims to crime locations varied by crime type. Aggravated assault had the shortest distance for all trips by victims (.13 miles), rape was next at .51 miles and non-commercial robbery was slightly longer at .52 miles. They compared travel distances for victims where the offender was unknown against those in which the offender was known. The travel distances for victims were consistently longer for events in which the offender was unknown (.67 miles for rape victims, .57 miles for non-commercial robbery victims and .35 miles for aggravated assault victims) than for known offender incidents (.33 miles for rape victims, .40 miles for non-commercial robbery victims, and

[4] Bullock does not state what type of measurement he used but given the age of the study, it is most likely he used

.009 miles for aggravated assault victims). The authors noted that these findings supported the notion that arrests are made more often in crimes in which the offender is known to the victim (i.e. crimes that occur at or near the victim's home). Further, once these 'easier to solve' crimes are removed, the greater the distance the victim traveled to where the crime occurred, the less likely the crime is to be solved. Together these studies lend credence to the further examination of victim travel as an important component in the convergence of victims and offenders.

Spatial Coincidence of Offender and Victim Home Addresses

There have been only two studies that examined the distance between the residences of victims and offenders (Bullock, 1955; Normandeau, 1968). One study looked at homicides and the other focused on robberies. As mentioned earlier, spatial proximity would tend to increase the potential for some type of relationship to exist between offender and victim. At the very least, the two share the experience of the particular area of the city in which they live and thus have more of a connection that complete strangers from different parts of the city.

Bullock's (1955) study of homicide in Houston, Texas, found that offenders and victims lived very close to one another. In fact, 32.8 percent of offenders and victims lived on the same block and 70 percent lived less than two miles. The average distance between home addresses was less than one mile. Normandeau (1968) reanalyzed Bullock's data to construct more specific estimates of the distance between victim and offender. He calculated a median distance as .65 miles for victims killed between 1945 and 1949, and .17 miles for victims killed between 1958 and 1961. Robbery distances found by Normandeau in Philadelphia were much farther; the median distance between homes was 1.61 miles with a mean of 2.19 miles. These findings led Normandeau (1968) to conclude that robbers travel farther to commit their crimes than do other violent criminals.

Individual Characteristics of Homicide Offenders and Victims

Beginning with the seminal research by Wolfgang (1958), the existing body of research provides a clear description of the personal characteristics of homicide offenders and victims. These characteristics have served as the basis for the construction of multivariate models to explore differences in the spatial typology of homicide events. For example, previous research

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Euclidean distance which is the easiest to measure manually.

indicates that age of victim and age of offender are related to the distance they are from home when a homicide occurs. Age is therefore a good candidate to be included in a model of homicide.

There are consistent patterns of race, sex, and age that distinguish those involved in homicide from the general population. Both homicide offenders and victims tend to be African-American (Miethe & Regoeczi, 2004; Wolfgang, 1958). Wolfgang's (1958) study in Philadelphia (1948-1952) found a significant association between race and homicide (75 percent of offenders and 73 percent of victims were African-American). Bullock's (1955) study of homicides between 1945-1949 in Houston, Texas found 67 percent of victims and offenders were African-American, which was significantly higher than the proportion of the population. Later studies have suggested that perhaps the relationship is not so straightforward (Blau & Blau, 1982; Messner Steven & Tardiff, 2005). Economic status may be influencing the relationship between race and homicide causing a relationship to appear where there is none.

In general, males are more likely to be involved in a homicide as either victim or offender than are females (Miethe & Regoeczi, 2004). Wolfgang (1958) found that 82 percent of offenders and 76 percent of victims were males. Within these major breakdowns, he found that both male and female victims tend to be killed by men. However, female offenders tend to kill males rather than other females.

The incidence of both victimization and offending varies significantly by age (Miethe & Regoeczi, 2004). Wolfgang (1958) found that offenders tend to be younger than victims on average. The two highest age groups for offending were 20 to 24 years old (with an annual mean rate of 12.6 per 100,000 population) and 25 to 29 years old (11.9 per 100,000 population). The highest rate age groups for victims were 25 to 29 years old (10.4 per 100,000 population) and 30 to 34 years old (10.4 per 100,000 population), followed by 35 to 39 years old (9.0 per 100,000 population).

In addition, Wolfgang (1958) found that African-American males have the highest *rates* of offending led by the 20 to 24 age group. African-American female offenders have their highest rates in the 25 to 29 and 30 to 34 age groups. Among victims, the highest rates for African-American males were in the 35 to 39 and 30 to 34 age groups. Mirroring the pattern for involvement as offenders, rates for African-American female victims were highest in the 25 to

29 and 30 to 34 age group. Turning to the rates for white individuals, male offenders were most frequently in the 20 to 24 age group, followed by the 35 to 39 age group. Similarly, rates for white female offenders were highest in the 20 to 24 age group, followed by the 35 to 39 age group. Among victims, white males had highest rates in the 55 to 59 age group, followed closely by the 50 to 54 age group. Highest rates for white female victims were in the 30 to 34 years of age group, followed by the 40 to 44 years of age group. A more recent review found homicide age patterns were still quite similar. The highest victimization rates remained in the 15 to 24 years of age group and African-American males continue to have the highest victimization rates (Zahn & McCall, 1999).

Homicide Event Characteristics and Locations

Research studies have consistently shown that homicide is an expressive crime (Miethe & Regoeczi, 2004). In other words, homicides result from an unplanned conflict rather than a planned activity initiated for gain of this type (i.e. instrumental crimes). Determining a single motive for a homicide is often difficult because many homicides have multiple driving factors. One example is when a homicide stems from an argument during the course of a drug sale. In this case, the homicide has both instrumental and expressive elements. Wolfgang (1958) found that 82 percent of homicides fell into six categories: altercation of trivial origin, domestic quarrel, jealousy, altercation over money, robbery, and retaliation. Among males, regardless of race, he found that the most frequent motive was an altercation of trivial origin. Among females, domestic quarrel was the most frequent. In fact, females in his study were more than twice as likely to be a victim of a domestic quarrel as males. African-American females were three times as likely to be offenders in a domestic quarrel as African-American males.

Most homicides involve offenders and victims with some type of intimate or casual relationship (Miethe & Regoeczi, 2004; Wolfgang, 1958). Regardless of race, women are more likely to have a family relationship with the offender while men are more likely to have a friendship. Another difference among homicides regarding victim-offender relationship that falls along racial lines is that whites are more likely to be killed by a stranger than are African-Americans.

Research studies (Dugan, Nagin, & Rosenfeld, 1999; Zahn & McCall, 1999) indicate that the rate of homicides in which a domestic quarrel is involved has been declining since 1965. In

1965, domestic violence homicides accounted for 23 percent of all homicides compared to only 6 percent in 1995. The difference reflects a trend away from homicides among intimates, and toward more homicides among acquaintances and strangers (Zahn & McCall, 1999). A comprehensive review of homicide studies by Zahn & McCall (1999) found the proportion of domestic homicides decreasing in Chicago, St. Louis, and Philadelphia.

Homicides most frequently involve one offender and one victim. Miethe and Regoeczi (2004) found that during the 1990s less than eight percent of homicides had more than one victim and approximately 13 percent had more than one offender. The percentage of homicides with multiple offenders has increased by about four percentage points since the 1970s. Homicides overwhelmingly involve firearms over knives and other weapons (Miethe & Regoeczi, 2004).

Homicides follow discernible temporal patterns. The three highest homicide days are Friday, Saturday, and Sunday, with Saturday having the highest rates for all African Americans and for white males. In Philadelphia, Wolfgang (1958) found almost half of all homicides occurred between 8 p.m. and 2 a.m. This time period was also the highest by race and by sex of victim (Wolfgang, 1958). Sixty-one percent of homicides in Tardiff, Gross & Messner's (1986) New York study occurred between 8 p.m. and 8 a.m.

Taylor (1997) provides a review of lessons learned and promising results from a place-based focus. Most of the place-based research has concentrated on spatial patterns of criminal events and environmental factors associated with crime. Further exploration of the contextual aspects of crime events will contribute to the development of a theoretical framework from which to examine the nexus between crime events and the places at which they occur (Murray, McGuffog, Western, & Mullins, 2001).

There is empirical evidence from macro level studies of homicide suggesting that areas with high levels of crime have high levels of offenders (Bensing & Schroeder, 1960; Bullock, 1955; Schmid, 1960a). More generally, there is support for assuming that characteristics of the neighborhood in which an event occurs have a high correlation with the socioeconomic and demographic characteristics of victims and offenders. This assumption is based on the fact that such a large number of homicides are domestic or acquaintance in nature, and are highly concentrated in specific areas of the city (Harries, 1997; Sampson, 1985). Bullock found that 87

percent of homicides in Houston occurred within eight city blocks of four specific streets. These areas formed four areas of concentration for homicides. A similar pattern of concentration was identified by Groff, McEwen and Wartell (2001) in Washington, D.C.

Mobility Triangles: Towards a Spatial Typology of Homicide

The spatial coincidence of crime location and offender's residence has been another area of interest to researchers. In other words, do offenders commit crimes in their own neighborhoods or elsewhere? Burgess (1925) developed a dual typology of delinquent behavior. He coined the term *neighborhood triangle* to describe events where delinquents lived and offended in the same neighborhood. Events where the delinquents resided outside the offense neighborhood were characterized as *mobility triangles*. Lind (1930) and Morris (1957) had variations of mobility triangle terminology in their research. Extending these initial forays, Normandeau (1968) created a five-category typology to describe the joint distribution of offender's address, victim's address, and crime location. Amir (1971) and Rand (1986) applied this typology to their analyses of crime data.

As previously noted, the emphasis of most research has been on separate analyses of offender and victim travel patterns. The joint spatial structure of those patterns has rarely been examined. One notable exception is research with mobility triangles to create a classification system based on three known locations: incident location, victim home address and offender home address. Conveniently, these locations represent the origins of offender and victim travel, and the convergence of the two at a crime location. Traditionally, the classification of incidents into mobility triangles has involved the assignment of each of the locations to a social area designation, most often neighborhood or census tract. The choice of neighborhoods reflects their importance as representations of relatively homogenous areas within which people are more likely to have shared acquaintances, mores, and characteristics.

Exhibit 1-2 describes research finding for the five different types of triangles:

- Neighborhood triangle
- Offender mobility triangle
- Victim mobility triangle
- Offense mobility triangle
- Total mobility triangle

In a *neighborhood* triangle, all three locations share a common neighborhood making the crime event a local phenomenon. An *offender* mobility triangle characterizes situations in which the victim and incident locations are in the same neighborhood but the offender travels from a different neighborhood. Similarly, a *victim* mobility triangle occurs when a victim travels to the offender's home neighborhood and is victimized. When the victim and offender live in the same neighborhood, and the crime occurs in another neighborhood, the event is part of an *offense* mobility triangle. A *total* mobility triangle occurs when there is no overlap among the neighborhoods containing the three locations. These five categories represent a mutually exclusive classification scheme describing the socio-spatial relationships between an offender's home, a victim's home, and a crime location.

Research applying mobility triangles is sparse but illuminating (see Exhibit 1-2). Burgess (1925) is widely credited with initially exploring whether a crime and its perpetrators were from the same neighborhood. Lind (1930) picked up on this theme and applied it to study delinquency triangles, specifically, the home address of juvenile delinquents and the location of the crime. He defined two types of delinquency triangles: 1) mobility delinquency triangles as triangles where the perpetrators were from the same neighborhood but offended outside their neighborhood and 2) neighborhood triangles of delinquency as ones in "which the homes of two or more delinquents and the place of the offense are found within the same neighborhood" (Lind, 1930 218). He found a pattern of delinquents starting as part of neighborhood triangles and then branching out to mobility triangles.

Exhibit 1-2: Overview of Mobility Triangle Research Findings

Crime Type (Unit of Analysis)	Neighborhood	Offender	Victim	Offense	Total
Homicide					
Pokorny (1965) (Census tracts)	64.4% (lived in same tract)	N/A	N/A	N/A	N/A
Rand (1986) (Census tracts)	37.5%	18.7%	18.7%	6.2%	18.7%
Tita and Griffiths (Forthcoming) (Census tracts)	26.9%	21.9%	18.3%	4.5%	28.3%
Rape					
Amir (1965a) (five city blocks)	68.5%	23.9%	3.5%	4.1%	Not used
Rand (1986) (Census tracts)	26.95%	19.2%	30.8%	7.7%	15.4%
Robbery					
Normandeau (1968) (Census tract)	14.1% (same tract)	17.4%	18.6%	11.9%	38.0%
Normandeau (1968) (Census tract)	17.9% (same or adjacent tract)	19.1%	21.7%	15.2%	26.1%
Rand (1986) (Census tracts)	12.6%	18.4%	16.1%	4.8%	48.1%
Aggravated Assault					
Rand (1986) (Census tracts)	18.8%	21.8%	18.0%	3.0%	38.3%
Simple Assault					
Rand (1986) (Census tracts)	24.8%	12.0%	16.2%	6.0%	41.0%

[a] As reported in Normandeau (1968 271)

Mobility triangles have been applied to rape (Amir, 1971), robbery (Normandeau, 1968), homicide (Tita & Cohen, 2001; Tita & Griffiths, 2006), and other crimes (Rand, 1986). Normandeau (1968) expanded the typology to the current five categories and demonstrated that different types of crime had different spatial typologies. Rand (1986) advanced mobility triangle research by applying Normandeau's five-category classification scheme to several different crimes in the same city. Tita and Griffiths(2006) continued with Normandeau's categories, albeit with new names, keeping the underlying criteria the same.

Previous research on mobility triangles found that the type of triangle varied with the type of crime (Exhibit 1-2). Robberies tended to be either *victim* or *offender* mobility triangles (Rand, 1986). *Neighborhood* triangle was the most frequently occurring triangle for rapes (Amir, 1971). Only two studies have examined homicide (Rand, 1986; Tita & Griffiths, 2006). Rand (1986) found neighborhood triangles were the most frequently occurring type of homicide triangle but she had only 17 observations. In contrast, Tita and Griffiths(2006) had 420 homicides in their data from Pittsburgh. They found *total* mobility triangles to be the most frequently occurring type of homicide (28.3 percent) and *neighborhood* triangles (26.9 percent) as the next most frequent. *Offender* mobility triangles (21.9 percent) and *victim* mobility triangles (18.3 percent) accounted for similar proportions while *offense* mobility triangles accounted for only 4.5 percent of the homicides.

These studies have demonstrated that there is an identifiable spatial typology in existence that describes the joint mobility of offender and victim. In addition, the type of spatial typology varies by type of crime. However, the value of mobility triangles goes beyond already substantial benefits derived from classification of events into joint distributions. Their real value is in laying the foundation for the simultaneous examination of victim, offender, place, and event characteristics (2006). Further, we believe the process of classifying incidents into mobility triangles enables 1) the identification of victim and offender 'pipelines' between neighborhoods and 2) a further analysis of the geography of mobility triangles.

These types of research activities have both theoretical and practical benefits. Mobility triangle research can aid in understanding the complex relationships between crime event locations in one area and the home addresses of victims and offenders. For instance, instead of simply reporting the rate of crime, we can describe whether robbery in an area is a local

phenomena or an imported one in which residents are victimized by nonresidents. This has important implications both for understanding the type of problem in a neighborhood and for formulating effective strategies for addressing the problem.

Challenges to Mobility Triangle Research

Despite the advantages outlined above, the validity of mobility triangles has been challenged on several fronts. One of the most serious challenges stems from the *modifiable areal unit problem* (MAUP)—a problem inherent in all research that aggregates individual level data to areal boundaries (Fotheringham, Brundson, & Charlton, 2000; Haining, 1990). Data aggregation is itself a type of categorization that enables large amounts of data to be summarized. The difficulty is that placement of boundaries to define an area determines which events are included in that area. The boundaries therefore influence the outcome of an analysis by placing events in one area rather than another. One solution to the MAUP is to develop a new mobility typology based solely on the distance between events. However, using distance to characterize spatial coincidence has its own drawback. Distance is a sterile measure that fails to integrate information about the social milieu in which the homicide took place. It is just this type of information that is conveyed so well through neighborhoods.

Another challenge with using areal data, particularly census delineations, is that the boundaries for census tracts are drawn down the center of a street. Thus the addresses on one side of a street may fall in one census area and those on the other side of the street in another. This is problematic because they are obviously part of the same social space. This means that an individual who crosses the street to commit a crime would be classified as part of an *offender* mobility triangle rather than correctly classified as a *neighborhood* mobility triangle. One goal of this research's exploration of distance as well as social area mobility triangles is to quantify the extent to which those types of classification errors occur.

The importance of neighborhoods and neighborhood boundaries on spatial behavior has been clearly demonstrated (Bursik & Grasmick, 1993). Crossing from one neighborhood to another often carries with it a significant change in housing, racial makeup, and exposure to crime. Thus the decision to go to another place may have less to do with physical distance than with social distance. People frequent areas within which they feel comfortable. Human

behavioral patterns are reflected in the spatial structure of their activities. Their activities, in turn, directly influence the convergence of victims and offenders.

In addition, neighborhoods provide easily recognizable 'places' for which analytical results can be discussed. For example, considerable information is conveyed if we can state, "The results of the analysis show the majority of robberies in the District of Columbia's Adams Morgan neighborhood are part of *offender* mobility triangles in which 30 percent of the offenders live in Anacostia." Contrast that statement with the one that could be made using a distance-only classification, "The results of the analysis show the majority of robberies in Adams Morgan are part of victim neighborhood-offender distant triangles". The latter description does reveal that nonresident offenders are victimizing neighborhood residents. However, it does not give any sense of the interaction that is present between Adams Morgan and Anacostia. Identifying the existence of and strength of relationships between areas is one of the major benefits of using the traditional method of mobility triangles.

The advantages of a distance measurement are two-fold. First, the classification is based on the distance traveled and is thus consistent for all incidents. This is in contrast to areal units where the classification of a particular configuration is impacted by the size and shape of the neighborhoods chosen. However, the determination of a cut-off distance (necessary to classify the three incidents) has a similar affect. A larger cut-off distance results in more triads being classified as *neighborhood* mobility triangles while a smaller cut-off distance produces more *total* mobility triangles. Second, distance-based measures for each 'side' of the triangle are produced and, when taken together, provide the basis for testing the differential impact of travel to crime across victim and offender travel distance; and the distance between residences.

As previously stated, a disadvantage to the distance method is that it does not incorporate the notion of social area. To address this, we also explore the possibility of developing a hybrid classification with both distance and social area to classify the joint mobility of homicide participants. Using a hybrid measure would account for events just on one side or the other of a boundary. These events have only a small distance between locations but involve different social areas.

In sum, both social area and distance methods offer important and in some ways complimentary information to the study of homicides. This project examines both traditional

and distance classification schemas for homicide events. The research also explores the feasibility of developing a hybrid classification scheme. In addition, the impact of distance traveled on individual 'legs' of the journey is analyzed.

Preventing Homicide

There are three key shortcomings of previous research that, if addressed, may provide information important to homicide prevention. First, homicides have traditionally been examined as one homogenous type of crime which made it impossible to identify underlying patterns in motives, triggers, and circumstances that may be at work (Harries, 1997). For a better understanding of homicide, the different types of homicide need to be examined separately (Block & Christakos, 1995; Wolfgang, 1958). Wolfgang (1958) was the first to recognize that each type of homicide had different patterns. Since then, the idea that homicides with different motives should be analyzed separately has gained proponents (Flewelling & Williams, 1999; Zahn & Jamieson, 1997).

A second inadequacy has to do with the study area boundaries. Previous studies examining travel of victims to crime location only included victims who lived in the same jurisdiction in which the crime occurred, and most studies of offenders suffer from the same drawback. By excluding victims and offenders from other jurisdictions, the investigators may be introducing a bias toward shorter trips into their results.

The third deficiency in the current literature is the emphasis on offender's spatial behavior to the exclusion of victims. Because convergence is the result of both offender and victim behavior, it is appropriate to include both in an analysis. Traditional mobility triangle research represents an initial attempt to incorporate the social intersection of a victim's home, an offender's home and homicide location. Here we select traditional mobility triangles for consistency, but also expand mobility triangles to include a distance-based classification. By including both, we explore the impact of physical distance versus social distance.

In sum, the research described here builds on the body of work just reviewed to provide a comprehensive examination of the distances and spatial configurations related to the convergence of victim and offender at a place for specific types of homicide. In addition, the exploration of disaggregated data regarding the journey to crime provides important information for homicide prevention programs. As noted by Block and Christakos (1995), the path to better

understanding consists of the following steps: identify where homicides are occurring, what is causing them, and which interventions can be implemented to address those specific situations. This, more holistic approach to understanding homicide, provides important information to inform action research efforts such as ‘pulling levers’(Kennedy, 1997; Kennedy, 1998; Kennedy & Braga, 1998b).

Chapter 2

Data and Methodology

Homicide Data

This research draws on homicide data from the Metropolitan Police, District of Columbia (MPDC) for the years 1990 through 2002. A total of 4,552 homicides occurred in the District during this 13-year period—an average of about 350 homicides per year. Between 1999 and 2003, the principal investigators were involved in a series of projects awarded to the Institute for Law and Justice, Inc. for improvement of homicide investigations. Those projects included a review of all homicide cases over the 13-year period, development of a case management system for the department's Homicide Division, annual analyses of homicide trends for the city council, and preparation and submission of homicide data to the FBI's Violent Criminal Apprehension Program (ViCAP).

ViCAP is a nationwide data information center developed for the purpose of collecting, collating, and analyzing crimes of violence, especially homicides. It includes open and closed homicides, missing persons (where the circumstances indicate a strong possibility of foul play), and sexual assault cases. Cases can be entered into the ViCAP system by law enforcement investigators for database comparison and possible matching with unsolved cases. The intent is to identify similar patterns of homicide which will in turn allow ViCAP personnel to pinpoint those crimes that have been committed by the same offender. When patterns are found, law enforcement agencies are notified of the results.

In 2000, the MPDC signed a memorandum of agreement with the FBI to provide its homicide cases to the ViCAP system. At the time, the FBI provided ViCAP coding booklets that could be completed on each homicide. The booklet has sections for victim information, offender/suspect information, offender's *modus operandi*, causes of death, sexual activity, weapons, and vehicle information. Booklets were completed for the 4,552 homicides occurring in the District during the 13-year period—a coding exercise that took over one year with ten coders. Most coders were retired MPDC investigators. Master case jackets maintained in the Homicide Division served as the source of information for coding the ViCAP booklets. Each

master case jacket includes the original homicide report, autopsy, investigative narratives, and arrest information. A key advantage of having retired investigators perform the coding was their familiarity with the master case jackets, which could be quite voluminous. On the other hand, they required more training time and supervision because they were unaccustomed to coding reports.

After each homicide was coded into a booklet, data entry personnel entered the information into a case management database that had been developed by ILJ. The case management system for the Homicide Division included ViCAP data elements along with locally beneficial information such as detectives assigned to a case and the district of occurrence for each homicide. On a periodic basis, the MPDC transmitted records to the FBI for inclusion in the ViCAP system.

The case management system served several purposes for the Homicide Unit. It was a tracking device for case assignments, case status (open, closed), suspects, and other information. It maintained a history of assignments for each case, which proved beneficial over time in determining who needed to be contacted about old cases. Some homicides take years to investigate and may be handled by several investigators. The case management system was linked to the department's Columbo system, which was a data warehouse accessible on a real-time basis. The Columbo system included calls for service, Part I crimes, criminal histories, warrants, and other information accessible by police officers and investigators. Information from the homicide case management system was uploaded into the Columbo system on a daily basis. In summary, the MPDC had one system for homicides for multiple purposes rather than having to maintain several independent systems.

As a data collection instrument for research, the ViCAP booklet has advantages and disadvantages. A key advantage is that it is a comprehensive and validated instrument. Many police departments across the country complete ViCAP booklets on their homicides and submit the information to the FBI's system. As an example of its comprehensiveness, the information on each victim includes name and aliases, home address, gender, race, date of birth, age, height, weight, hair color, hair length, general lifestyle, and physical features. The booklet includes 20 different motives and allows for more than one motive to be checked for a homicide. Other parts of the coding booklet are equally detailed.

The ViCAP system includes open cases, cases closed by arrest, and exceptional clearances. A closure by arrest means that investigators made a physical arrest by having sufficient evidence to obtain an arrest warrant through prosecutorial approval. Closed by exception means that the investigators believed they have identified the offender and have supporting evidence for arrest, but are unable to make an arrest because the offender may already be incarcerated on another offense, may have fled from the area, was killed during the instant offense, or has died since the offense. In the MPDC, cases not closed are considered to be open through active investigation (the department does not designate cases as suspended or inactive). For the study period, 2,311 homicides had been closed for a clearance rate of 58.4 percent, while 1,644 (41.6 percent) remained open. These rates are as of our cutoff date for data collection of March 2003.

Information on suspects entered into the ViCAP database on open cases includes name, sex, race, age, and home address. In many instances, only a portion of this information may be available (e.g., a suspect's sex and race may be known from witnesses, but not the suspect's age and home address). For the current study, we included suspects in our analysis if the VICAP record contained a valid home address. Our reasoning was that sufficient evidence existed to provide a link to a homicide, but not enough evidence at the time of our study to close the case. Approximately eight percent of the homicides fall into this category of open cases having suspects with valid home addresses. Because suspects account for only a small percent of the total, the remainder of this final report will use the term offender for both groups.

Another advantage of the ViCAP system is that the information can be updated as investigative leads are followed. For example, the motives behind a homicide may not be known at the time of the incident, but may be determined through investigation and arrest. Once determined, the system can be updated. Similarly, information on suspects and offenders can be added based on the results of an investigation.

Our experience with the ViCAP booklet identified several disadvantages as far as employing the booklet for research purposes. The victim's height, weight, and hair color were not generally available in the master case jacket, and the coders were instructed not to devote much time to making these determinations—a decision predicated on the belief that this information has minimal value either for research purposes or local application. In addition,

coders occasionally encountered problems in determining how to code certain fields. For example, choices for the relationship between offender and victim included overlapping categories—friend, acquaintance, neighbor, and ex-girlfriend/ex-boyfriend. The coding booklet does not contain clarifying definitions and examples to differentiate clearly between these categories.

Of particular interest for our study, the database includes the address where the homicide occurred, the home address of the victim and the home address of offenders. While most victims resided in Washington, D.C., the database includes victims killed in the city but whose homes were in the adjoining states of Maryland and Virginia. We excluded about one percent of victims and offenders who lived elsewhere.

The street networks of the District of Columbia, Maryland, and Virginia are important to the study because about 13 percent of the offenders lived outside the District. While the street pattern in the city is basically a grid network in the downtown area, there are numerous circles, parks, and diagonal streets that make it unique. In addition, outside the downtown area, there is a more suburban street pattern. Maryland and Virginia have suburban street patterns except in the downtowns of some of the larger cities.

All three addresses (incident address, victim's home address, and offender's home address) were geocoded in the first phase of the research.[5] Initially, the addresses were batch geocoded to the street centerline file developed by city's department of transportation. The city's file is more accurate than the TIGER files provided by the U.S. Bureau of the Census. Addresses that could not be matched through the batch process were then interactively geocoded. A final step was that we attempted to locate all remaining unmatched addresses by consulting both the Internet[6] and printed maps. Addresses that were successfully located via these sources were manually placed at the correct location.[7] While time consuming, the result was a homicide location dataset with both a high degree of accuracy and a high match rate. A similar process was repeated for home addresses that fell within Washington, D.C. Home addresses outside the

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5 All geocoding was done in ArcGIS® 8.3. Minimum match scores of 85 (D.C. street layer) and 80 (TIGER streets) were selected as criteria for the batch geocoding. A higher minimum match score was used in the city because the NE, NW, SE, SW quadrant system required more accurate matches.

6 The Mapquest site (http://www.mapquest.com) was used to identify the location of addresses during the interactive geocoding process.

city were matched to the TIGER files for Maryland and Virginia. There were 4,151 victim home addresses, of which 3,955 (95.3 percent) were successfully geocoded. A total of 3,434 home addresses were available for offenders of which 3,304 (96.2 percent) were successfully geocoded.

Both Euclidean distances and street distances were calculated for the study. The key advantage of the Euclidean distance is that it is easy to calculate through a geographic information system. However, it does not take into account the urban transportation network and topography of an area that might lengthen a trip. Street distance offers a more accurate measure of the actual path between two points but is more difficult to determine, especially in an automated manner. If available, it may be more beneficial for police in identifying suspects, canvassing areas, and designing prevention strategies because it provides a more realistic measure of actual distance traveled than does Euclidean distance. Despite the accuracy gained through analyzing the transportation network, street distance is still only an estimate of the journey to victimization because there is no way of knowing if victims and offenders took the shortest path route available. Moreover, victims and offenders are not necessarily traveling from or to their homes just prior to the homicide. These distances do, however, serve as good proxy measures for activity spaces (Rhodes & Conly, 1981) of the participants. Routines for calculating these two distances are available from the web site maintained by ESRI, Inc.[8]

Factors Affecting the Analysis

Although the data set assembled for this analysis is comprehensiveness, it has several limitations. Four factors introduce an unknown amount of bias into the study results: (1) limiting analysis to homicides where all three locations were known, (2) the necessity of geocoding the events for a geographic analysis, (3) the assumption that the crime trip began at home, and (4) the use of two different study area boundaries.

In Chapter 4, we present an analysis of mobility triangles for homicides in which all three locations were known. As Block, et al. (2004) noted, this subset of cases may not be

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7 The PickAddress script available at \arcgis\arcexe83\ArcObjects Developer Kit\Samples\Geocoding\Pick was accessed for this purpose.

8 See http://support.esri.com. The script used in this study for calculating Euclidean distances is called pt2pt_distance.ave. The new script developed by James Cardona to measure street distance is under 'Calculate Network and Euclidean Distance.'

representative of the population of cases. The impact of this source of bias on the results of the analysis is not known. Block, et al. (2004) conjecture that homicides in which an address is known might be homicides in which the victim and offender had some prior relationship or the distance traveled by both parties was short.

The set of observations is further reduced during the geocoding process because only those locations that are successfully geocoded are included in the data used in the analysis. Limiting the analysis to geocoded events introduces an unknown level of bias since systematic bias can occur, for example, when certain types of locations are not geocoded. The analysis with mobility triangles has the greatest loss of data because it includes only those homicides for which all three addresses could be geocoded. Having thirteen years of data offsets some of the losses because it raises the initial number of homicides with the result that our analysis is based on 2,773 mobility triangles.

The measurement from home to location in our analysis should not be taken as assuming that the victim or offender began at home and proceeded directly to the location of the crime. Following Rhodes and Conly (1981), the distance between home address and incident location is used as a heuristic device for characterizing how far the offender or victim was from their home when the crime occurred. We recognize that it is far more likely that the trip to the location of the homicide did not start at home for either the offender or the victim, and that it involved intermediate stops. However, information was not available on other locations or anchor points from which victim or offenders (e.g. work, recreation, a friend's residence) may have started (Horton & Reynolds, 1971; Wiles & Costello, 2000).

Finally, our research uses two different geographic extents to define the study area. The study area for homicide locations is Washington, D.C. even though some victims and offenders lived outside the city. We did not exclude these non-residents from our study. The decision to include victims and offenders who live outside of the city inflates the mean travel distance. Consequently in some of our analysis, we rely on the median as a more accurate measure of the average.

Phases of the Analysis

The research is divided into three major phases. The first phase involves the measurement of three distances: 1) victim's home to homicide location, 2) offender's home to homicide location and 3) victim's home and offender's home. This descriptive analysis sets the stage for later multivariate analyses. The second phase is an in-depth exploration of the mobility triangle methodology and involves contrasting the traditional typology with a new distance-based typology. The third phase, discussed in a separate document, explores techniques for cartographic visualization (McEwen & Groff, 2005).

Phase 1: Distance-to-Crime Analysis

This phase represents a replication of previous journey to crime studies that focused on offenders but with additional analyses of the victim's journey to crime and the distance between homes. Examining the relative distances between the three locations provides a measure of the overlap in the routine activity spaces of victims and offenders. A geographic information system (GIS) calculated the Euclidean and shortest path distance along the streets between home addresses, and then between each of their addresses and the homicide location. The measurement process is automated via an Avenue® program.

A question raised in the literature concerns whether travel behavior is different for the crimes in which an arrest is made versus those in which no arrest is made. Following the lead of Block et al. (2002), we compare the victim travel distances for events in which there was no arrest with those in which an arrest was made. The two distributions are also compared to improve our understanding of the differences.

Recognizing the impact of events where the offense occurs at the offender's or victim's home address, we analyze each distribution two ways: (1) with all the events included, and (2) with the zero distance events removed. With this technique, Block et al. (2002) found large differences in distances traveled.

The final part of the distance to crime analysis uses a curve-fitting program to determine the values of parameters for a given function or equation and can handle exponential, logistic, periodic, and general nonlinear functions. As suggested by Brantingham and Brantingham

(1981b), we pay particular attention to three possible functions that have proven beneficial in other studies—the Pareto function, exponential function, and Pareto-exponential function.

Phase 2: Explore Spatial Interactions

This portion of the study explores more robust ways to use the descriptive power of the traditional mobility triangle classification typology. Three different typologies are explored: (1) traditional mobility triangles; (2) distance-based mobility triangles, and (3) a hybrid distance/area mobility triangle typology. Too coarse or too fine a typology masks variation in the distribution, so the differences among different distance-based typologies are quantified and compared. While the authors recognize the difficulties posed by the modifiable areal unit problem when aggregating to areas, we believe the added benefit of neighborhoods outweighs the potential cost. Neighborhoods have several significant advantages as units of analysis.[9] They have identifiable and widely recognized boundaries (Gottfredson and Taylor 1985; Saarinen 1976; Skogan and Maxfield 1981). Neighborhoods encompass a portion of the city in which residents feel connected via a common bond of "place" (Skogan and Maxfield 1981). These traits of neighborhoods make communicating results much more straightforward. In addition to the intrinsic advantages of neighborhoods, the proposed hybrid distance-mobility triangle spatial typology has the potential to keep the advantages and mitigate the overall costs of both methods.

Phase 3: Explore Cartographic Representation

In the final phase of the research, we examine point, line, and area techniques for visualizing origin and destination relationships. For maps in which both offender and victim trips are short, the use of point mapping techniques or origin-destination line maps are demonstrated. At a large scale (e.g. neighborhood), these types of maps are best at revealing relationships among event locations. For situations where the distance for the offender is short and for the victim is longer (or vice versa), the application of choropleth mapping is tested. Finally, where both offender and victim travel extensively, desire flow maps are created. These maps allow a more stylized view of the data by summarizing aggregate flows between areas. Desire flow maps are used when examining a small-scale map of the entire city or the regional view.

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[9] Several neighborhood typologies have been developed; for example, more detailed information can be found in Bursik and Grasmick (1993)and Saarinen (1976).

The most basic technique is the use of point patterns to show the distribution of events. One example would be to map all crime locations and color-code them by distance classification. Another point mapping technique would be to pick one area and only display the point locations of associated victim and offender home addresses.

Choropleth maps are frequently used to depict aggregate data for areas (Dent 1990; Rengert, Piquero and Jones 1999). An offender journey to crime map could highlight an origin neighborhood and then shade all the other neighborhoods by the percent of total events committed by offenders from the origin neighborhood in the various destination neighborhoods. Another example would be to shade each neighborhood by whether it is a net importer or exporter of offenders/victims (separate map for offenders and victims). The details of these techniques are presented in *Visualization of spatial relationships in mobility research: A primer* (Groff & McEwen, 2005a).

Overview of Homicides in the District of Columbia

Basic Statistics

Exhibit 2-1 gives basic information on the homicide victims and offenders for which we have geocoded addresses.[10] Males dominate in both the victim and offender categories accounting for 3,457 victims (87.4 percent) and 3,113 offenders (94.5 percent). With regard to race, African-Americans predominate accounting for 3,679 victims (93.0 percent) and 3,185 offenders (96.7 percent). The average age of male victims was 28.1 years (with a median of 25.0 years), while female victims are older at 32.2 years (median of 29.0 years). Offenders are younger on average. Male offenders average 23.5 years of age (with a median of 21.0 years), while female offenders average 27.9 years old (median of 26.0 years). Most homicide incidents involve only one victim, with just fewer than five percent having two or more victims.

[10] In this report, the term 'offender' includes both arrested persons and suspects with valid home addresses. The breakdown is 2,966 arrestees and 327 suspects.

Exhibit 2-1: Basic Statistics on Victims and Offenders, Washington, D.C., 1990-2002

Characteristic	Victims		Offenders	
Gender	Number	Percent	Number	Percent
Male	3,457	87.4	3,113	94.5
Female	498	12.6	176	5.3
Total	3,955	100.0	3,289	100.0
Race				
African-American	3,679	93.0	3,185	96.7
White	138	3.5	69	2.1
Hispanic	107	2.7	27	0.8
Other	31	0.8	4	0.3
Total	3,955	100.0	3,285	100.0
Age	Mean	Median	Mean	Median
Male	28.1	25.0	23.5	21.0
Female	32.2	29.0	27.9	26.0

NOTE: Gender was not available on four offenders.

As previously discussed, one of the advantages of the ViCAP system is that more than one motive can be coded for the underlying causes of a homicide. For example, a gang-related homicide over drug turfs can be coded as both gang- and drug-related, rather than trying to decide the most important motive. The capability to code more than one motive eliminates the need to make choices about the predominant motive and provides more information on the extent of different types of homicides.

Victim and Offender Locations

The maps on the following three pages reflect the core of analysis presented in the remainder of this report. Exhibit 2-2 shows the home locations for victims killed in the District for the two-year period, 2000 and 2001.[11] The map reflects the fact that a significant number of victims resided outside the city's borders. Exhibit 2-3 maps the locations of the homicides for the two years. It shows several concentrations including areas just north of the center of the city and the southeast area along with border of Prince George's County. Finally, Exhibit 2-4 shows the home locations of offenders for the two-year period. Many offenders lived outside the city.

[11] Maps based on these two years appear throughout the report for illustrative purposes.

Exhibit 2-2: Map of Home Locations for Homicide Victims, 2000-2001

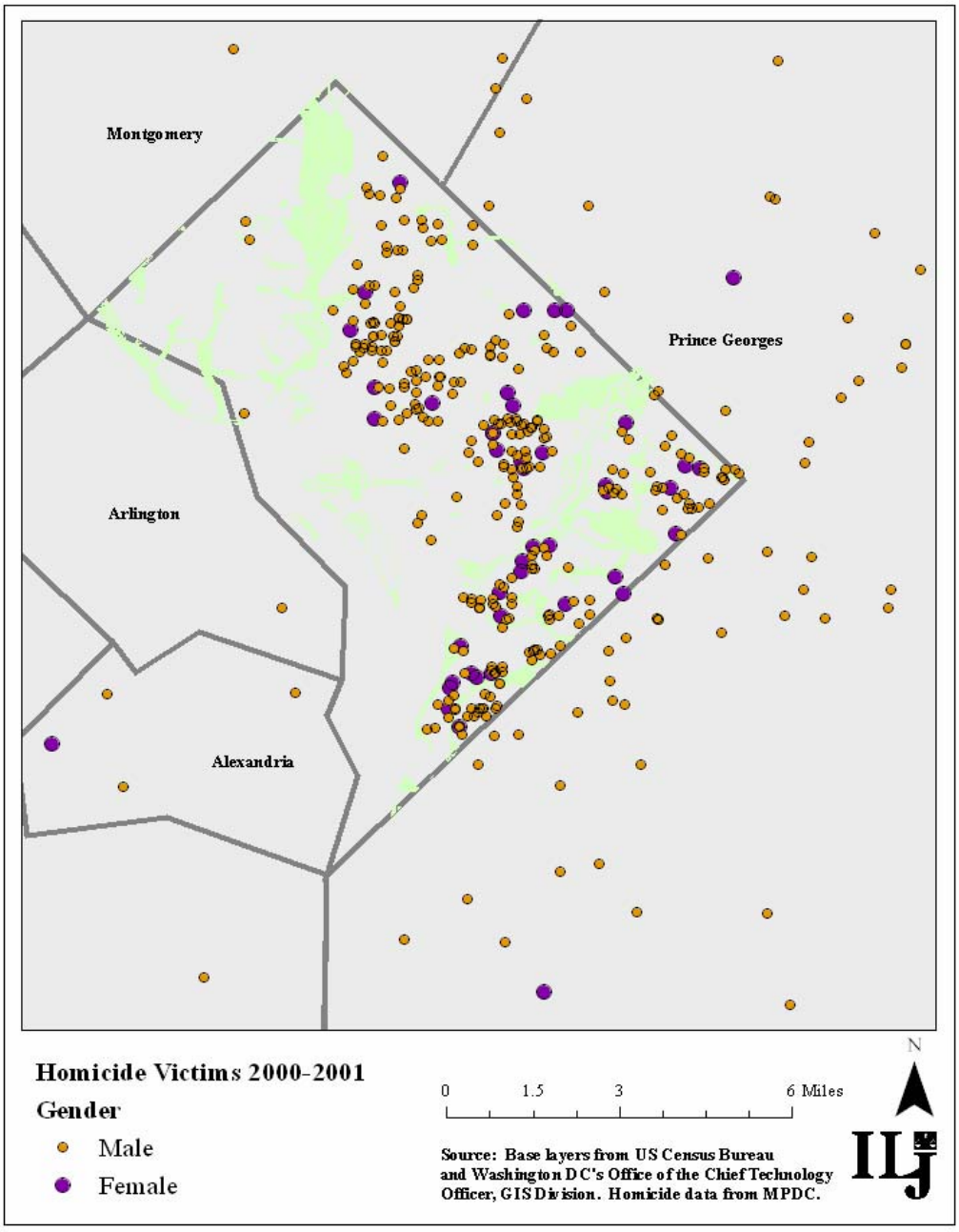


Exhibit 2-3: Map of Homicide Locations for Victims, 2000-2001

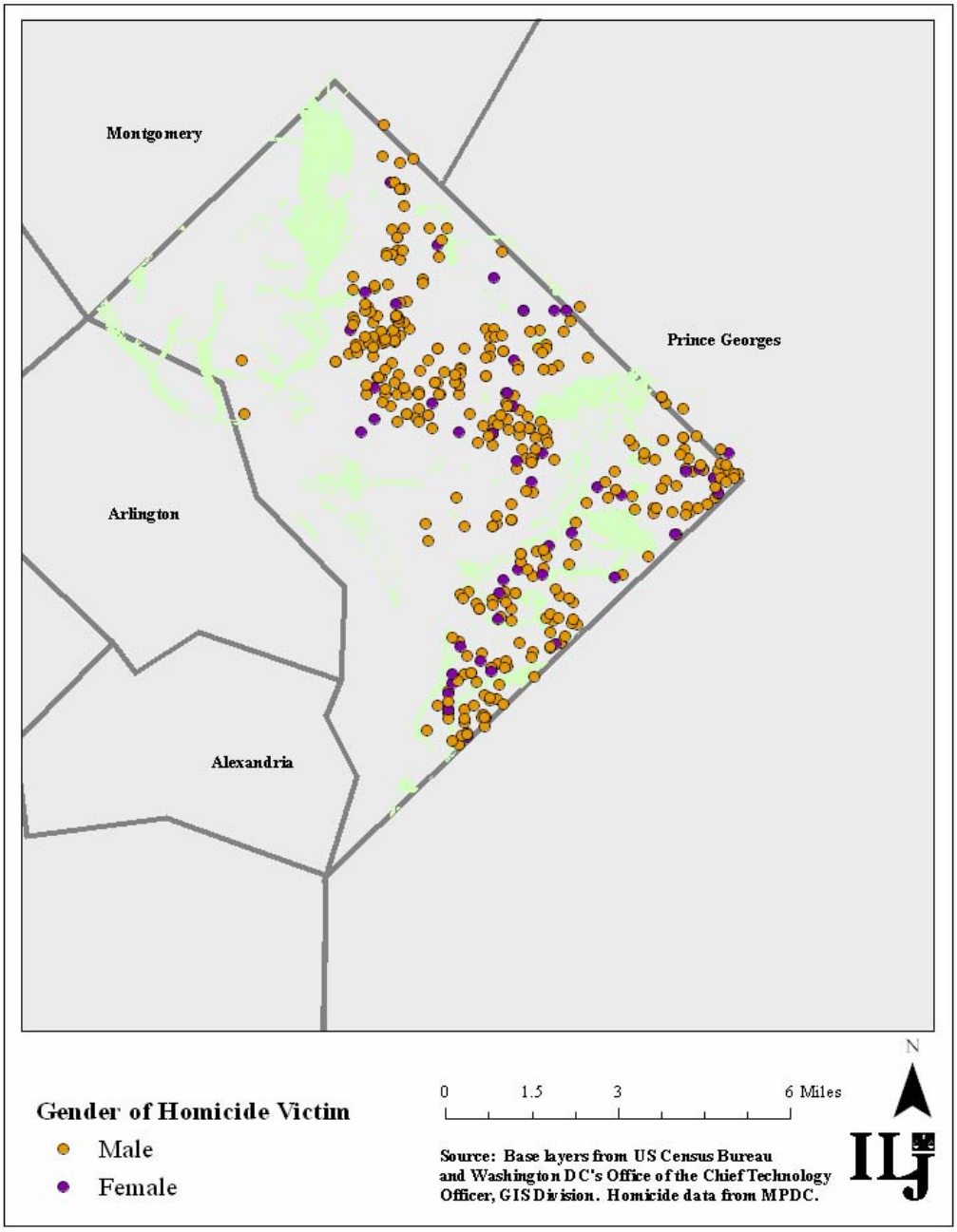
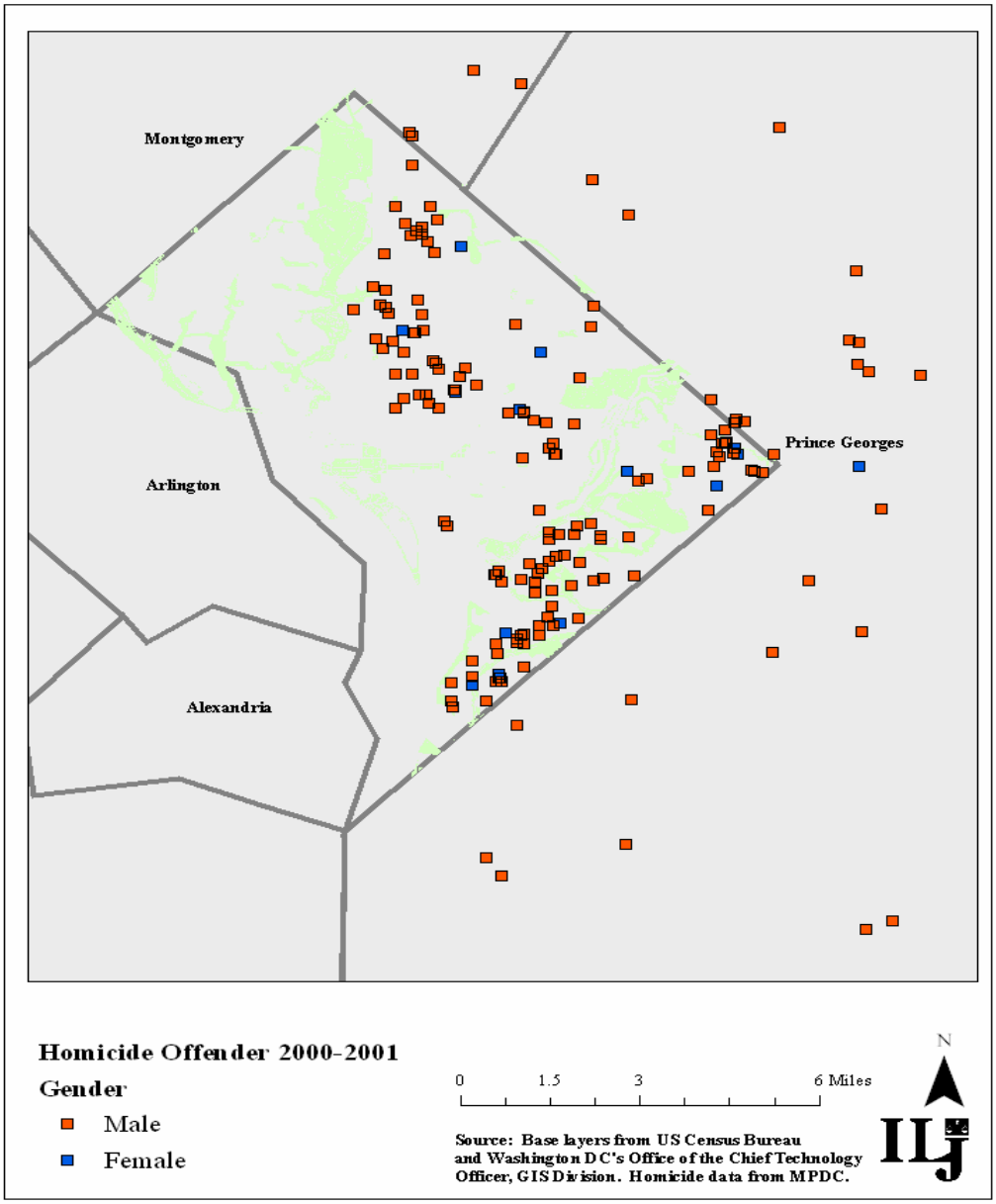


Exhibit 2-4: Map of Home Locations for Offenders, 2000-2001



Homicide Motives

As seen in Exhibit 2-5, a total of 7,001 motives were recorded for the 3,955 homicides, giving an average of 1.8 motives per homicide. Further analysis shows that about 17 percent of the homicides had three or more motives. Argument is the most frequent motive recorded. By definition, coders are instructed to check this category if the argument led directly to the homicide. Five other motives are predominant—drug-related, retaliation, robbery, gang-related, and domestic violence. Collectively, the top six motives accounted for more than 80 percent of the motives. Other motives include arson, burglary, child abuse, sexual motivation, and witness elimination.

Definitions for the six predominating motive categories are as follows (Office of Quality Assurance 2001):

- Argument: A disagreement between two or more parties with intent to provoke a breach of the peace by annoying, disturbing, interfering, or offending others.
- Domestic violence: The deliberate and premeditated killing of another family member, to include any person with whom the offender is related by blood, legal custody, marriage, having a child in common, or with whom the offender shares or has shared a mutual residence; or any person with whom the offender maintains or maintained a romantic relationship not necessarily including a sexual relationship.
- Drug-Related: Any criminal act that directly or indirectly involves substances recognized as a controlled substance.
- Gang-Related: A group of two or more individuals involved in any type of criminal activity, typically recognized as gang membership by their neighborhood.
- Retaliation: A violent act committed against another person as the result of retaliation for a perceived wrong done to the offender.
- Robbery: The taking of anything of value from another person or their immediate possession by force or violence, whether against resistance or by sudden or stealthy seizure or snatching, or by putting the person in fear.

Exhibit 2-5: Motives for Homicides, Washington, D.C., 1990-2002

Motive	Number of Homicides	Percent of Motives	Percent of Homicides
Argument	2,073	29.6	52.4
Drug-related	1,379	19.7	34.9
Retaliation	971	13.9	24.6
Robbery	797	11.4	20.2
Gang-related	523	7.5	13.2
Domestic violence	223	3.2	5.6
Other	902	12.9	23.8
Undetermined	133	1.9	3.4
Total	7,001	100.0	

Chapter 3

Analysis of Distances

A primary interest in our research centers on the three distances that can be calculated from the data—distance between victim's home and the homicide location, distance between offender's home and the homicide location, and distance between victim's home and offender's home. A secondary interest involves the relationship between two different distance measures, street distance and Euclidean distance. Results of this comparison are reported at the end of the chapter and influenced our decision to report all distances based on Euclidean distance.

Victim's Distance to Incident

Exhibit 3-1 gives statistics for the distances between a victim's home and location of the homicide. The exhibit is for the 3,955 victims for whom these distances could be determined. The overall mean distance is 2.68 miles (standard deviation of 6.94) with a median of .54 miles.[12] Other breakdowns in the exhibit show differences depending on the category:[13]

- The average distance for males (2.74 miles) is greater than for females (1.68 miles).
- Average distances generally increase with age until age 35 after which they decrease. For juveniles (under 18 years old), the average distance is 1.57 miles compared to adults between 25 and 34 years old (3.59 miles).
- Distances vary significantly depending on the motive. Domestic violence incidents have average distances of 1.72 miles, while robbery and drug-related homicides averaged more than three miles.
- Distances by case status are about the same at 2.74 miles for open cases and 2.64 miles for closed cases.
- Distances are longer for homicides that involve firearms. Those homicides average 2.85 miles compared to 2.10 miles for homicides using other weapons.

[12] The large difference between the mean and median is due to outliers in the data—more specifically to the fact that some victims lived more than 100 miles from the city.

[13] All differences in distances, except for case status, are statistically significant at the 5 percent level, as determined by either t-tests or analysis of variance.

Exhibit 3-1: Distances in Miles Between Victim's Home and Homicide Location

Category	Number	Mean (s.d.)	Median
Overall	3,955	2.68 (6.94)	0.54
Gender			
Males	3,457	2.83 (7.09)	0.69
Females	498	1.68 (5.75)	0.06
Age			
Under 18 years	399	1.57 (3.36)	0.37
18 – 24 years	1,459	2.47 (5.86)	0.69
25 – 34 years	1,140	3.59 (9.61)	0.89
35 – 49 years	693	2.50 (5.29)	0.37
50 years or more	262	2.14 (6.06)	0.00
Motives			
Robbery	797	3.24 (6.13)	0.92
Drug-related	1,379	3.03 (7.93)	0.74
Argument	2,073	2.58 (7.49)	0.47
Retaliation	971	2.29 (6.07)	0.62
Gang-related	523	2.16 (4.20)	0.67
Domestic violence	223	1.72 (7.35)	0.00
Case Status			
Open cases	1,644	2.74 (6.82)	0.64
Closed cases	2,311	2.64 (7.03)	0.47
Weapon Used			
Firearm	3,076	2.85 (7.07)	0.73
Other weapon	879	2.10 (6.45)	0.12

The medians are instructive in providing further insight into the differences. The median distance for females was .06 miles, compared to a median of .69 miles for males. Victims over the age of 50 had medians of zero, indicating that more than half of these victims were killed in their residences. Similarly, victims of domestic violence have a median of zero, as should be expected by the definition of these incidents.

The skewness present in the data structure on distances has a major impact on the averages presented in Exhibit 3-1. Many homicides occur at home while other victims are more than 100 miles from their homes. For these reasons, the arithmetic differences between the means and medians are large, and standard deviations are sometimes more than three times the mean. The data are not tightly structured around the mean.

Our approach to make better sense of the data is to split the distances into three groups. The first group consists of 'home' homicides, the second are 'middle-distance' homicides, and

the final group consists of 'long' distances between the victim's home and the location of the homicide. With this breakdown, we find there are 807 homicides (20.4 percent) in which the victim's distance from home to incident is less than .01 miles (about 52 feet).[14] There are 2,959 (74.8 percent) of the homicides with 'middle distances' defined as .01 to 10 miles from victim's home to incident. Finally, there are 189 homicides (4.8 percent) where the distances are greater than ten miles.

Some of the key differences across the three groups are as follows:

- Forty-six percent of the female victims are killed at their home, compared to only 16.7 percent of the males.
- The average age of victims killed at home is 34.7 years, compared to 26.8 years for the middle-distance victims, and 31.2 years for the long-distance victims.
- Sixty-six percent of the home homicides are closed compared to 56.5 percent of the middle-distance homicides, and 56.1 percent of the long-distance homicides.
- Motives varied across the three groups—
  - Arguments are found as a motive in over half of the home and middle-distance homicides, and in 44.4 percent of the long-distance homicides.
  - Drug-related motives are more likely to be found in the middle- and long-distance homicides (37.1 and 39.2 percent, respectively) than home homicides (25.7 percent).
  - Gang-related motives are a factor in 6.7 percent of the home homicides, 15.3 percent of the middle-distance homicides, and 9.0 percent of the long-distance homicides.
  - Retaliation motives are in 15.5 percent of the home homicides, 27.6 percent of the middle-distance homicides, and 15.9 percent of the long-distance homicides.
  - Domestic violence is a motive in 16.0 percent of the home homicides, compared to 2.9 percent of the middle-distance homicides and 3.7 percent of the long-distance homicides.
- About 55 percent of the home homicides involve firearms compared to 83.7 and 81.0 percent of the middle- and long-distance homicides.

[14] We have assumed that a distance of less than 50 feet, or about .01 miles, indicates that the homicide took place at the victim's home or very close by.

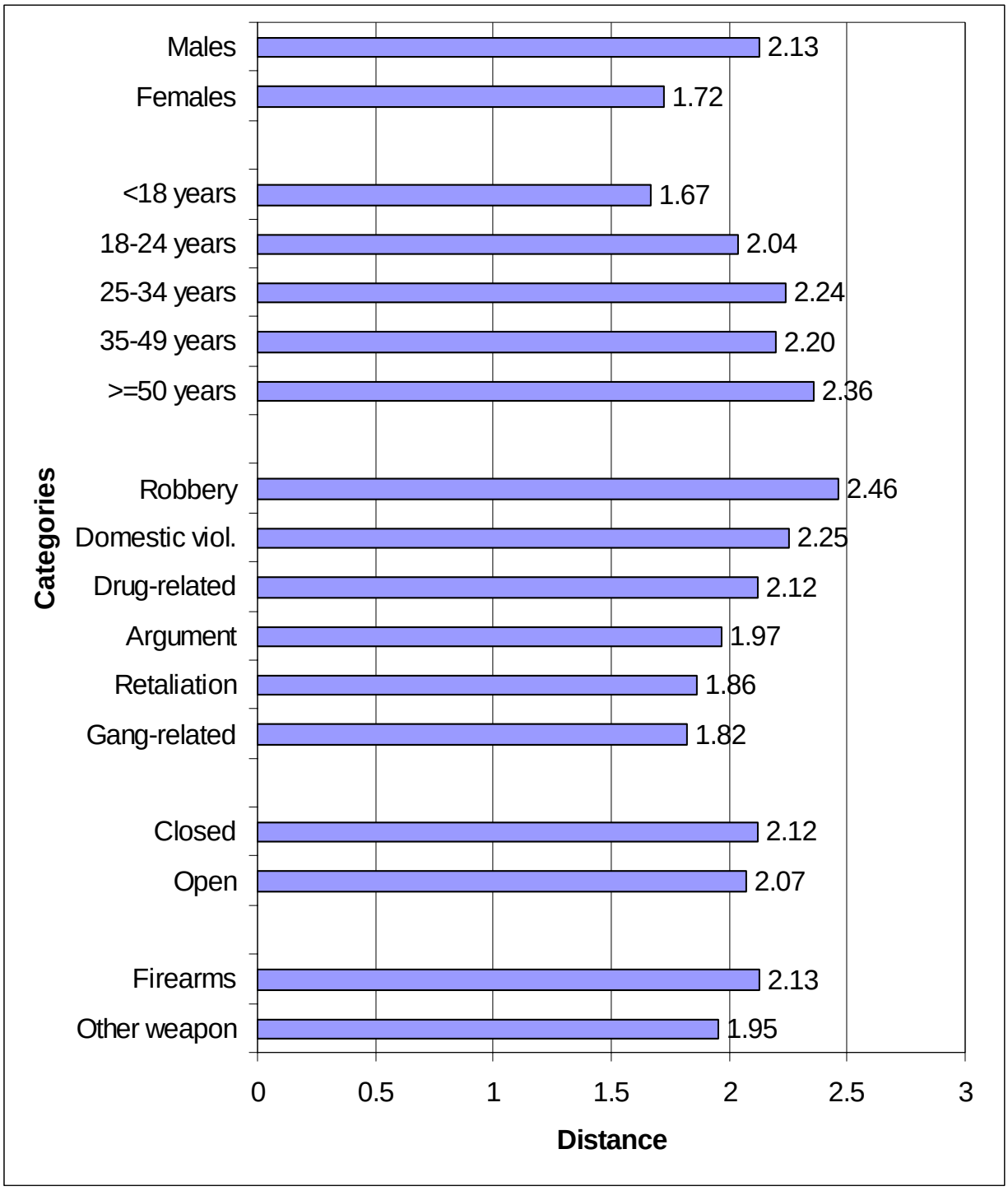
Middle-distance Victim Homicides

Summary Statistics

The middle-distance homicides are analyzed in greater detail because they represent the largest group in our breakdown. Focusing on the middle-distance homicides removes the effects of the outliers on each end of the distribution. For these homicides, the overall average distance is 2.10 miles, with a median of 1.09 miles between the victim's home and the location of the homicide. As seen in Exhibit 3-2, for male victims, the average distance is 2.13 miles (median 1.12 miles), and for female victims, 1.72 miles (median .69 miles). For victims under 18 years old, the average distance is 1.67 miles, increasing to 2.04 miles for victims between 18 and 24 years old, and then remaining about the same at about 2.2 miles for victims over 24 years old. Average distances for motives range from 1.82 miles for gang-related homicides to 2.46 miles for robbery homicides. With regard to case status, the average distances are not significantly different staying near the average distance of 2.1 miles (t=.58; p-value=.56). Finally, victims killed by firearms averaged 2.13 miles from home, while those killed by other means averaged 1.95 miles. The difference was not found to be statistically significant (t=1.52; p-value=.13).

The average distance of 2.25 miles for victims of domestic violence is the second longest distance among the motives even though those victims had the shortest overall distance (1.72 miles) in the previous exhibit. This apparent conflict can be explained by the following observations. The majority of victims of domestic violence were killed in or very close to their homes; more specifically, 51.4 percent are 'home' homicides (hence the median in Exhibit 3-1 is zero). In fact, victims of domestic violence have the largest percentage of home homicides as compared to the other motives. The high percentage of home homicides results in a relatively low overall distance. When home homicides are removed, the average distance naturally moves upward, and moves to the extent that middle-distance homicides for this motive exceed the overall average.

Exhibit 3-2: Middle-distance Homicides for Victims' Home to Incident



NOTE: Distances for this exhibit were in the range from .01 to 10 miles.

Curve Fitting

A well-established finding in prior studies on distance to crime is that the distribution of distances that offenders take to their crimes follow what is generally called a *distance decay* function (for example, see Capone & Nichols (1976)), which means that fewer crimes take place as distance from home increases. Based on our analysis, the same can be said for the distances that victims are from their homes. Following Capone & Nichols (1976), we analyzed the middle distances by fitting several statistical distributions—exponential, Pareto, Pareto-exponential, Beta, and Weibull. For this analysis, we used the software package GraphPad Prism, Version 4.0. Values of R^2 (coefficient of determination) were compared among the fits for the statistical distributions to determine the distribution that best fit the data. The R^2–values for the final fits were all greater than .90, indicating a close fit between the selected statistical distribution and the data.

The Pareto-exponential function was found to provide the best fit over the motives for which enough cases existed for analysis. In functional form, the Pareto-exponential function is defined as follows:

$$y = a\, D^{-b}\, e^{-cD}$$

where y is the number of homicides that occur at a given distance D, and *a*, *b*, and *c* are the estimated parameters for the distribution. (The Pareto-exponential curve usually lies between the Pareto and exponential curves that are fit to the same set of data. It therefore moderates the effects of the two distributions.).

Exhibit 3-3 gives the parameters with standard errors for the Pareto-exponential functions by motive. In Exhibit 3-4, the curves based on these parameters and the actual data are shown. It can be seen that the Pareto-exponential function gives a good fit to the five distributions of motives.

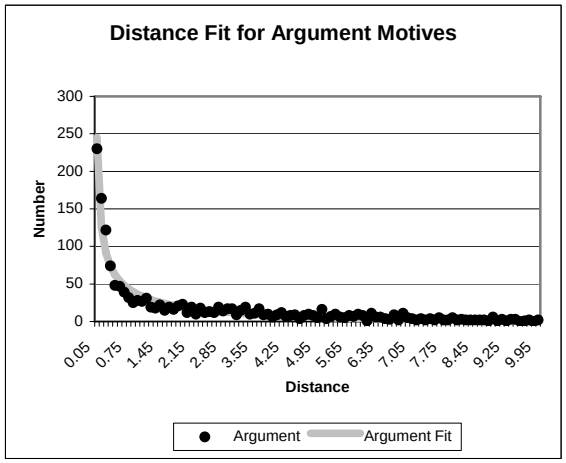
Exhibit 3-3: Parameters for Pareto-exponential Function, Middle-distance Victims

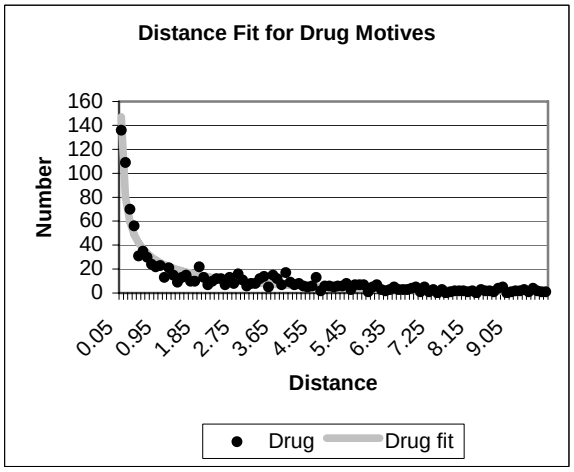
Motive	a Parameter (s.e.)	b Parameter (s.e.)	c Parameter (s.e.)
Arguments	42.97 (2.88)	0.58 (0.02)	0.21 (0.04)
Drug-related	29.78 (2.05)	0.54 (0.03)	0.54 (0.04)
Gang-related	13.61 (0.97)	0.54 (0.03)	0.26 (0.05)
Robberies	12.98 (0.93)	0.54 (0.03)	0.12 (.04)
Retaliation	25.64 (1.94)	0.52 (0.29)	0.29 (0.05)

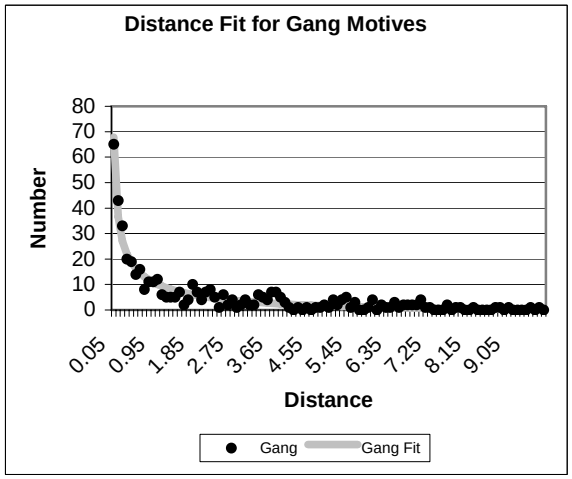
NOTE: There were not enough cases for domestic violence homicides to develop a fit.

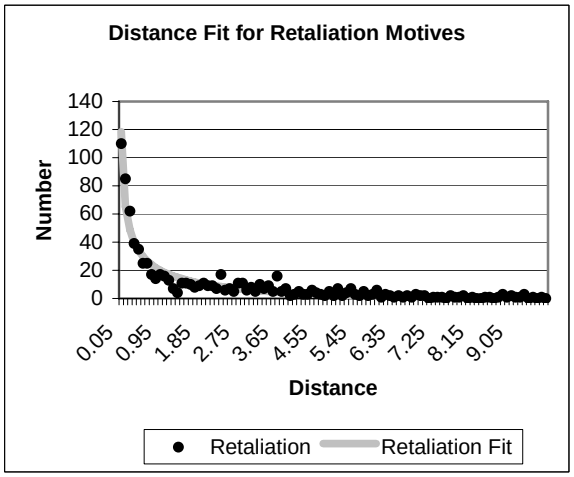
The distributions summarized in Exhibit 3-3 could be the basis for an event simulation program that simulates the distances victims travel from their homes. In a similar way, the distributions presented later in this chapter on fitting offender distances could be used in an event simulation program.

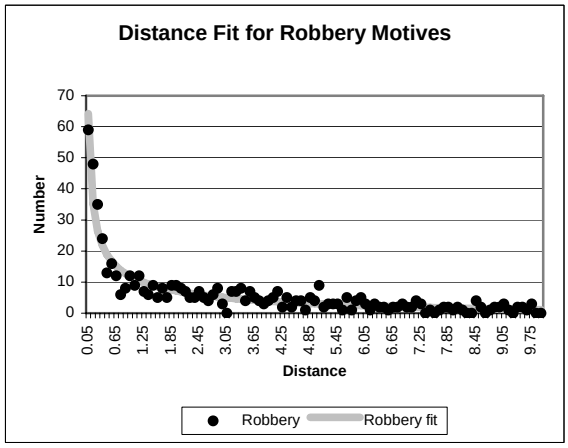
Exhibit 3-4: Middle-distance Fits for Victims











NOTE: Distances are in miles.

Euclidean Versus Street Distance for Victims

A secondary interest in our study was to inform the debate on whether to calculate Euclidean or street distance between locations. We calculated both distances between a victim's residence to the location of the incident. The street distance for the entire file of 3,955 victims averaged 3.14 miles (s.d.=7.94 miles) with a median of .69 miles. The average street distance is greater than the average Euclidean distance of 2.68 miles as reported in Exhibit 3-1. Moreover, an almost perfect correlation exists between the two distances.

Exhibit 3-5 gives the results of a bivariate linear regression with street distance as the dependent variable and Euclidean distance as the independent variable. All R^2 values were found to be over 98 percent.

Exhibit 3-5: Regression Results for Street and Euclidean Distances—Victims

Motive	No. of Cases	Euclidean Distance	Street Distance	Regression Equation
All Cases	3,955	2.68 (6.94)	3.14 (7.94)	.079 + 1.142*Euclidean Distance
Arguments	2,073	2.58 (7.49)	3.01 (8.44)	.113 + 1.125*Euclidean Distance
Domestic Violence	223	1.72 (7.35)	1.99 (8.21)	.063 + 1.116*Euclidean Distance
Drug-related	1,378	3.03 (7.93)	3.57 (9.12)	.093 + 1.147*Euclidean Distance
Gang-related	523	2.16 (4.20)	2.56 (4.77)	.101 + 1.134*Euclidean Distance
Retaliation	971	2.29 (6.07)	2.71 (7.18)	.006 + 1.179*Euclidean Distance
Robbery	797	3.24 (6.13)	3.79 (7.05)	.073 + 1.148*Euclidean Distance

Note: All distances are in miles.

These results suggest that investing in software to measure street distance may be unnecessary for most analysis. Euclidean distance is easy to calculate with GIS software, does not require the purchase of additional software modules, and is easy to explain. Further, it is a mathematical formula that can be included in an analytical routine. Exhibit 3-5 shows that good estimates of street distance can be made by knowing Euclidean distance.

Offender's Distance to Incident

In this section, we present a similar analysis of distances related to offenders, specifically, the distances between the homes of offenders and the locations of the homicides. The dataset for this analysis consists of 3,293 offenders for which distances from home to incident could be calculated. As shown in Exhibit 3-6, the overall mean distance is 2.66 miles (standard deviation of 8.89 miles) and a median of .71 miles. Other highlights from the exhibit are as follows:[15]

- The average distance for males from their homes is 2.69 miles, which is greater than the average distance for females at 2.22 miles.
- By age groupings, the distances for offenders less than or equal to 24 years old is 2.56 miles, increasing to 3.24 miles for offenders between 25 and 34, then decreasing for older offenders down to 1.42 miles for those 50 years or over.
- Distances vary significantly by motive with drug-related homicides having the greatest average distance for offenders at 2.99 miles, down to 1.62 miles for domestic violence offenders.
- As discussed in Chapter 2, the database for offenders includes some cases in which the case was still open because not enough evidence had been gathered. Offenders in these open cases live an average of 1.79 miles from the incident, compared to 2.76 miles for closed cases.
- Offenders with firearms live farther away from their homicides. On average the distance is 2.80 miles, compared to offenders with other weapons at 2.19 miles.
- In stranger-to-stranger homicides, the offender lives an average of 2.73 miles from the incident, compared to 2.60 for acquaintance homicides, and 2.176 miles for intimate homicides.

A review of the statistics in Exhibit 3-6 shows the same phenomena as with the distances for victims: the means have relatively large standard deviations, and are much larger than their associated medians. The most obvious case illustrating the differences is with the relationship category. As should be expected, homicides in which the offender and victim are intimate (e.g., husband and wife) have a median distance of zero, meaning that the majority of these homicides took place in the home. The medians increase to .64 miles for acquaintance homicides (e.g., friends or neighbors), and 1.16 miles for stranger-to-stranger homicides.

[15] Unlike the distances for victims, none of the differences in the following list are statistically significant at the 5 percent level, as determined by either t-tests or analysis of variance.

Exhibit 3-6: Distances Between Offender's Home and Homicide Location

Category	Number	Mean (s.d.)	Median
Overall	3,293	2.66 (8.89)	0.71
Gender			
Males	3,113	2.69 (8.69)	0.76
Females	176	2.22 (11.96)	0.07
Age			
Under 18 years	501	2.56 (11.14)	0.53
18 – 24 years	1,781	2.55 (8.68)	0.81
25 – 34 years	667	3.24 (8.26)	0.92
35 – 49 years	251	2.36 (7.89)	0.27
50 years or more	70	1.42 (2.59)	0.06
Motives			
Drug-related	1,091	2.99 (8.54)	0.84
Argument	1,888	2.81 (10.57)	0.65
Gang-related	515	2.71 (9.74)	1.02
Retaliation	835	2.69 (8.98)	0.89
Robbery	762	2.52 (5.67)	1.02
Domestic violence	224	1.62 (2.88)	0.10
Case Status			
Closed cases	2,966	2.76 (9.29)	0.74
Open cases	327	1.79 (3.66)	0.48
Weapon Used			
Firearm	2,519	2.80 (9.11)	0.87
Other weapon	774	2.19 (8.14)	0.33
Relationship			
Stranger	657	2.73 (6.45)	1.16
Acquaintance	2,226	2.60 (8.94)	0.64
Intimate	257	2.17 (9.87)	0.00

Note: All distances are in miles.

Because of the skewness present in the distributions, we divide the offender distances into the same three categories as for the victim distances: home homicides (distances from offender's home to incident is less than .01 miles), middle-distance homicides (between .01 and 10 miles), and long-distance homicides (more than 10 miles). The subdivision results in 356 (10.8 percent) home homicides (meaning that the victim is killed in or very near to the offender's home), 2,838 (86.2 percent) middle-distance homicides, and 99 (3.0 percent) long-distance homicides. Chi-square values based on cross-tabulations with the three distance categories were statistically significant at the five percent level for gender, motive (except argument), age category, weapon, status, and relationship.

Offenders in the home and long-distance categories had the following characteristics:

Characteristics of 356 Home Offenders

- 283 (79.5 percent) are males and 73 (20.5 percent) are females. The female home offenders account for 41.4 percent of the total female offenders.
- Firearms are the weapons used by 152 (42.7 percent) home offenders, compared to 204 (57.3 percent) home offenders with other weapons.
- Motives for the home offenders include 214 (60.1 percent) arguments, 98 (27.5 percent) domestic violence homicides, 62 (17.4 percent) drug-related homicides, 10 (2.8 percent) gang-related homicides, 40 (11.2 percent) retaliations, and 32 (8.99 percent) robberies.
- The average age of home offenders is 30.1 years, compared to 22.9 years for middle-distance offenders and 25.5 years for long-distance offenders.
- For the 333 offenders for which relationship to victim was known, 25 (7.5 percent) are stranger-to-stranger homicides, 169 (50.8 percent) are acquaintances, and 139 (41.7 percent) are intimate relationships.

Characteristics of 99 Long-distance Offenders

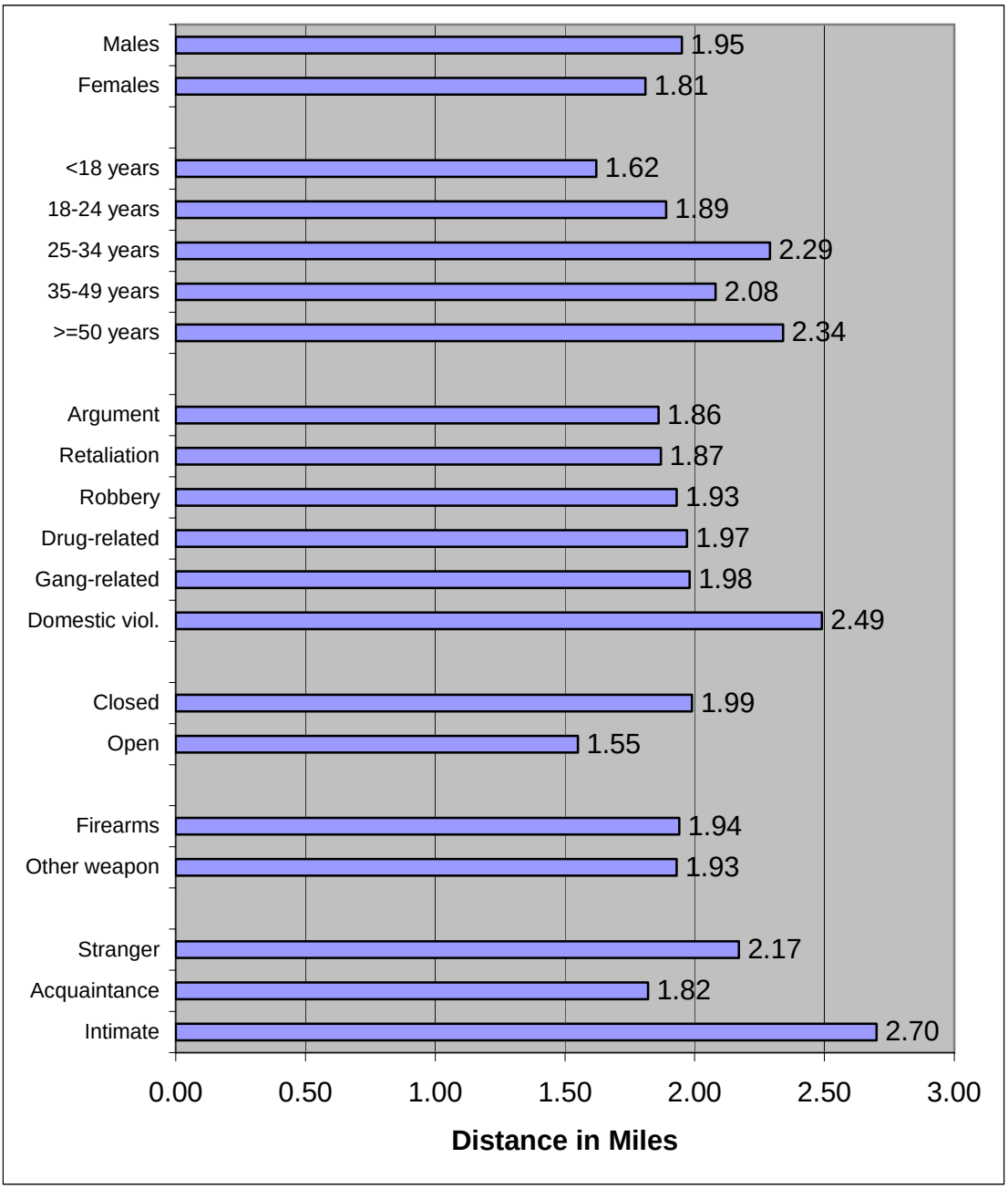
- 94 offenders are males and five were females.
- 76 offenders used firearms in their offenses compared to 23 offenders with other weapons.
- Motives for the long-distance offenders include 61 arguments, 4 domestic violence homicides, 41 drug-related homicides, 13 gang-related homicides, 28 retaliations, and 21 robberies.
- For the 90 long-distance offenders for which relationships with victims are known, 21 were stranger-to-stranger, 60 are acquaintances, and 9 are intimate relationships.

Middle-distance Offender Distances

The 2,838 (86.2 percent) middle-distance distances were analyzed in more detail because they represent the largest majority of the offenders and focusing on the middle-distance homicides also removes the effects of the outliers on each end of the distribution. The middle-distance category consists of 2,736 males (96.5 percent) and firearms are the weapon of choice with 2,291 offenders (80.7 percent). Motives include 1,613 arguments (56.8 percent), 122 domestic violence homicides (4.3 percent), 988 drug-related homicides (34.8 percent), 492 gang-related homicides (17.3 percent), 767 retaliations (27.0 percent), and 709 robbery homicides (25.0 percent). With regard to relationships, 611 (22.5 percent) are stranger-to-stranger homicides, 1,997 (73.5 percent) are acquaintances, and 109 (4.0 percent) are intimate relationships. The age distributions show 460 (16.3 percent) offenders under 18 years old, 1,610 (57.1 percent) between 18 and 24years old, 547 (19.4 percent) between 25 and 34 years old, 165 (5.9 percent) between 35 and 49 years old, and only 36 (1.3 percent) at 50 years or older.

Exhibit 3-7 gives basic statistics on the average distance from offenders' homes to the locations of the homicides for these middle-distance offenders. The distances for males and females are about the same at 1.95 and 1.81 miles, respectively. With age groupings, the distances of offenders' homes to locations get longer as age increases. Offenders under 25 years old are less than two miles from home, while those 25 years or older are more than two miles. Interestingly, the distances for motives range only from 1.86 to 1.98 miles, except for domestic violence, which is 2.49 miles. The distances by weapon are virtually the same of middle-distance offenders at 1.94 miles for those with firearms and 1.93 miles for those with other weapons. Finally, the distances by relationship show an average of 2.17 miles for stranger-to-stranger homicides, 1.82 miles for acquaintances, and 2.70 for intimate homicides.

Exhibit 3-7: Middle-distance Homicides for Offenders' Home to Incident



One of the aims of the research is to test whether significant differences existed by motive for offender's distance from home to the homicide location. Offenders with middle distances are an appropriate set on which to conduct these tests. We want to determine, for example, whether the average distance for homicides with argument motives differs from those with motives of domestic violence, drug-related, gang-related, retaliation, and robbery. Exhibit 3-8 shows the results of these tests. For this test, we select only those records for which the particular motive is the only motive for the homicide. This screening is necessary to avoid dependences in the tests for differences. The average distances at the top of Exhibit 3-8 therefore differ from those previously presented because they are the singular motive.

Exhibit 3-8: Tests for Differences by Motive Between Distances for Offenders

Motive	Number	Mean (s.d.)
Arguments	646	1.82 (2.21)
Domestic violence	34	2.97 (2.42)
Drug-related	224	2.16 (2.47)
Gang-related	34	2.15 (2.81)
Retaliation	140	1.94 (2.20)
Robberies	325	1.73 (2.06)

NOTE: Distances (in miles) are for those incidents for which the motive was the singular motive in the homicide.

t-values for pairwise comparisons:

Motive	Domestic Violence	Drug-Related	Gang-Related	Retaliation	Robberies
Arguments	2.94***	1.92*	0.85	0.60	-0.60
Domestic Violence		-1.78*	-1.28	-2.39**	-3.28***
Drug-related			-0.01	-0.85	-2.21**
Gang-related				-0.48	-1.10
Retaliation					-1.00

NOTE: *** Significant at the .001 level
** Significant at the .05 level
* Significant at the .10 level

The bottom portion of the exhibit shows the results of t-tests for pairwise comparisons across motives. Results show significant differences for offender travel for arguments versus

domestic violence and drug-related homicides. Offender travel for domestic violence also is significantly different from drug-related, retaliation, and robbery homicides. The final significantly different offender travel was between drug-related and robbery homicides. None of the other comparisons resulted in significant differences.

Exhibit 3-9 and Exhibit 3-10 give the parameters and figures that were determined from fitting the distances for offenders to the Pareto-exponential distribution. One difference is that this distribution did not fit well with drug-related distances. For these homicides, a better fit was found with an exponential distribution, with the parameters shown in the exhibit.[16] With all five motives, the distributions give an excellent fit to the distances.

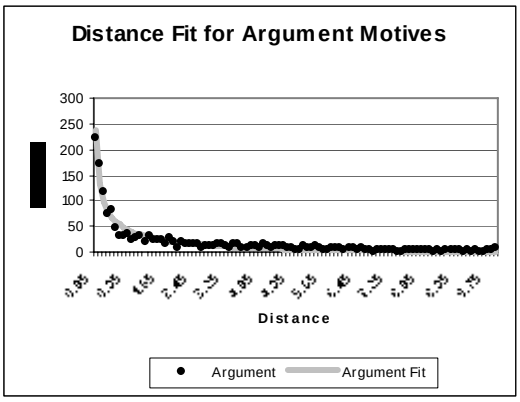
Exhibit 3-9: Parameters for Distance Fits, Middle-distances Offenders

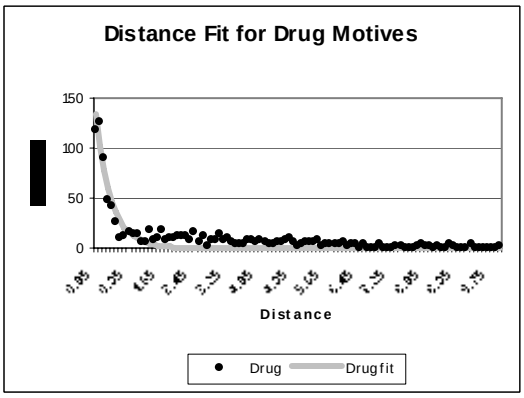
Motive	a Parameter (s.e.)	b Parameter (s.e.)	c Parameter (s.e.)
Arguments	51.14 (3.59)	0.52 (0.03)	0.30 (0.05)
Drug-related	152.5 (10.18)	N/A	2.45 (0.15)
Gang-related	18.78 (1.73)	0.39 (0.04)	0.41 (0.07)
Robberies	22.71 (2.20)	0.47 (0.04)	0.29 (0.07)
Retaliation	30.52 (3.10)	0.40 (0.04)	0.45 (0.08)

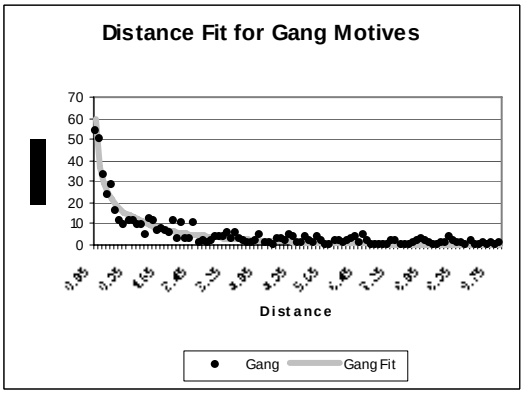
NOTE: The fit for drug-related offenders was an exponential distribution. All others are Pareto-exponential distributions. There were not enough cases for domestic violence homicides to develop a fit.

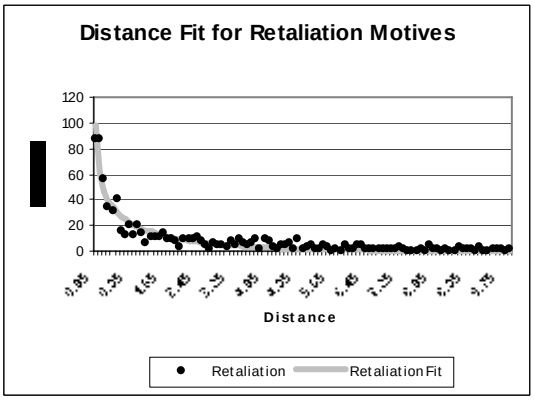
[16] The Pareto-exponential distribution reduces to the exponential distribution when the second parameter, b, is zero.

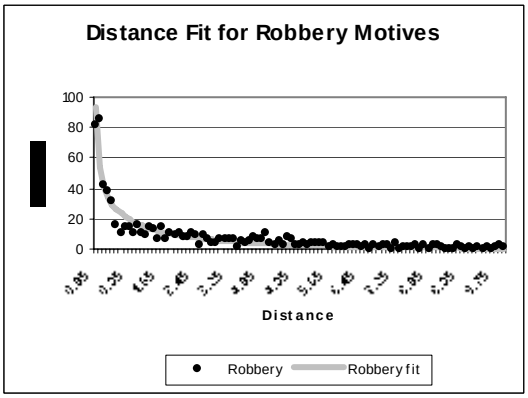
Exhibit 3-10: Middle-distance Fits for Offenders











NOTE: Distances are in miles.

Euclidean Versus Street Distance for Offenders

As with victims, we compared Euclidean and street distances between an offender's residence to the location of the incident. The street distance for the entire file of 3,293 offenders averaged 3.13 miles (s.d.=10.46 miles) with a median of .88 miles. The average street distance is greater than the average Euclidean distance of 2.66 miles as reported in Exhibit 3-6. An almost perfect correlation exists between the Euclidean and street distances for offenders.

Exhibit 3-11 gives the results of a bivariate linear regression with street distance as the dependent variable and Euclidean distance as the independent variable. All R^2 values were found to be over 98 percent.

Exhibit 3-11: Regression Results for Street and Euclidean Distances—Offenders

Motive	No. of Cases	Euclidean Distance	Street Distance	Regression Equation
All Cases	3,293	2.66 (8.89)	3.13 (10.46)	.010 + 1.174*Euclidean Distance
Arguments	1,888	2.81 (10.57)	3.31 (12.44)	.017 + 1.175*Euclidean Distance
Domestic Violence	224	1.62 (2.88)	1.91 (3.27)	.079 + 1.134*Euclidean Distance
Drug-related	1,091	2.99 (8.54)	3.50 (9.92)	.033 + 1.160*Euclidean Distance
Gang-related	515	2.71 (9.74)	3.21 (11.31)	.069 + 1.160*Euclidean Distance
Retaliation	835	2.69 (8.98)	3.16 (10.43)	.044 + 1.160*Euclidean Distance
Robbery	762	2.52 (5.67)	2.96 (6.38)	.124 + 1.124*Euclidean Distance

Note: All distances are in miles.

Distances Between Residences

This analysis in this section is based on the 2,773 homicides for which the distance between the offender's residence and the victim's residence could be determined. Analysis of these distances provides some idea of the extent of the potential overlap in the activity spaces of the victim and offender prior to the incident. Overall, the Euclidean distance between residences averaged 4.32 miles (standard deviation of 10.95 miles) with a median of 2.01 miles. As with the distances previously discussed in this chapter, these statistics indicate a considerable amount of skewness in the distance distribution.

Dividing the homicides into home (living within .01 miles of each other), middle-distance (living .01 to 10 miles apart), and long-distance (living more than 10 miles apart) categories provides a better picture of the distances. This breakdown gives totals of 194 homicides in the home category, 2,383 in the middle-distance category, and 196 in the long-distance category. The 194 homicides in the home category obviously consist mostly of homicides where the victim and offender live together. Exceptions occurred, for example, when the victim and offender lived in the same complex, such as an apartment complex, but in different residences. Eighty-eight percent of these homicides had motives of either arguments or domestic violence.

Homicides in the long-distance category between residences tended to have different characteristics. These homicides included 88 (46.8 percent) stranger homicides, 90 (47.9 percent) acquaintance homicides, and 10 (5.3 percent) intimate homicides. The distances between residences averaged 27.73 miles (standard deviation of 32.08 miles), with a median of 14.93 miles and a range of 10 to 205.3 miles. Firearms were used in 150 homicides (76.5 percent). Motives varied across the six major motivations and included 103 arguments, 8 domestic violence, 70 drug-related, 25 gang-related, 37 retaliation, and 65 robberies.

Finally, homicides in the middle-distance category between residences consisted of 453 (19.8 percent) stranger homicides, 1,740 (76.0 percent) acquaintance homicides, and 96 (4.2 percent) intimate homicides. The distances between residences averaged 2.75 miles (standard deviation of 2.0 miles) with a median of 2.01 miles. These homicides were a mixture of categories with 1,446 arguments, 119 domestic violence, 846 drug-related, 439 gang-related, and 689 retaliation, and 560 robbery homicides. Firearms were used in 1,943 (81.5 percent) of these homicides.

Relationships Between Distances

This section of the report develops a relationship through linear regression with the distance between the victim and offender residences as the dependent variable. The analysis is restricted to the middle-distance homicides because these are most frequent homicides in our dataset. Further, from a practical investigative viewpoint, the middle-distance homicides are the most difficult to solve. Home homicides are easier for investigators to close because the offender may be immediately identified at the scene. Long-distance homicides represent about

seven percent of the total homicides for which we have complete distance data. They are outliers with respect to the analysis presented in this section.

The regression is based on 1,824 closed homicides for which data on the dependent variable and 23 independent variables were available. As a starting point, Exhibit 3-12 shows the correlation between the three distances for this data set. The correlation of .035 between the victim's residence to the homicide and the offender's residence to homicide indicates a random relationship. On the other hand, a significant correlation exists between the victim's residence to the homicide location and the distance between the two residences. The positive correlation means that a short distance from the victim's residence to the homicide location is correlated with a short distance between the residences of the victim and offender. Conversely, a longer distance from the victim's residence to the homicide location is correlated with a longer distance between the two residences.

Exhibit 3-12: Correlations Between Distances

Distance	Offender to Homicide	Home to Home
Victim to Homicide	.035	.616***
Offender to Homicide		.536***

*** Correlation is significant at the .01 level.

Exhibit 3-13 shows the means and standard deviations for the independent variables in the analysis. For the dichotomous variables, the mean is the percent for the particular variable. For example, 95 percent of the victims were African-Americans, 93 percent were male, and 84 percent resided in the District. The three continuous variables in the exhibit are the victim's distance to the homicide location with an average of 2.07 miles (standard deviation of 2.31 miles), the victim's age with an average of 25.85 years (standard deviation of 9.39 years), and the offender's age with an average of 22.30 years (standard deviation of 6.84 years). The mobility categories in the table are based on the distance triads with a reference distance of one-half mile. Only one of these categories is designated with a value of one and zeroes in all four categories would represent the *total* mobility category.

The regression results are shown in Exhibit 3-14. Variables with statistically significant coefficients were as follows:

- Victim's distance to the homicide location
- Victim's residence (inside or outside the District)
- Victim's age
- Offender's age
- Offender's residence (inside or outside the District)
- Gang-related, retaliation, and robbery motives
- *Neighborhood, offender, victim,* and *offense* mobility indicators

The R^2 value for the regression is .619, which indicates a relatively good fit.

Exhibit 3-13: Means and Standard Deviations for Independent Variables

Characteristic	Mean	Standard Deviation
Victim's Distance to Homicide Location (miles)	2.07	2.31
Victim Characteristics		
Victim's age (years)	25.85	9.39
Victim's race (0 = Other; 1=African-American)	0.95	0.21
Victim's gender (0 = Female; 1=Male)	0.93	0.26
Victim's residence (0=Not D.C.; 1=D.C. resident)	0.84	0.37
Offender Characteristics		
Offender's age (years)	22.30	6.84
Offender's race (0 = Other; 1=African-American)	0.98	0.15
Offender's gender (0 = Female; 1=Male)	0.98	0.14
Offender's residence (0=Not D.C.; 1=D.C. resident)	0.90	.29
Victim/Offender Relationship		
Intimate (0=No; 1=Yes)	0.02	0.14
Acquaintance (0=No; 1=Yes)	0.77	0.42
Event Characteristics		
Firearm used (0=No; 1=Yes)	0.85	0.36
Location (0=Inside; 1=Outside)	0.81	0.39
Motives		
Argument (0=No; 1=Yes)	0.60	0.49
Domestic violence (0=No; 1=Yes)	0.03	0.17
Drug-related (0=No; 1=Yes)	0.36	0.48
Gang-related (0=No; 1=Yes)	0.20	0.40
Retaliation (0=No; 1=Yes)	0.32	0.47
Robbery (0=No; 1=Yes)	0.23	0.42
Mobility Category		
Neighborhood (0=No; 1=Yes)	0.16	.37
Offender (0=No; 1=Yes)	0.20	0.40
Victim (0=No; 1=Yes)	0.24	0.43
Offense (0=No; 1=Yes)	0.03	0.16

Exhibit 3-14: Regression Analysis for Distances Between Residences

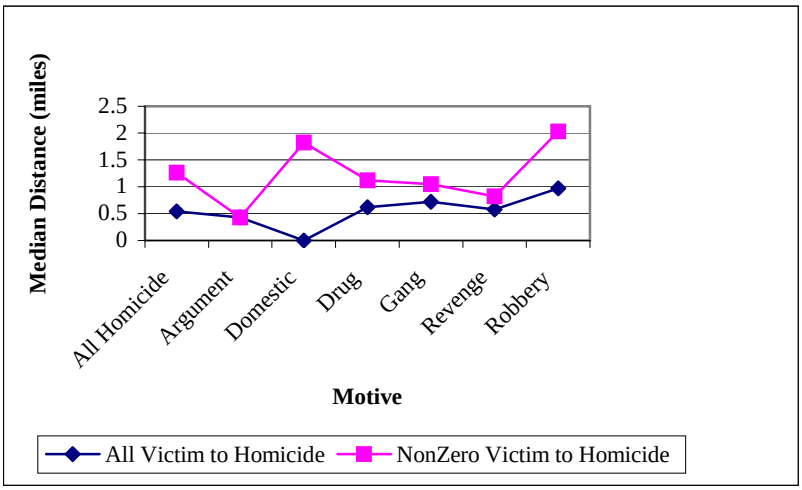
Variable	B	Standard Error
Constant	3.520***	.515
Victim's Distance to Homicide Location	.640***	.027
Victim Characteristics		
Victim's age (years)	.008*	.005
Victim's race	-.170	.199
Victim's gender	.053	.167
Victim's residence	-.602***	.140
Offender Characteristics		
Offender's age (years)	.012**	.006
Offender's race	.138	.278
Offender's gender	.139	.283
Offender's residence	-2.078***	.139
Victim/Offender Relationship		
Intimate	-.109	.329
Acquaintance	-.148	.102
Event Characteristics		
Firearm used	.100	.120
Location	.047	.102
Motives		
Argument	-.078	.091
Domestic violence	-.171	.271
Drug-related	.005	.089
Gang-related	.317***	.104
Retaliation	-.228***	.089
Robbery	-.200**	.109
Mobility Category		
Neighborhood	-1.259***	.137
Offender	1.192***	.126
Victim	-.441***	.103
Offense	-2.495***	.244

*** Significant at the .01 level.
** Significant at the .05 level.
* Significant at the .10 level.
R^2 = .619

Removing Home-based Incidents

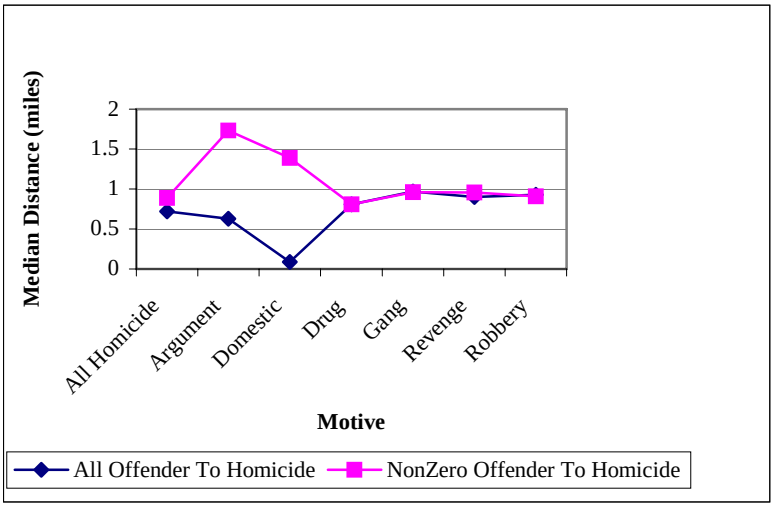
To tease out the effect of home-based incidents on travel distances for offenders and victims by type of homicide, the data were analyzed with all events included and with the zero-distance trips removed. Not surprisingly, the average distance of trips increased for most types of homicide and for both victims and offenders. However, the types of crime that increased were different depending on whether a victim trip, offender trip or distance between offender and victim home address was being examined. For all homicides, taking out zero distance trips increased the average distance for victims much more than for offenders. When just victim trips are considered, domestic violence homicide has the largest change (+1.82 miles) (Exhibit 3-15). Followed by Robbery (+1.06 miles) and drug-related homicides (+.50 miles).

Exhibit 3-15: Distance From Victim Home to Homicide Location: All vs. Nonzero Distances



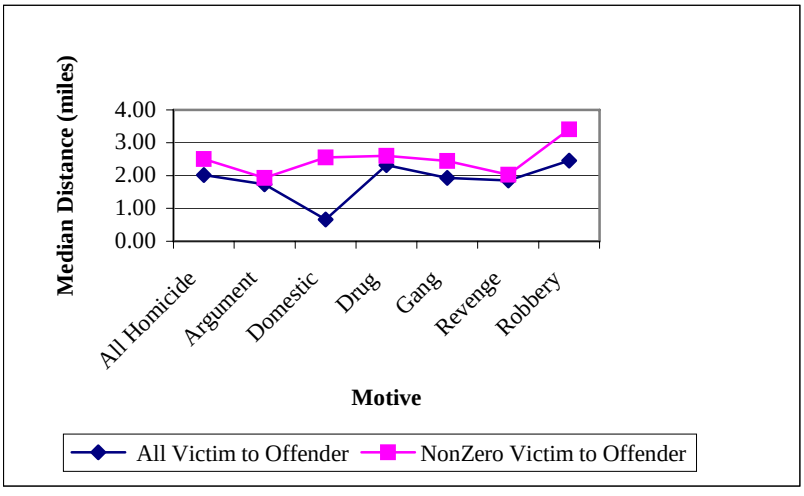
This pattern contrasts with the impact of offenses that occur at the offender's home on median offender travel distances (Exhibit 3-16). Removing zero distance trips by offenders had almost no effect on the offender travel distances for drug-related, gang-related, retaliation, and robbery homicides indicating these types of homicide rarely occur at the home of the offender. On the other hand, domestic violence (1.3 miles) and argument-related (1.10 miles) homicides were greatly increased, signifying that homicides with these motives often occur at the offender's residence.

Exhibit 3-16: Distance From Offender Home to Homicide Location: All vs. Nonzero Distances



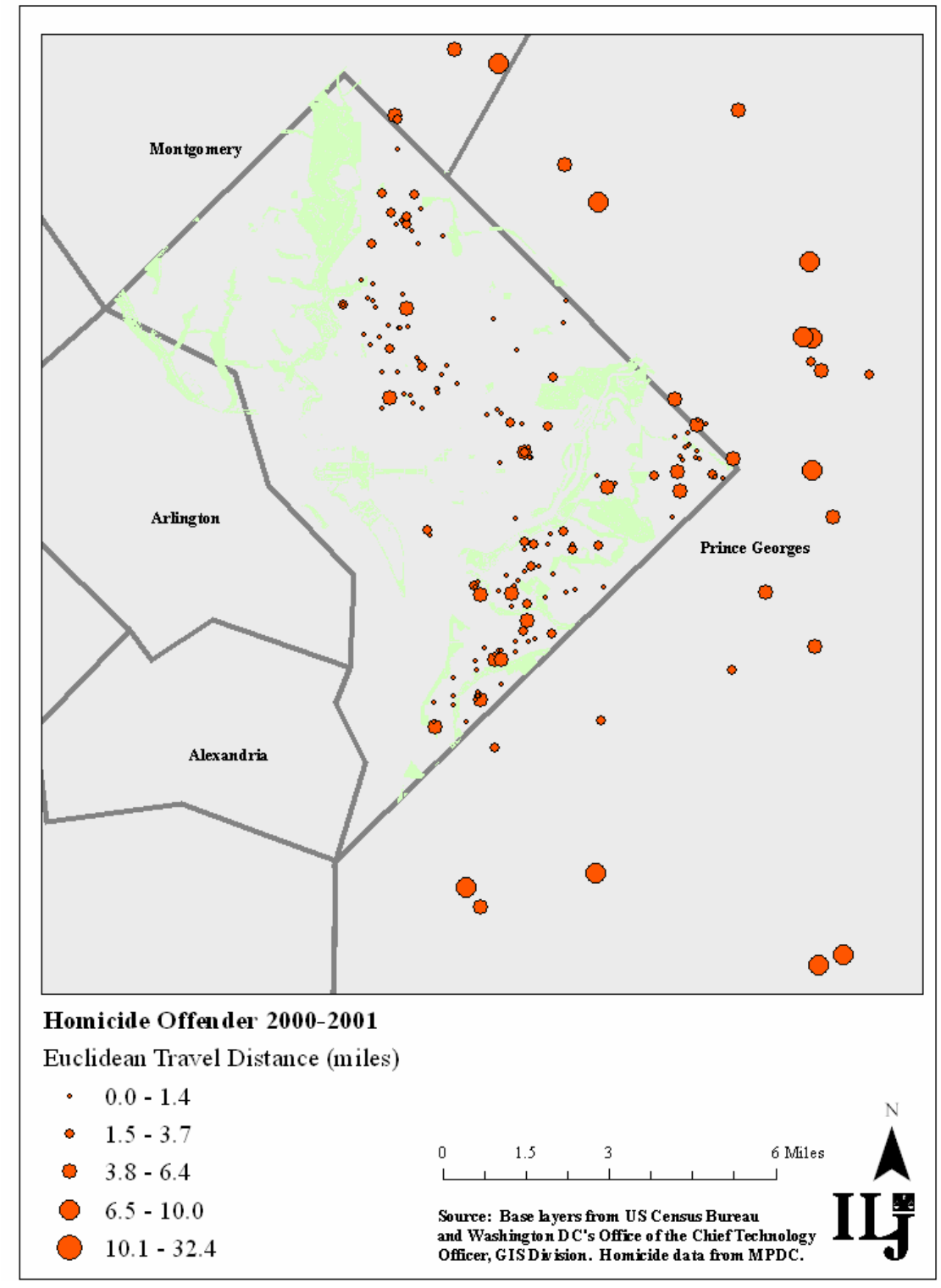
The impact of home-based homicides on the distance between victim home address and offender home address is slightly different than either of the previous patterns (Exhibit 3-17). Although the biggest impact is seen in domestic homicides (+ 1.89), robbery homicides (+ .96 miles) are also strongly affected. Argument (+.49 miles) and gang-related (+.51 miles) also see an increase.

Exhibit 3-17: Distance From Victim Home to Offender Home: All vs. Nonzero Distances



The map shown on the following page (Exhibit 3-18) gives one way to portray information about Euclidean distances. The emphasis is on where offenders lived and how far they traveled. The sizes of the circles increase according to the distance traveled. The predominance of small circles inside the city reflects the results already presented that many offenders travel short distances for committing their offenses. As expected, circles outside the city are larger. The exhibit does not reflect the direction traveled because the intent is to show how far they traveled.

Exhibit 3-18: Distribution of Offenders by Distance Traveled to Homicide Locations, 2000-2001



Chapter 4

Spatial Typologies of Homicide

This phase of the data analysis explores spatial typologies to increase our understanding of the convergence of victims and offenders in space. Following Block et al. (2004), the unit of analysis is a *triad*, which is defined as the combination of a homicide location, victim's home address, and offender's home address. Multiple triads are formed when multiple offenders are associated with a homicide. For example, three triads would be developed for an incident in which there are three offenders who killed a victim. We believe it is important to include all known offenders because they have different mobility patterns. In total, we developed 2,773 homicide triads by combining our data on the addresses of homicide locations, home addresses of victims, and home addresses of offenders.

We begin with a descriptive analysis of the triads and then examine their geometry. Triads form three different geometric figures—dots, lines, and triangles. Dots represent homicides where the victim and offender lived in the residence where the homicide occurred. Lines represent homicides that occur in the home of either the victim or offender. Triangles consist of three non-coincident locations; that is, a victim and offender did not live together, and the homicide crime took place somewhere else.

Next we apply two separate mobility triangles classification schemes to our triads. *Traditional mobility triangles* are created according to Normandeau's (1968) five-category typology, based on shared or disparate social areas. Studies using the traditional mobility triangle typology typically depend on census tracts or other neighborhood-level areas to define the social areas. Each offender's home, victim's home, and homicide address is assigned to its corresponding social area and then classified based on the confluence of areas. We then introduce a *distance mobility typology* based entirely on the relative distances between locations. The distance mobility typology allows a researcher to explore the effects of distance chosen on the relative proportions of triangle types. Results from the two typologies are discussed and compared to each other. Our unsuccessful attempt to produce a *hybrid mobility typology* is also discussed. The final section addresses whether there are event and person characteristics that are common to particular types of triangles. Multinomial logistic regression characterizes each

category of triangle. This analysis has special significance to practitioners because it reveals characteristics that are significantly different between mobility classification types.

Assigning Locations to Social Areas

Using the homicide locations, home address of victims, and home address of offenders, the following procedures were undertaken to assign a typology to each triad. First, a spatial join was conducted in ArcView 8.2 to attach a neighborhood cluster number to each of the three locations—homicide location (n = 4,534), victim's home address (n = 3,972) and offender's home address (n = 3,293).[17] Exhibit 4-1 on the following page lists the neighborhood clusters for the District. The three individual files were then joined into one comprehensive file. Only those records with neighborhoods designated for all three locations (n = 2,917) are retained.[18] After dropping the triads that did not have one of the six main motives under study, we were left with 2,773 triads for the final analysis. A Visual Basic® program, created for this purpose, assigned the appropriate typology type to each triad after evaluating the 'Location Neighborhood,' 'Offender Neighborhood,' and 'Victim Neighborhood'. One part of the program uses the traditional mobility triangle topology and another uses a distance mobility triangle topology to designate triangle types.

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[17] Homicide locations that occur at an intersection have to be manually assigned to a neighborhood. Assignment rules are as follows: 1) locations on the border between a non-neighborhood and a neighborhood are assigned to the neighborhood; and 2) locations on the border of two named neighborhoods are randomly assigned to the left or right cluster. Events that occur outside of D.C. are designated at the county level. Three areas with homicide events that are not designated neighborhood cluster areas are named so they could be included. These areas are: 'Rock Creek Park', the 'Mall', and an area designated 'Waterfront' that is located in Southeast D.C. However, these homicide events drop out of the triad analysis because they lack offender and/or victim information.

[18] As mentioned earlier, triads have to have information for all three locations to be included. Triads with one or two pieces of information are excluded from further analysis. For example, if the homicide location and victim home address location are successfully geocoded but there is no suspect information, the record is excluded.

Exhibit 4-1: Neighborhood Name Reference Table

Cluster Id	Neighborhood Name
Cluster 1	Adams Morgan/Kalorama
Cluster 2	Columbia Heights/ Mount Pleasant
Cluster 3	Shaw/LeDroit Park
Cluster 4	Georgetown
Cluster 5	Foggy Bottom/GWU
Cluster 6	Dupont Circle
Cluster 7	Cardozo/Logan Circle/Vernon Square
Cluster 8	Chinatown/Downtown
Cluster 9	Fort McNair/ SW Waterfront
Cluster 10	Chevy Chase
Cluster 11	American University/Friendship/ Tenleytown
Cluster 12	Forest Hills/Van Ness
Cluster 13	Foxhall
Cluster 14	Cathedral Heights/Glover Park
Cluster 15	Cleveland/Woodley Park
Cluster 16	Colonial Park
Cluster 17	Brightwood/Takoma Park
Cluster 18	Petworth/Crestwood
Cluster 19	Fort Totten/Queens Chapel
Cluster 20	University/Michigan Park
Cluster 21	Eckington/Edgewood
Cluster 22	Brookland/Brentwood
Cluster 23	Trinidad/Ivy City
Cluster 24	Fort Lincoln
Cluster 25	Kingman/Stanton Park
Cluster 26	Historic Capitol Hill
Cluster 27	Navy Yard
Cluster 28	Historic Anacostia
Cluster 29	Eastland Gardens/Kenilworth
Cluster 30	Mayfair Central
Cluster 31	Deanwood/Lincoln Heights
Cluster 32	River Terrace/Greenway
Cluster 33	Benning/Marshall Heights
Cluster 34	Fairlawn/Twinning/Fort Davis
Cluster 35	Hillcrest/Naylor Gardens
Cluster 36	Woodland
Cluster 37	Barry Farm
Cluster 38	Douglass/Shipley
Cluster 39	Congress Heights/Washington Highlands
Cluster 97	Rock Creek Park
Cluster 98	Mall
Cluster 99	Waterfront

The maps shown as Exhibits 4-2 and 4-3 on the following two pages are graphic presentations of the flows of offenders and victims from their homes to homicide locations. Both maps are based on homicides occurring during 2000-2001, and the distances are represented as Euclidean distances. In Exhibit 4-2, circles indicate intra-neighborhood homicides with the size of the circles increasing with the number of victims. Neighborhood Cluster 3 (Shaw/LeDroit Park) had three intra-neighborhood homicides, while Cluster 2 (Columbia Heights/Mount Pleasant) had more than five. Lines depict the travel of victims outside their neighborhood clusters, with the width of the line increasing with the number of victims. For example, more than 10 victims traveled from Cluster 3 to Cluster 39 (Congress Heights/Washington Highlands). The map reveals that Cluster 3 had several victims who traveled toward the southeast border of the city. All the homicides in Cluster7 (Cardozo/ Logan Circle/Vernon Square) were intra-neighborhood.

Exhibit 4-3 conveys the same information for offenders. The pattern is similar to the prior exhibit, with many offenders originating in Cluster 3 and traveling toward the southeast border of the city to commit their offenses. Most of the homicides in Clusters 2 and 7 were committed by offenders who lived within the cluster's boundaries.

Exhibit 4-2: Victim Flows to Incident Clusters, 2000-2001

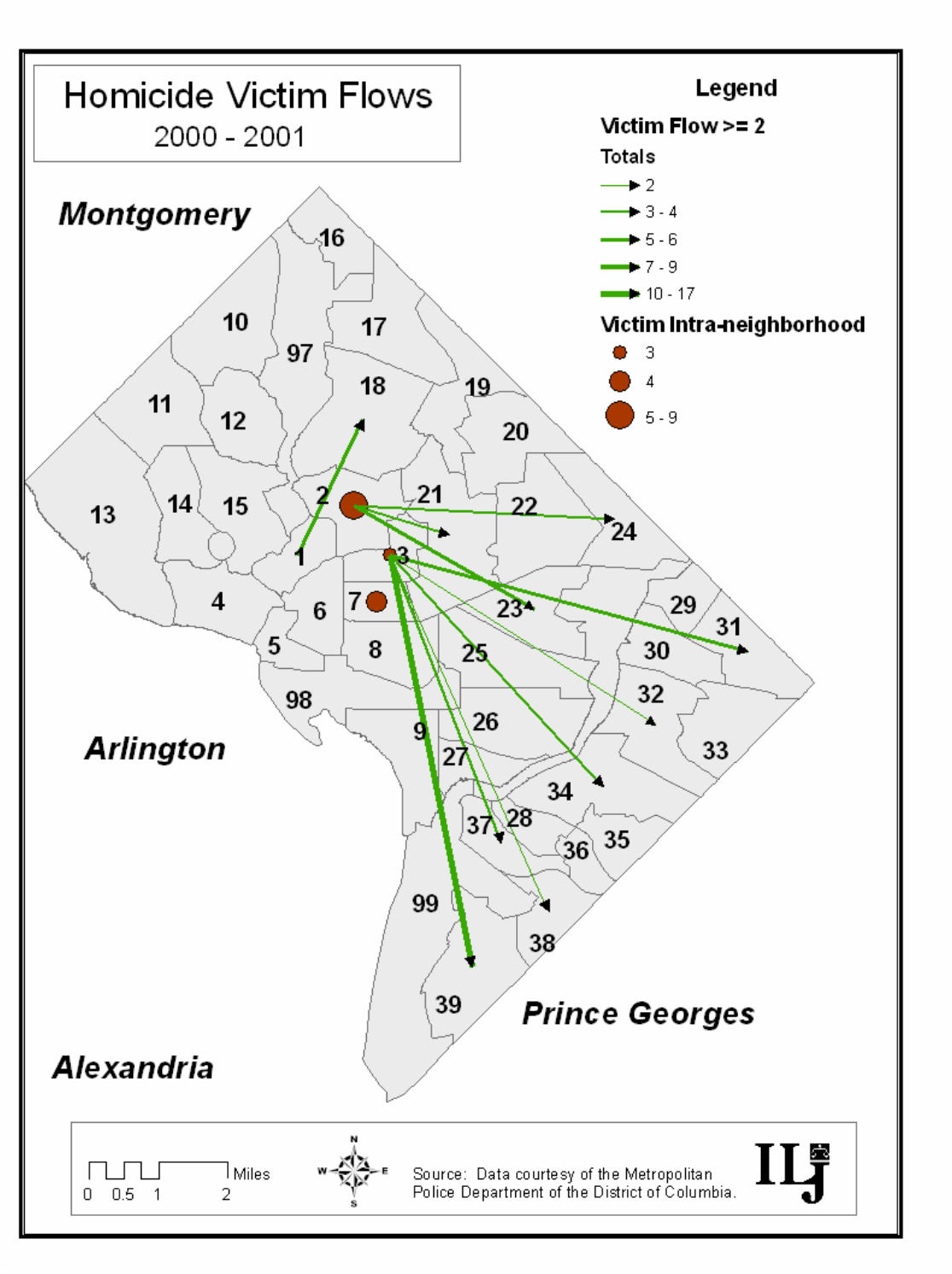
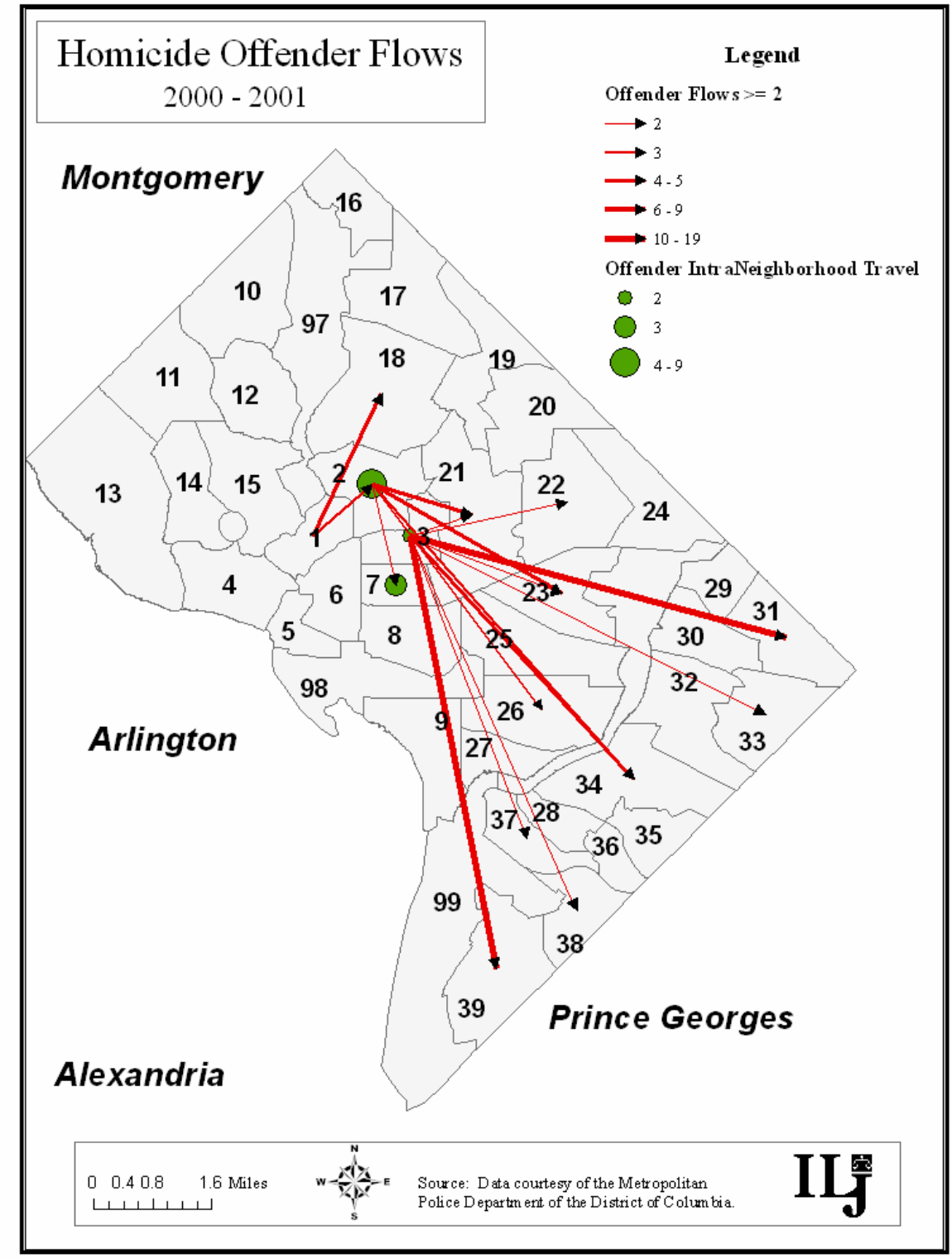


Exhibit 4-3: Offender Flows to Incident Clusters, 2000-2001



Triad Characteristics

For the homicides comprising the triads, Exhibit 4-4 shows that victims and offenders were overwhelmingly male (88 percent of victims and 95 percent of offenders) and African-American (94 percent of victims and 97 percent of offenders). Because of the high percentage of African-Americans, it was not possible to perform any meaningful comparisons with other races for the remainder of this chapter. The average age of victims was 28.3 years (s.d.=12.4 years), and the average age of offenders was 23.8 years (s.d.=8.8 years).

The distributions from Exhibit 4-4 do not differ significantly from results presented in the previous chapter. For example, in Chapter 3 we showed that 87.4 percent of the victims were male and 12.6 percent were females, and that the average age of victims was 28.6 years (s.d.=12.9 years). Similarly, Chapter 3 gave the results that 94.5 percent of offenders were male and 5.5 were female, and that the average age of offenders was 23.8 years (s.d.=8.66 years). Of course, the primary difference is that virtually all triads are closed cases. While demographics do not differ, we cannot generalize our results to all homicides with complete confidence.

Exhibit 4-4: Demographics of Triad Victim and Offenders

Characteristic	Victims		Offenders	
Gender	Number	Percent	Number	Percent
Male	2,426	87.5	2,633	95.0
Female	347	12.5	140	5.0
	2,773	100.0	2,966	100.0
Race				
African-American	2,595	93.6	2,689	97.0
White	82	3.0	20	0.7
Hispanic	71	2.6	55	2.0
Other	25	0.8	9	0.3
	2,773	100.0	2,773	100.0
Age Category				
Less than 18 years	292	10.5	443	16.0
18 – 24 years old	1,067	38.5	1,503	54.2
25 – 34 years old	781	28.2	554	20.0
35 – 49 years old	464	16.7	213	7.7
More than 50 years	169	6.1	60	2.2
	Average Age (mean)	**Standard Deviation**	**Average Age (mean)**	**Standard Deviation**
Age	28.3	12.4	23.8	8.8

As with actual distances between the points of a triangle, traditional mobility triangle findings confirm the relatively short distances that offenders travel. Approximately, 46.3 percent (n=1,283) of offenders committed murder in their home neighborhood cluster. About 50.7 percent (n=1,405) of victims died in the same neighborhood cluster in which they lived. Victims and offenders lived in the same neighborhood in about 30.7 percent (n=850) of the cases. If we stopped our analysis with just the individual journeys to crime, the only information we could give an investigator would be that they could expect little less than a 50/50 chance that an offender lives in the neighborhood in which the homicide occurred. The full typology allows for more exact relationships to be drawn.

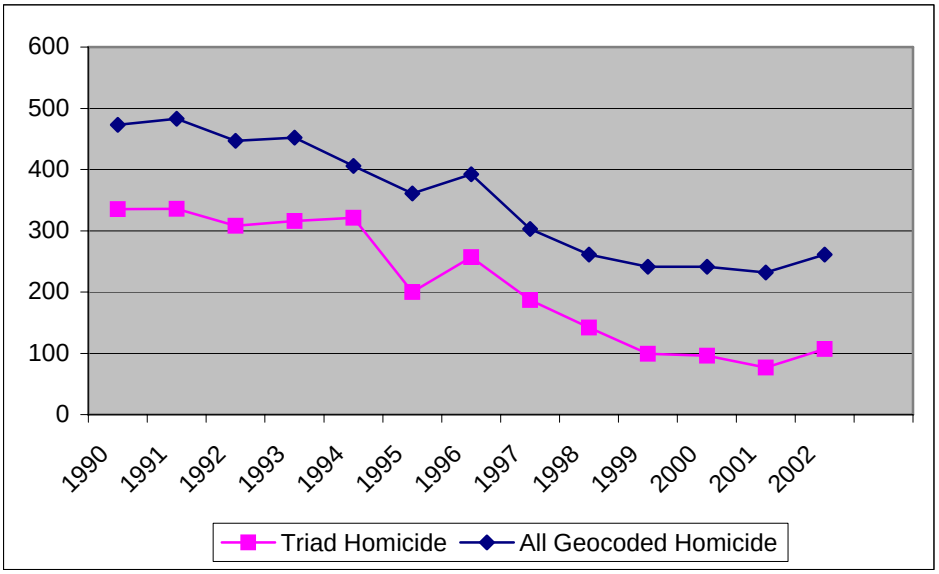
Other information in the analysis describes characteristics of the event itself such as number of offenders, setting, type of weapon used, and year of occurrence. Approximately 75 percent of homicide triads (n=2,096) involved only one offender. Almost 60 percent (n= 1,655) occurred outdoors or on a transportation route (Exhibit 4-5). A firearm was used 78.1 percent (n=2,166) of the triads.

Exhibit 4-5: Locations of Homicides

Location	Number	Percent
Outdoors	1,408	50.8
Living Quarters	720	26.0
Unknown	262	9.4
Transportation	247	8.9
Other Indoors	136	4.9
Total	2,773	100.0

One other characteristic of the triad data set is worth noting. The distribution of triads over time is weighted toward the oldest cases. Exhibit 4-6 below shows over half of the triads occurred between 1990 and 1995. Except for a spike in 1996, the number of homicides from recent years declined steadily over the time period. Only about 10 percent of the triads occurred in the last three years (2000-2002). There are two primary reasons for the decline. First, the overall homicide rate in the District declined from 2000 to 2002. A second factor has to do with the increasing likelihood that cases will be cleared over time. As a result, more recent homicides are less likely to have had an arrest and less likely to have the three addresses necessary for a triad. The declining homicide rate and the tendency for a lower percentage of more recent homicides to have an arrest combine to bias our sample toward older homicide events. At the same time, Exhibit 4-6 demonstrates consistency in the proportion of triads over the study period.

Exhibit 4-6: Homicides by Year



Motives

For the triads, arguments are the most frequent motive, followed by drug-related, retaliations, robberies, gang-related and domestic violence homicides. The distribution of motives is comparable to the distributions presented in Chapter 3.

Exhibit 4-7: Distribution of Motives Among Triads

Motive	Homicides	Percent
Argument	1,687	35.8
Drug-related	946	20.1
Retaliation	751	15.9
Robbery	647	13.7
Gang-related	469	10.0
Domestic violence	203	4.3
Total	6,830*	100.0

*The total reflects multiple motives for some homicide events. The 2,773 homicide triads have a total of 6,830 motives in the database.

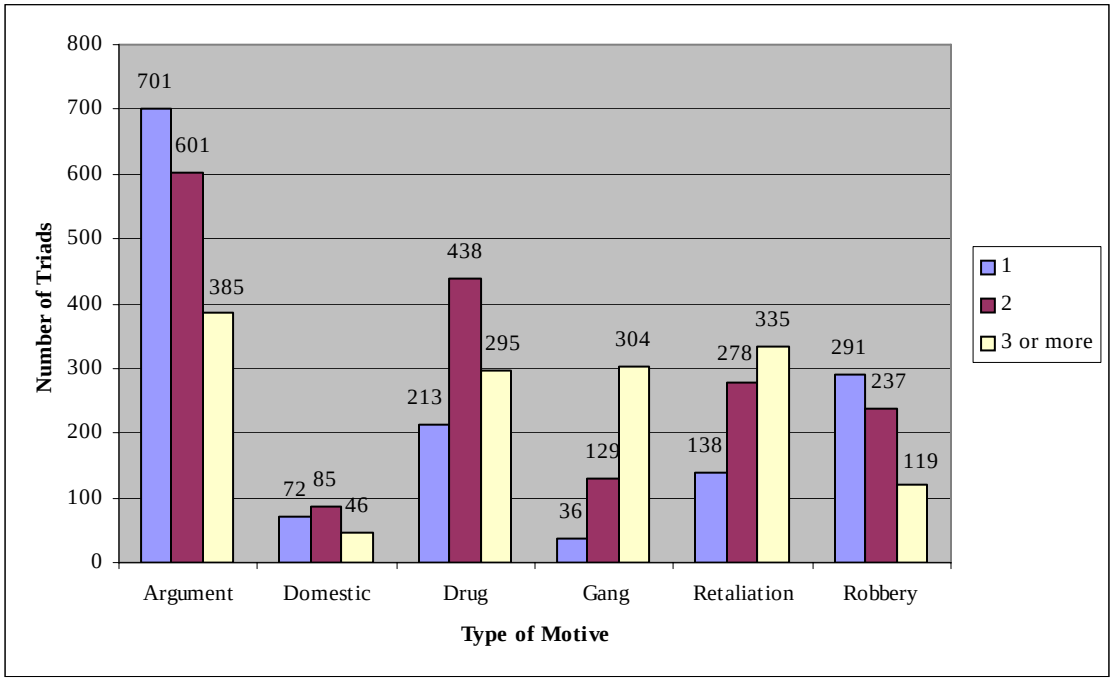
The number of motives per triad ranged from one to six (see Exhibit 4-8). Just over half (52.3 percent) of the homicide triads have a single motive and over two-thirds (84.2 percent) have no more than two motives.

Exhibit 4-8: Number of Motives Per Triad

Number of Motives	Number of Triads	Percent of Triads
1	1,451	52.3
2	884	31.9
3	300	10.8
4	108	3.9
5	28	1.0
6	2	.1
Total	2,773	100.0

Another interesting pattern emerges among type of motive when the triads are examined by number of motives checked (Exhibit 4-9). Argument is the most frequent type of homicide motive regardless of the number of motives and the number of argument homicides per category decreases as the number of motives increases. Robbery follows the same pattern as argument but with far fewer events. Gang-related and retaliation motives share yet another pattern of increasing frequency as the number of motives increases. Domestic violence and drug-related homicides exhibit two additional patterns. Domestic violence homicides are fairly static across number of motives. The drug-related motive occurred fewer times among homicide triads with only one motive and most often among those with two motives. These patterns demonstrate that the motives of argument, drug-related, retaliation, and robbery are most likely to be present when there are two motives for the crime. Among homicides with three or more motives, arguments, retaliations, gang-related and drug-related motives are most likely to be identified. Domestic violence homicides have little overlap with the other motives. Finally, among homicides with only one motive, argument is the most likely motive followed by robbery and drug-related homicides.

Exhibit 4-9: Total Motives Per Triad by Type of Motive



The in-depth examination of motive reveals a significant amount of overlap among triads with argument, drug-related, retaliation, and robbery motives. The existence of overlap will be important as we begin to examine the distances traveled for each type of homicide.

Relative Distances Within Triads

In addition to the typology type, we also measure the three distances involved in a homicide: victim's home to homicide location; offender's home to homicide location; and victim's home to offender's home. An examination of each of these sides to the homicide distance triangle offers a unique view on the spatial relationships among the three locations. Exhibit 4-10 contains a summary of these relationships by both the motive and trip type.

Exhibit 4-10: Distances by Type of Trip and Homicide Motive (in miles)

	All Homicides n=2,773	Arguments n=1,687	Domestic Violence n=203	Drug-Related n=946	Gang-Related n=469	Retaliation n=751	Robbery n=647
Victim to Homicide Location							
Mean	2.63	2.34	1.30	2.74	1.91	2.09	3.50
Standard Deviation	7.30	7.06	2.90	7.61	2.57	6.12	6.64
Median	0.54	0.43	0.00	0.62	0.72	0.58	0.97
Offender Home to Homicide Location							
Mean	2.59	2.60	1.55	2.84	2.73	2.67	2.39
Standard Deviation	8.50	9.62	2.85	7.84	10.18	9.3	4.66
Median	0.72	0.63	0.09	0.81	0.97	0.9	0.93
Victim Home to Offender Home							
Mean	4.32	4.08	2.33	4.70	3.79	3.85	4.73
Standard Deviation	10.95	11.57	3.61	10.95	10.29	11.46	7.24
Median	2.01	1.73	0.66	2.31	1.93	1.85	2.45
Total Triad Distance*							
Mean	9.55	9.02	5.18	10.27	8.43	8.61	10.62
Standard Deviation	22.20	23.44	7.79	22.10	20.67	23.04	15.19
Median	4.92	4.24	1.96	5.40	5.04	4.79	6.59

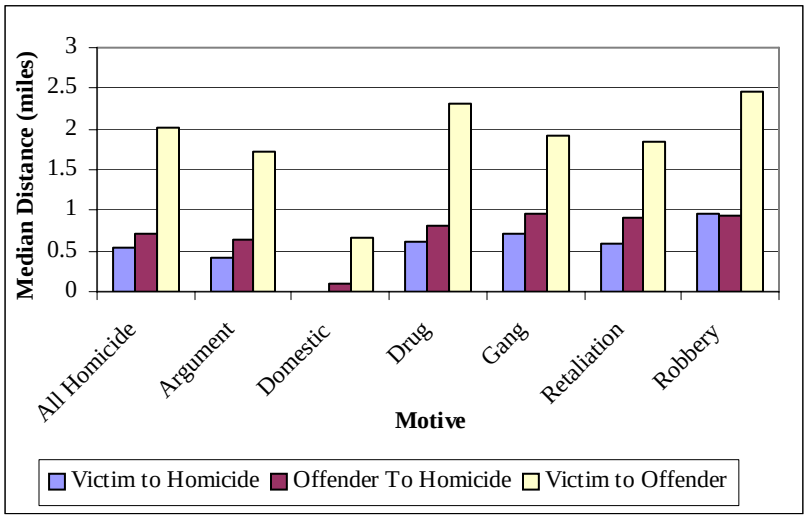
Note: Euclidean distances are in miles.

* Sum of all three distances.

When the distances are broken down by motives, an interesting picture emerges (Exhibit 4-11). The distance between offenders and victims homes is longest on average for drug-related and robbery offenses. This could reflect victimization of commuters and drug buyers by city residents. However, given that home addresses outside of the District are used, it could reflect travel by suburban residents to offend in an environment more conducive to crime than outlying counties. Both victims and offenders travel farthest when involved in gang-related, retaliation, and robbery homicides. Robbery homicides are the only type of homicide in which the victim travels farther than the offender, and the overall distance is the longest of all types of homicide. The findings related to robbery homicides are not consistent with those reported by Normandeau (1968) for all robberies which may be due to either the unique nature of robbery homicides, a

different study area (Philadelphia vs. Washington, D.C.), or the larger study area used in this research.

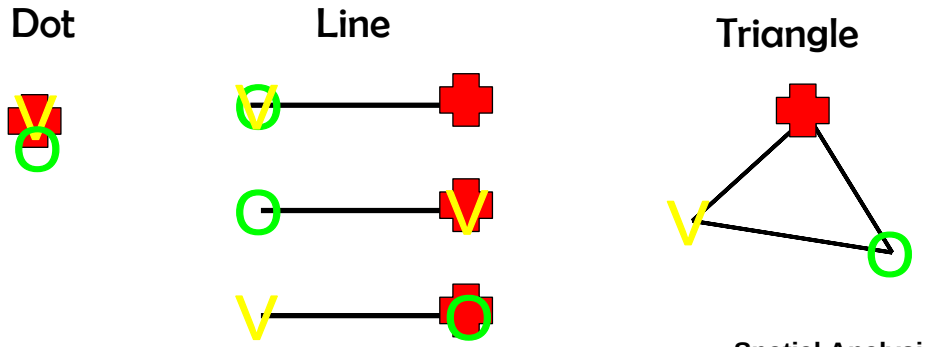
Exhibit 4-11: Distances by Trip Type and Motive



Geometry of Homicide: Dots, Lines and Triangles

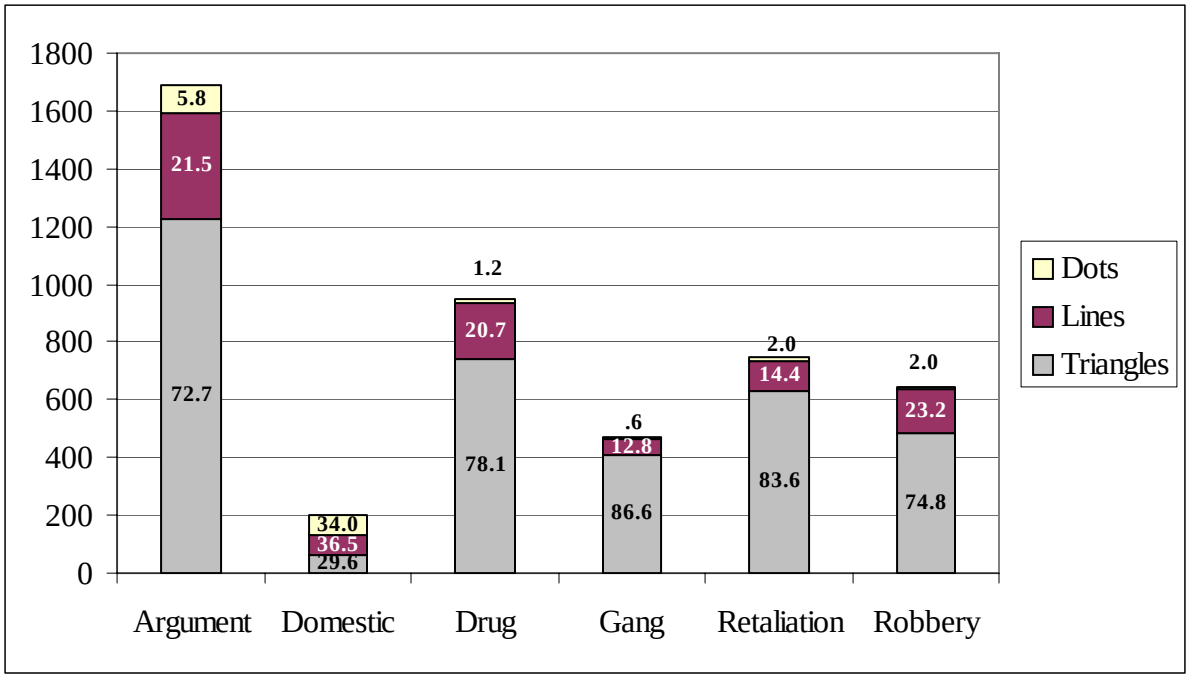
During the distance analysis we discovered three types of geometry to describe relationships among offender, victim, and offense locations. These geometries are dots, lines and triangles (Exhibit 4-12). *Dots* are the simplest case and occur when the victim and offender lived together and the homicide occurred in their home, giving all three components a common location. Only 5 percent of triads were dots (n=141). *Lines* are formed when two of the components share the same location. Almost 21 percent (n=576) of triads were lines. *Triangles* result when all three components have non-coincident locations. They were the largest category with approximately 74 percent of triads in the triangle category.

Exhibit 4-12: Three Types of Geometry to Describe Relationships



The characteristics of the homicides are significantly different by dot, line and triangle classification.[19] By motive, domestic violence homicides have the highest proportion of dots (34 percent) and the second highest proportion of lines (20.8 percent) (Exhibit 4-13). Argument homicides have the next highest proportion of dots (5.8 percent). Lines account for approximately 20 percent of triads among argument, domestic violence, drug-related, and robbery homicides. Triangles are the most frequently occurring type of geometry for all motives except domestic violence. One interesting finding concerns the relatively high percentage of lines in robbery homicides (23.2 percent) indicating that the incident took place at the home of the victim or offender.

Exhibit 4-13: Dot, Line, and Triangle Homicides by Motive



In addition to the motives, the demographics are different for each type of geometry (Exhibit 4-14). Male victims are far more likely to be involved in triangle homicides. Female victims are involved in dot homicides at four times the rate of males and twice as likely to be part of a line homicide. As victims, African-Americans are more likely to be part of a triangle

[19] Pearson chi-square is used to test for significant differences in motive,demographics (for both suspects and victims) and event characteristics across geometry types. Figures available from authors.

than are whites, but less likely than Hispanics. However, racial differences were not significant. Until age fifty, victims are approximately three times as likely to be part of a triangle; afterwards they are more likely to be part of a line.

Characteristics of offenders are similar to victims. Males are overwhelming involved in triangles (76.4 percent) while females are most likely to be in lines followed by triangles. As with female victims, female offenders are seven times more likely to be part of a dot than males. Racial differences are significant for offenders. The breakdown for African-American offenders matches that of African-American victims. White offenders are more likely than African-American offenders and white victims to be part of a line homicide (55 percent) rather than a triangle homicide (45 percent). No white offenders were part of a dot homicide. Starting with age 35, offenders tend to be involved in fewer triangle homicides.

Event characteristics also vary significantly across the geometries. Homicide events that occur inside are evenly split between lines and triangles while almost 90 percent of those that occur outside are triangles. Homicides in which a firearm was used (80.2 percent) are also overwhelmingly triangles. The number of offenders is significantly different across geometries but in general multiple offenders are associated with lines and triangles.

Exhibit 4-14: Person and Event Characteristics by Type of Geometry

Characteristic	Victim Characteristics			Offender Characteristics		
Gender*	**Dots**	**Lines**	**Triangles**	**Dots**	**Lines**	**Triangles**
Male	3.4	18.3	78.3	3.9	19.7	76.4
Female	16.7	38.3	45.0	27.9	40.7	31.4
Race						
African-American	5.1	20.6	74.3	5.1	20.6	74.3
White	4.9	26.8	68.3	0.0	55.0	45.0
Hispanic	4.2	19.7	82.6	3.6	20.0	76.4
Other	0.0	24.0	76.0	11.1	0.0	88.9
Age Category*						
Less than 18 years	3.1	21.6	75.3	1.8	17.5	80.7
18 – 24 years old	2.1	13.9	84.1	2.1	19.5	78.4
25 – 34 years old	3.5	21.1	75.4	7.0	20.6	72.4
35 – 49 years old	10.3	26.7	62.9	19.7	34.3	46.0
50 years or more	20.7	45.0	34.3	35.0	31.7	33.3
Homicide Characteristics						
Location*	**Dots**	**Lines**	**Triangles**			
Inside	14.4	43.1	42.5			
Outside	0.6	10.1	89.3			
Weapon*						
Other	16.8	30.8	52.4			
Firearm	1.8	18.0	80.2			
Relationship*						
Intimate	41.8	36.2	21.9			
Acquaintance	2.5	20.6	76.9			
Stranger	0	15.3	84.7			
No. Offenders*						
One	6.3	20.1	73.6			
Two or more	1.2	22.9	75.9			

*Pearson chi-square significant at $p < .05$

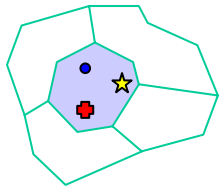
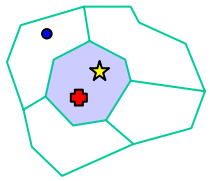
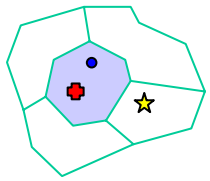
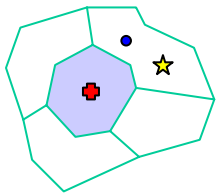
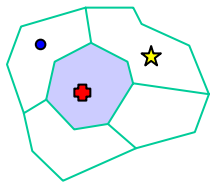
Mobility Triangles

This research expands earlier studies exploring the spatial relationships between offender, victim, and crime locations in three ways. First, we include victims and offenders who did not live in the same jurisdiction in which the homicide was committed, thereby enabling a more realistic view of the spatial relationships regardless of jurisdictional boundaries. Second, we disaggregate homicide triads according to motive to gain new insight into factors at work in particular types of homicide incidents. Third, on the methodological front, we use distance to classify incidents rather than social area boundaries. This strategy negates many of the criticisms of mobility triangle research that are specific to the use of social areas as a classification scheme. The results are divided into two sections—the first describes traditional mobility triangle classification and the second describes distance mobility triangle classification.

Traditional Mobility Triangles

In contrast to studying either the victim's or offender's journey to crime, mobility triangles offer a method for examining the spatial relationships among the location of the crime, offender's residence and victim's residence. In this way, we can take the first step to understanding why offenders and victims converge in space and time. Our analysis of mobility triangles begins with the traditional typology developed by Normandeau (1968). In this typology the spatial relationships are expressed through the neighborhood in which the three addresses are located. Exhibit 4-15 shows the five types of traditional mobility triangles. These triangles were created to be mutually exclusive as each set of three locations can be in only one type of triangle. In a *neighborhood triangle*, all three addresses fall within the same neighborhood. A *victim mobility triangle* occurs when the homicide and the offender residence are in the same neighborhood but the victim lives in a different neighborhood. The *offender mobility triangle* involves the purposeful travel by the offender to the neighborhood where the victim lives and the homicide occurs. If the offender and victim live in the same neighborhood but the homicide occurs in a different neighborhood, the event is classified as an *offense mobility triangle*. Finally, if all three addresses are in different neighborhoods, the event is a *total* mobility triangle.

Exhibit 4-15: Traditional Mobility Triangle Typology

Type of Homicide	Sample Diagram Code
Neighborhood	**1** 
Offender Mobility	**2** 
Victim Mobility	**3** 
Offense Mobility	**4** 
Total Mobility	**5** 

Incident Location Victim Home Offender Home

The results of applying the traditional typology to homicides in Washington, D.C are compared in Exhibit 4-16 with results from Tita and Griffiths (2006) for Pittsburgh, Pennsylvania. In Washington, D.C., the most frequently occurring triangle is the *neighborhood triangle* (26.1 percent) which is followed by the *offender* and *total* triangles (both at 24.6 percent). About 20.2 percent of triangles were *victim* mobility and only 4.5 percent were *offense* mobility. These findings differ somewhat from Pittsburgh, where *total* mobility triangles were the most frequent (28.3 percent), followed by *neighborhood* mobility (26.9 percent) and *offender* (21.9 percent). Only 18.3 percent of homicides in Pittsburgh were *victim* mobility triangles. The *offense* mobility triangle occurs with the lowest frequency in both cities at 4.5 percent.

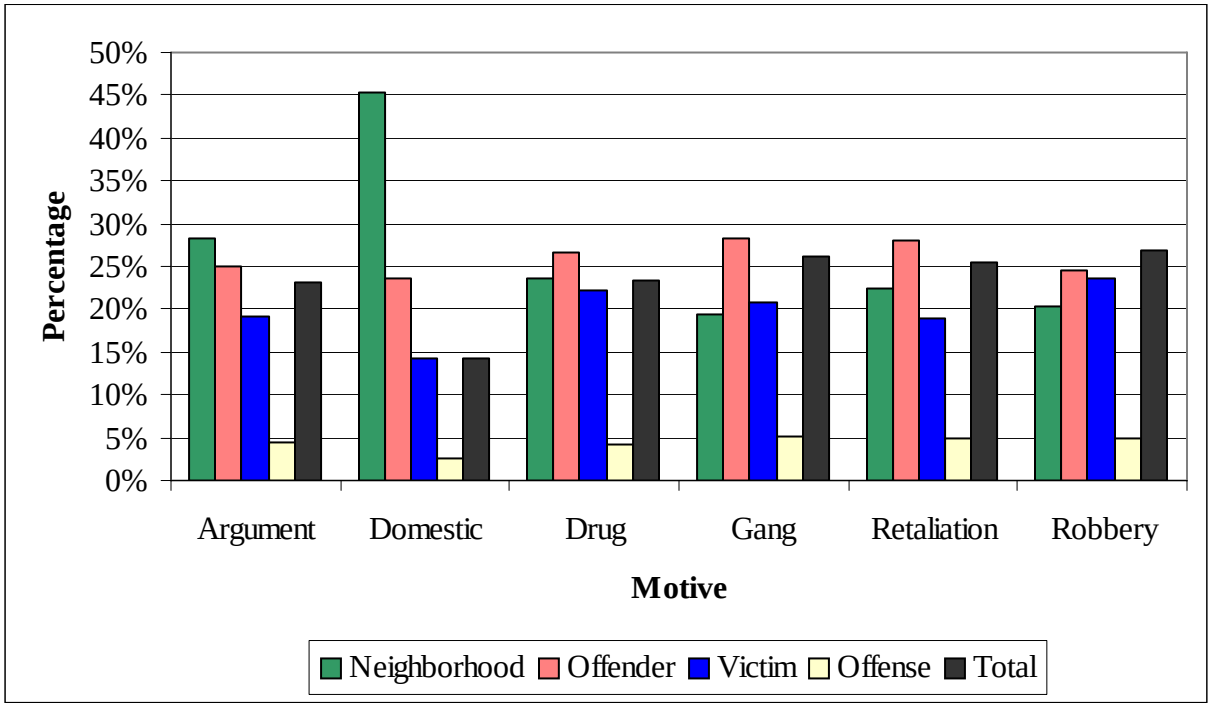
Exhibit 4-16: Traditional Mobility Triangles

Traditional Mobility Triangle	Washington, D.C. 1990 – 2002 Number of Triads	Percent	Pittsburgh, PA 1987 - 1995 Number of Triads	Percent
Neighborhood Mobility	724	26.1	113	26.9
Offender Mobility	681	24.6	92	21.9
Victim Mobility	559	20.2	77	18.3
Offense Mobility	126	4.5	19	4.5
Total Mobility	683	24.6	119	28.3
Total	2,773	100.0	420	100.0

* From Tita & Griffiths (2006)

Disaggregating the homicide triads by motive offers more insight into how the spatial structure varies (Exhibit 4-17) in the District. Argument and domestic violence homicides have the highest proportions of *neighborhood* triangles. This finding is consistent with the geometry of homicide travel analysis presented earlier. Over 25 percent of drug-related, gang-related and retaliation homicides are *offender* mobility triangles. In other words, the offender traveled to another neighborhood and killed a resident of that other neighborhood. Robbery homicides are most frequently *total* mobility triangles indicating that in over 25 percent of robberies there is no spatial coincidence among the residences and the location of the crime.

Exhibit 4-17: Homicide Motives by Traditional Spatial Typology Classification



By depicting the results of the traditional mobility triangle analysis on a map, both the spatial distribution of triangle types across the city and within neighborhoods can be studied. Two maps, as shown in Exhibits 4-18 and 4-19, were developed for this purpose. Exhibit 4-18 show two years of data (2000-2001) to illustrate the distribution of types of triads across the city. The central part of the city has a mix of triangle types, as does southeast (especially Cluster 39, Congress Heights/Washington Highlands). The map in Exhibit 4-19 uses pie charts to show the proportion of each classification that occurred in a particular neighborhood. This map shows that there is considerable variability in the relative proportion of triangles by neighborhood. It also enables us to easily identify neighborhoods with high proportions of *offender* mobility triangles (i.e. where the homicide problem is being brought into a neighborhood). This is in contrast to neighborhoods with high proportions of *neighborhood* mobility triangles indicating a local problem with violence involving residents.

Exhibit 4-18: Traditional Mobility Triangles for Homicide: 2000 - 2001

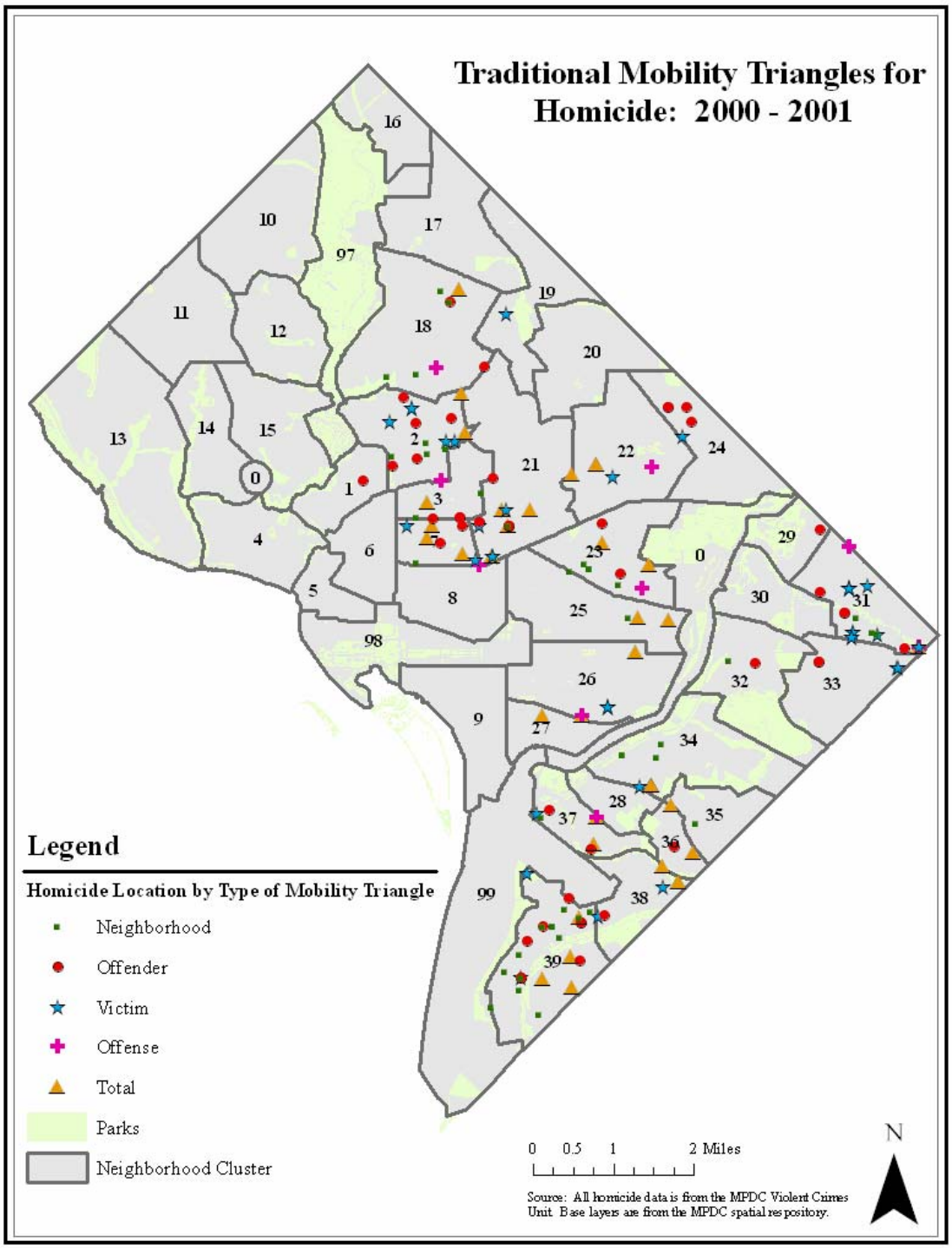
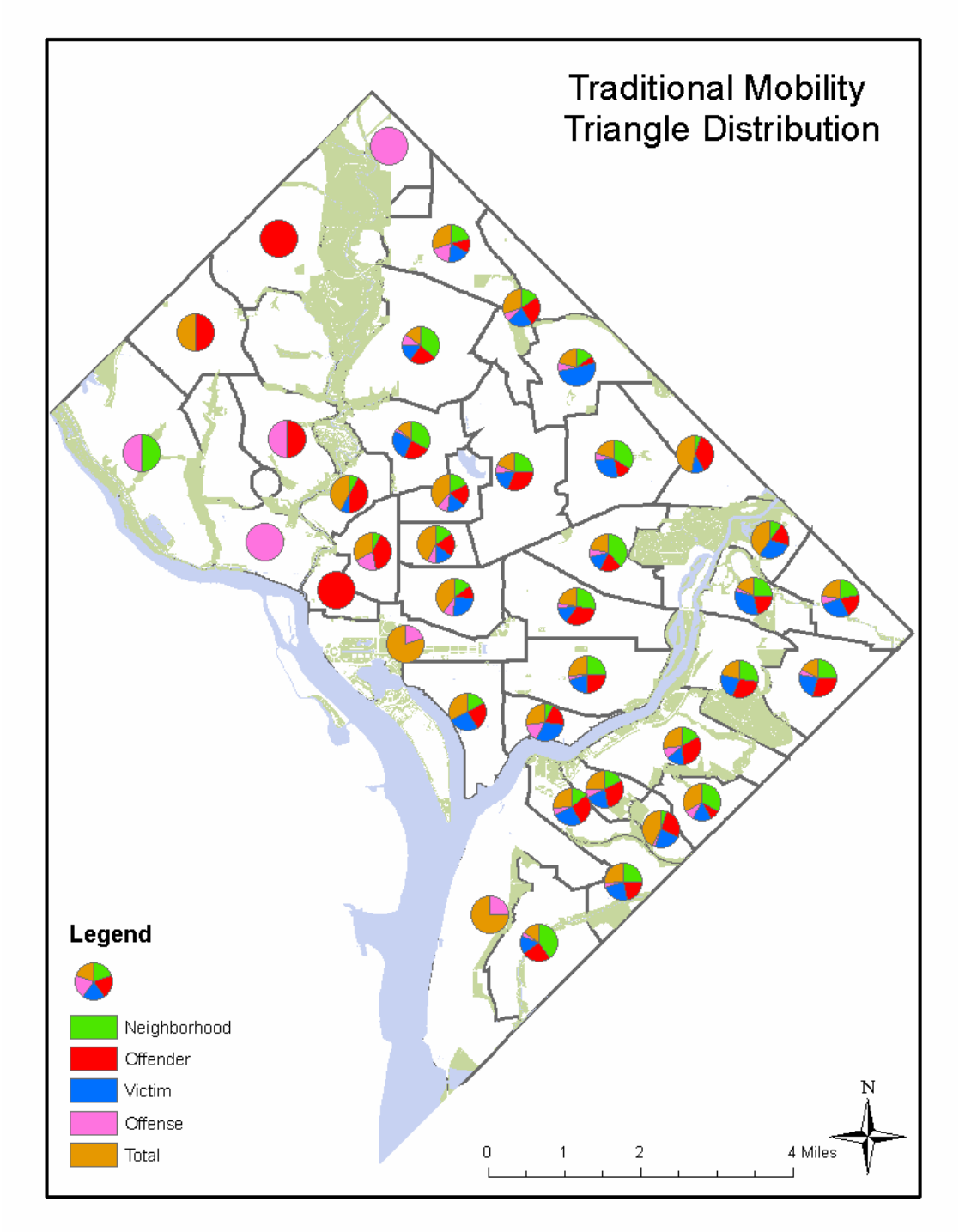


Exhibit 4-19: Spatial Distribution of Traditional Mobility Relationship



Conclusions

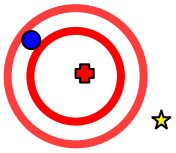
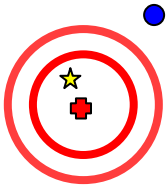
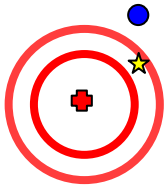
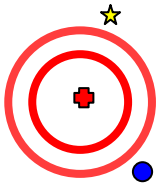
The analysis of homicide using a traditional typology reveals two important findings. First, there are significant differences in the spatial configurations of homicides. *Neighborhood* mobility triangles are the most frequently occurring type followed by *offender*, *victim* and *total* mobility triangles. Second, the spatial configurations vary by motive, victim characteristics, offender characteristics and other event characteristics. Specifically, the biggest differences are between *neighborhood* triangles and all other types.

Distance Mobility Triangles

One of the main focuses of our study is to examine distance rather than neighborhoods to classify the spatial relationships among locations. As mentioned earlier, the use of distance rather than areal units addresses the most serious objections to the mobility triangle methodology (i.e. primarily the modifiable areal unit problem). The next section discusses both the classification schemes that were considered but discarded as well as the one that was selected.

When attempting to incorporate distance, two major types of classification schemes are considered. The first uses a series of distance cut-offs (i.e. distance bins) and the second considers distance as a single measure. Distance bins offer the advantage of being easy to understand; they simply evaluate whether one location is within a certain distance of another location. They also allow the ability to quantify how close or far the locations are from one another. Considering only two distance measures, victim to crime and offender to crime, combined with three distance bins (e.g. less than .25 miles, .25 to 1 mile, and greater than one mile) produces a nine-category classification scheme (Exhibit 4-20). Each distance relationship is classified separately as micro, meso or macro. *Micro* locations are within .25 miles of each another, *meso* locations are between .25 and one mile of each other and *macro* locations are greater than one mile apart. For clarity, Exhibit 4-20 depicts each type of classification with the incident location in the center of the circle. Only the relative positions of the symbols are important to understanding the classification scheme. This relatively complex scheme is still insufficient; it fails to incorporate the variation in distances between the home addresses of offender and victim. Adding the distance between home addresses requires another seven categories in the typology and introduces a level of complexity that makes it difficult to communicate results. The complexity led us to discard this classification scheme.

Exhibit 4-20: Distance Mobility Typology

	Victim to offense - MICRO (LT ¼ mile)	**Victim to offense MESO** (GT ¼ mile and LT 1 mile)	**Victim to offense MACRO** (GT 1 mile)
Offender to offense – MICRO (LT ¼ mile)	**1**  **Micro**	**2**  **Meso Victim and Micro Offender/Offense**	**3**  **Macro Victim and Micro Offender/Offense**
Offender to offense MESO (GT ¼ mile and LT 1 mile)	**4**  **Meso Offender with Micro Block Victim/Offense**	**5**  **Meso**	**6**  **Macro Victim and Meso Offender/Offense**
Offender to offense MACRO (GT 1 mile)	**7**  **Macro Offender and Micro Victim/Offense**	**8**  **Macro Offender and Meso Victim/Offense**	**9**  **Macro**

Homicide Location ☆ Victim Home ● Offender Home

Taking a simplified approach, we develop a distance typology with only one cut-off distance. The simplest version of this type of classification is detailed in Exhibit 4-21. The cutoff can be any distance but we use a quarter mile as an example. To be classified as a *neighborhood* mobility triangle, all distances must be less than one quarter of a mile. Because three separate distances have to be quantified, classification requires eight categories (rather than the five-categories in traditional mobility triangles) to ensure mutual exclusivity.

Exhibit 4-21: Distance-based Mobility Triangles

Code	Type of Triangle	Distance Comparison		
		Offender Home to Crime	Victim Home to Crime	Offender Home to Victim Home
1	Neighborhood (all local)	Less than cutoff	Less than cutoff	Less than cutoff
2	Local event/Nonlocal homes	Less than cutoff	Less than cutoff	Greater than cutoff
3	Offender (Offender travels/ Local homes)	Greater than cutoff	Less than cutoff	Less than cutoff
4	Offender travels/ Nonlocal homes	Greater than cutoff	Less than cutoff	Greater than cutoff
5	Victim (Victim travels/ Local homes)	Less than cutoff	Greater than cutoff	Less than cutoff
6	Victim travels/ Nonlocal homes	Less than cutoff	Greater than cutoff	Greater than cutoff
7	Offense	Greater than cutoff	Greater than cutoff	Less than cutoff
8	Total	Greater than cutoff	Greater than cutoff	Greater than cutoff

The eight-category distance-based typology produced the results in Exhibit 4-22. In a 'local event' both the offender and victim lived within the cut-off distance of the crime location. The category, 'local homes', refers to when offender and victim live within the cut-off distance of each other. The minimum criterion for distances to be classified as 'non-local' was that they were both greater than the cut-off. Classifications in which the home addresses are local but the distance either the offender or victim traveled to the scene of the crime had the fewest observations (Codes 2, 4 and 7). An example of this type of scenario would be when the victim and offender lived near one another but one lived slightly farther from the crime than the other. Another classification with very few observations is the 'local event/non-local homes' category, code 7 (.9 percent). In this type of triangle the incident location lay in between the home address of the victim and the offender so that the distance from each home is less than the cut-off but the distance between home addresses is greater than the cut-off.

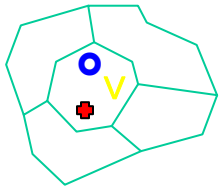
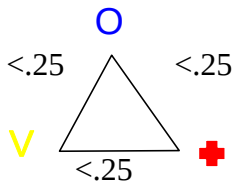
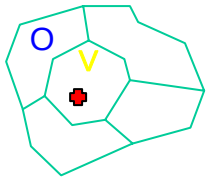
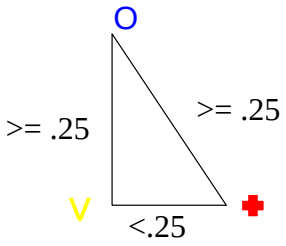
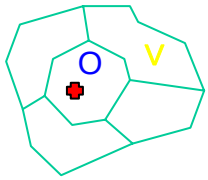
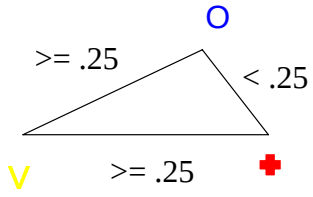
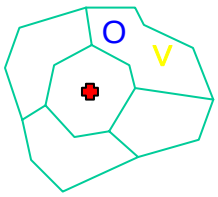
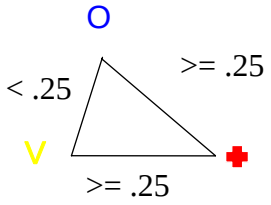
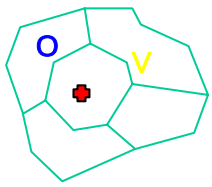
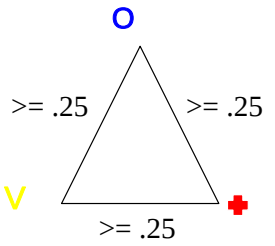
Exhibit 4-22: Percentage of Triads in Each Classification

		Distance Cutoff (in miles)			
Code	**Description**	**.25**	**.5**	**.75**	**1.0**
1	Local Event/Local Homes	16.2	23.9	28.8	32.4
2	Offender Travels/Local Homes	.8	.4	.5	.5
3	Offender Travels/Non-local Homes	23.3	23.6	23.5	23.1
4	Victim Travels/Local Homes	.4	.5	.5	.6
5	Victim Travels/Non-local Homes	16.5	19.9	20.5	20.4
6	Victim and Offender Travel/Local Homes	1.9	2.4	2.4	2.7
7	Local Event/Non-local Homes	.9	1.0	.9	1.0
8	Non-local Event/Non-local Homes	40.0	28.3	22.9	19.3
	Total Percent	100.0	100.0	100.0	100.0

Finally, we tested a hybrid distance/social area mobility triangle typology. This typology produced an unmanageable number of classifications. For example, our first attempt included a set of two cut-off distances for comparison. The number of categories jumped from 8, in the distance only schema, to 32 in the hybrid schema even before the social area delineations were added. If we included three distance bins, but only considered victim and offender distances to the crime, the number jumped to 50 classes. Based on our experience with the eight-category distance classification typology, the difficultly in providing a meaningfully description of more than five categories was clear. Consequently, we conducted the initial analysis with one cut-off distance for our distance-based analysis. To make the results comparable to the social areas method we matched the descriptions as closely as possible to the traditional typology and primarily considered the distance between offender and victim and the location of the crime.[20] For example, on the *offender* and *victim* mobility triangles, the distance between the home addresses was not utilized in classifying the event. Exhibit 4-23 contains the final typologies to compute the remaining analyses in the report.

[20] The following eight category distance codes are recoded to match the traditional mobility triangle typology: 1 and 2 remained the same. Distance codes change as follows: 3 to 2, 4 to 3, 5 to 3, 6 to 5, and 8 to 5. Code 7 events are discarded since there is no corresponding traditional typology classification for Local events/Nonlocal Homes. This changes the total number of observations to 2,745 triads for the distance classifications.

Exhibit 4-23: Traditional and Distance Mobility Triangle Typologies

Type of Homicide	*Sample Traditional Diagram* **Code**	*Sample Distance Diagram* **Code**
Neighborhood	**1** 	**1** 
Offender Mobility	**2** 	**2** 
Victim Mobility	**3** 	**3** 
Offense Mobility	**4** 	**4** 
Total Mobility	**5** 	**5** 

The comparison distance classification is applied using four different cut-off points quarter mile, half mile, three-quarter mile, and 1 mile. A quarter mile is considered to be the distance an individual will walk to public transportation, shopping etc. and thus makes a good surrogate for frequent interaction space (Calthrope, 1993; Duaney & Plater-Zyberk, 1993; Nelessen, 1994). A quarter mile is just over 3 blocks in Washington, D.C. The quarter mile distance has also been shown to be important in criminal behavior. Research on drug dependent criminals indicates they travel about three blocks from a drug sale location to commit property crimes (Rengert, 1996). The other three cut-offs build on the quarter mile distance band and offer the ability to cut the problem into fixed width slices.[21] Exhibit 4-24 below compares the distribution of the traditional mobility triangles with each of the distance classifications. The half-mile distance cut-off produces a distribution most similar to the traditional one. As one would intuitively expect, increasing the cut-off distance increases the number of *neighborhood* triangles and decreases the number of *total* mobility triangles. Interestingly, the number of *offender* and *victim* mobility triangles remain relatively constant across distance cut-offs (especially the *offender* mobility). This may reflect the more nuanced view obtained from the distance typology because home addresses outside of the District still have measurements whereas in the traditional typology they were assigned the residence county name for the offender and/or victim.

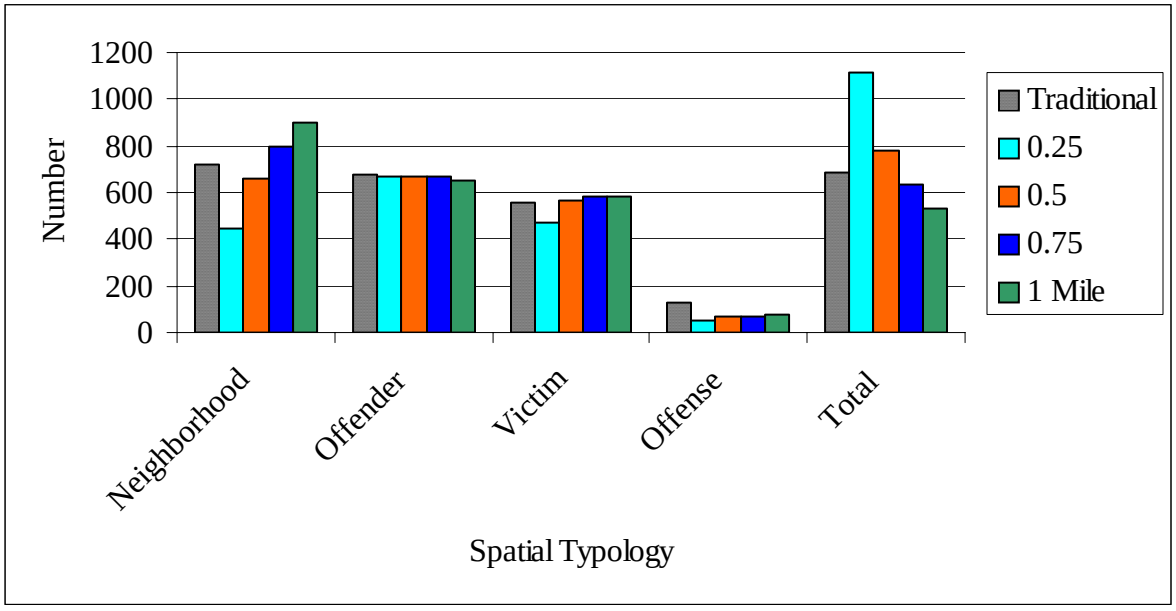
Exhibit 4-24: Distribution of Traditional and Distance Mobility Triangles

		Traditional		.25 miles		.5 miles		.75 miles		1 mile	
Code	Description	No.	Per.	No.	Per.	No.	Per.	No.	Per.	No.	Per.
1	Neighborhood	724	26.1	450	16.2	663	23.9	798	28.8	900	32.5
2	Offender	681	24.6	668	24.1	665	24.0	666	24.0	653	23.6
3	Victim	559	20.2	468	16.9	566	20.4	582	21.0	583	21.0
4	Offense	126	4.5	51	1.8	67	2.4	66	2.4	75	2.7
5	Total	683	24.6	1113	40.1	784	28.3	637	23.0	534	19.3
		2773	100.0	2750	99.1	2745	90.0	2749	99.2	2745	99.2

[21] Previous researchers have pointed out, the area under each distance band increases exponentially away from the center (e.g. the area under a .50 mile buffer is more than twice the area under a .25 mile buffer) (Rengert et al., 1999; Turner, 1969). However, in this research we are using the actual distances between pairs of points to classify the event rather than summarizing a distribution of events within some distance cut-off.

Plotting each type of triangle across all the traditional and distance typologies reveals which types of homicide are stable across distances (Exhibit 4-25). The *offender* mobility triangle is the most stable across all distances. This is probably related to the longer distances that most offenders travel to commit a crime. Both *victim* mobility triangles and *offense* mobility triangles are fairly stable with only slight increases in their proportion of events with increasing distances. The proportion of *victim* mobility triangles at .25 miles is approximately 3 percent lower than at other distances or under a traditional mobility triangle classification. This suggests that those additional 3 percent are between .25 and .5 miles away from home when the homicide occurs which fits with the relative short distances victim travel. The *neighborhood* and *total* mobility triangles are the most sensitive to distance cut-off points. As the distance increases, the number of *neighborhood* triangles increases and the number of *total* mobility triangles decreases.

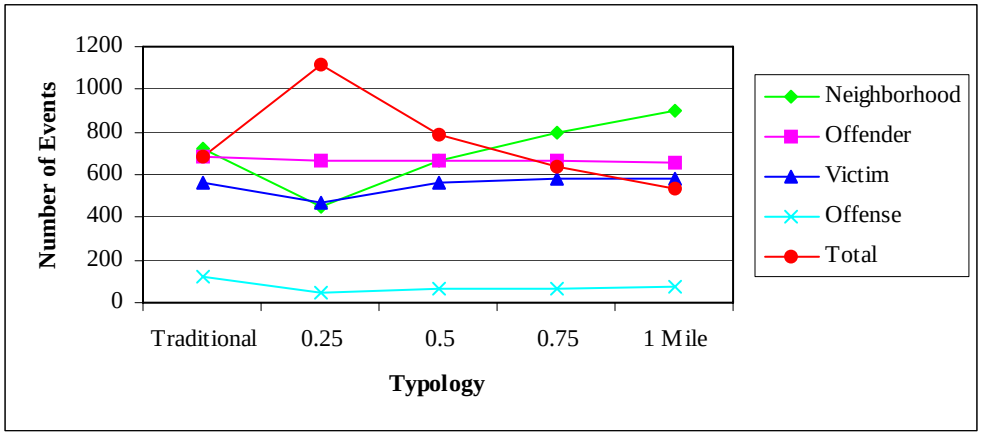
Exhibit 4-25: Comparison of Traditional and Distance Mobility Triangles



Another way of looking at the same data is a line graph (Exhibit 4-26). This view clearly shows the sensitivity of the classification over various typologies. The numbers of *offender*, *victim*, and *offense* triangles are relatively stable regardless of the classification scheme used (e.g. distance versus traditional and different distances such as .25 versus 1 mile). However, the proportion of *victim* mobility triangles dips between traditional and distance typologies. This

finding reflects the difference in classification depending on typology; homicides that would be coded as *victim* mobility using neighborhood boundaries are instead coded *total* mobility triangles when a distance typology is employed. The biggest shifts are for *total* and *neighborhood* triangles and occur between the traditional and the quarter mile distance typology. This finding makes sense given that most neighborhoods are larger than one-quarter mile across. As the distance cut-off increases, the number of *total* mobility triangles decreases and the number of *neighborhood* distance triangles increases.

Exhibit 4-26: Changes in Proportion of Triangle Types Based on Typology Used



One of the major criticisms of the traditional typology involves the modifiable areal unit problem (MAUP) (Bailey & Gatrell, 1995; Openshaw, 1983). In general, the MAUP problem occurs when data are spatially classified using areal units. If the boundaries of the areal units change, so do the numbers and types of events assigned the areas. Specific to this study, the problem is that the number of homicides classified as belonging to particular classes (e.g. *neighborhood* mobility, *offender* mobility etc.) changes as the boundaries of the social areas used for aggregation purposes change. The results of this analysis support the validity of concerns related to MAUP, because the social areas used are relatively sensitive to this problem. For example, only 62 percent (n=450) of the traditional *neighborhood* triangles (n=724) remained *neighborhood* triangles under the quarter mile distance classification, while about 92 percent (n=663) remained at the half-mile distance cut-off. At one mile, the number of *neighborhood* triangles is 124% (n = 900) higher than under a traditional classification.

An examination of the distance typologies by type of homicide yields some interesting contrasts. Looking first at the distance classification at one half mile (Exhibit 4-27), argument and domestic violence homicides are most frequently *neighborhood* triangles. Drug-related, gang-related, retaliation and robbery homicides are dominated by *total* and *offender* mobility triangles. *Victim* mobility triangles occur most often among robbery- and drug-related motives.

Traditional mobility triangles show similar patterns but with some interesting differences (Exhibit 4-27). Most striking is the reduction in *total* mobility triangles as compared to the distance classification for argument, drug-related, gang-related, retaliation, and robbery homicides. This occurs even though the relative proportions of triangles in each spatial typology type remain consistent across motives.

A final question has to do with whether the distribution of mobility triangle types, varies by homicide motive (Exhibit 4-28). As with the traditional typology, the domestic violence homicides have more *neighborhood* triangles. There are differences for the other motives. *Neighborhood* triangles account for almost the same proportion of events as do *total* mobility triangles under the distance typology. In addition, for drug-related, gang-related, and retaliation the most frequently occurring type is the *total* mobility triangle, followed by the *offender* mobility triangle. Robbery remains the same with *total* mobility triangle as the most frequent. The descriptive analysis has provided a wealth of information about the spatial configuration involved in homicide events. Next we use multinomial logistic regression to determine which characteristics of the homicide events are associated with specific types of triangles.

Exhibit 4-27: Half-Mile Distance Typology Classification by Motive Type

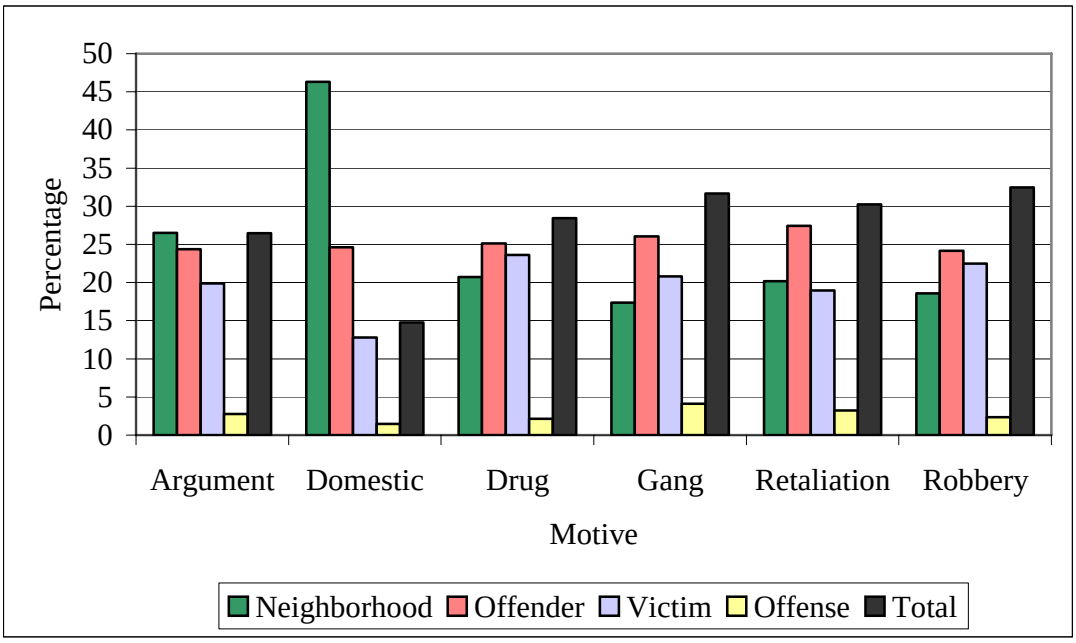
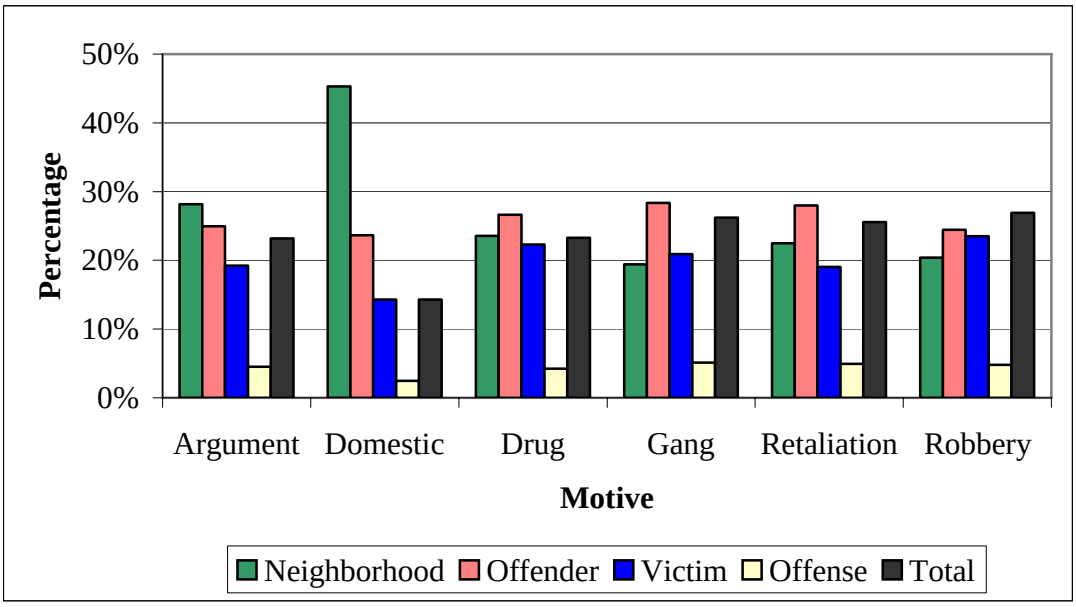


Exhibit 4-28: Traditional Typology Classification by Motive Type



Understanding Homicide Events Using Mobility Triangles

This section of the report presents the results of two multinomial logistic regressions, one for traditional and the other for distance mobility triangle typologies. Since our dependent variable, mobility triangle type, is nominal we use a multinomial logistic regression. In a multinomial logistic regression, a single regression applies to the five categories in a typology (i.e., *neighborhood*, *victim*, *offender*, *offense*, and *total*). The regression determines the most significant variables that differentiate cases across the five categories. Only the half mile distance typology is examined for this analysis.

The independent variables for the regressions were as follows:

- Victim Variables
  - Race (African-American = 1 ; Other = 0)
  - Sex (female = 0 ; male = 1)
  - Age (<18 years old= 1 ; 18-24 years old = 2 ; 25-34 years old = 3 ; 35 years or older (reference category))
- Offender Variables
  - Race (African-American = 1 ; Other = 0)
  - Sex (female = 0 ; male = 1)
  - Age (<18 years old = 1 ; 18-24 years old = 2 ; 25-34 years old = 3 ; 35 years or older (reference category))
- Motives
  - Argument (no = 0 ; yes = 1)
  - Domestic violence (no = 0 ; yes = 1)
  - Drug-related (no = 0 ; yes = 1)
  - Gang-related (no = 0 ; yes = 1)
  - Retaliation (no = 0 ; yes = 1)
  - Robbery (no = 0 ; yes = 1)
- Firearm (no = 0 ; yes = 1)
- Relationship
  - Intimate (no = 0 ; yes = 1)
  - Acquaintance (no = 0 ; yes = 1)
  - Stranger (reference category)

Exhibit 4-29 shows the values for the significant variables resulting from the regressions. The multinomial regression gives results for each pairwise combination of outcomes. With five possible outcomes, there are ten possible combinations (*neighborhood* versus *victim*, *neighborhood* versus *offender*, etc.). These combinations form the columns in the table, with the

first column providing the list of variables. Exhibit 4-29 shows the values of the parameters for those variables that were found to be statistically significant at the .10 level. Values in plain text are from the multinomial regression based on the traditional mobility triangle typology, while values in bold text are from the regression using the distance mobility triangle typology with a half-mile distance[22]. In order to improve readability of the table, relationships are reported in only one direction. For example, on the variable Male Victim, *neighborhood* vs. *victim* for the traditional typology is -.39. Only the sign would change if *victim* mobility triangles were being compared to *neighborhood* mobility triangles (i.e. the value is .39).

Results in Exhibit 4-29 show similar results in several instances for the two regressions. For example, for *victim* versus *total* categories, the same three variables are identified as significant in the two regressions—African-American offender, drug-related motive, and use of firearm—and the parametric values are almost identical. On the other hand, there are several differences with the two approaches, such as the following:

- For *neighborhood* versus *victim*, the distance typology includes two significant variables (victim's age less than 18 years and drug-related motive) not included in the traditional typology.
- Two additional variables (victim's age less than 18 years and African-American offender) are also identified in the *neighborhood* versus *offender* categories.
- For the *neighborhood* versus *offense* categories, the two regressions identified completely different variables, with the traditional typology having seven significant variables, and the distance typology only two significant variables.
- For the *neighborhood* versus *total* categories, the distance typology includes three more significant variables—male victim, victim's age less than 18 years, and offender's age 18 – 24 years.
- For the *victim* versus *offender* categories, the traditional typology has two additional significant variables—victim's age 18 – 24 years old and domestic violence motive.
- For *victim* versus *offense*, the two regressions identified different variables with the exception of Intimate relationship.
- For *offender* versus *offense*, the regression for the traditional typology lists three significant variables, while the distance typology yielded only one variable (gang-related motive).
- For *offender* versus *total*, the traditional typology has two additional significant variables (victim's age less than 18 years and victim's age 18 – 24 years).

[22] Odds ratios were not computed since the tables only show significant variables.

The results for each type of triangle are discussed in detail in the next few sections. In addition, our results are compared with those reported by Tita and Griffiths(2006) in order to offer some idea of the consistency of characteristics across cities.

Exhibit 4-30 summarizes the numeric results to show the direction that the significant variables take the odds when comparing two categories. The upper left corner is for *neighborhood* versus *victim* indicates, for example, that *neighborhood* incidents are less likely to be male victims than those in the *victim* category. The following sections summarize the similarities and differences between triangle types that are noted in Exhibit 4-30.

Neighborhood Triangles

Neighborhood triangles differ significantly from other types of triangles on victim, offender and event characteristics. Only the statistically significant differences are discussed here. Both sex and age of the victim are significantly different from other triangles. *Neighborhood* triangles are more likely than *victim, offense* or *total* mobility triangles to have a female victim. The victim is more likely than all other types of triangles to be under the age of 18. Offenders are more likely to be 18-34 years of age. The homicide events are less likely than all other types of triangles except *victim* mobility triangles to involve a firearm. The largest differences between *neighborhood* and other types of triangles are in the relationship between victim and offender. *Neighborhood* triangles are more likely to involve intimates or acquaintances than any other triangle type.

These findings are consistent with the literature on activity spaces. Women and young people tend to have the smallest activity spaces so they are more likely to be close to home when killed. In addition, people tend to have the greatest amount of interaction with close friends, family members and neighbors near or in their own homes so the predominance of close relationships and close distances is reasonable.

Motive did not consistently differentiate among the triangle types. This was an especially surprising result given the predominance of domestic violence motives among *neighborhood* triangles. We agree with Tita and Griffith's(2006) assessment that the relationship variable (i.e. intimate and acquaintance categories) is mediating the effect of motive. *Neighborhood* triangles had three significant differences related to motive, they were less likely to be: drug-related than *victim* mobility triangles, gang-related than *offense* mobility triangles, and retaliation-related than

offender mobility. Homicides with drug-related, gang-related and retaliation-related motives had some of the longest travel distances especially between victim and offender home addresses making them unlikely to fit the definition of a *neighborhood* triangle.

As compared with the findings from the earlier study in Pittsburgh, there are some general similarities but more differences(2006). The variables that are consistent between the studies were the non-stranger relationship. All other findings vary by either the variable found significant or the pairings that are significant. While both cities have similar proportions of *offense* mobility triangles, more of the *neighborhood* triangle characteristics differ significantly from *offense* triangles in the District than in Pittsburgh.

Victim Mobility Triangles

Victim mobility triangles have several significant differences from events in both *neighborhood* and *offender* triangles. As compared to *neighborhood* triangles, *victim* triangles are more likely to have male victims but both are less likely to have older victims. The larger activity spaces of men make it more likely that they will be outside their neighborhood if involved in a homicide. In addition, *victim* triangles are less likely than *neighborhood* ones but more likely than *total* mobility triangles to involve drugs as a motive. In other words, victims in drug-related homicides tend to either be killed in their own neighborhoods or in the neighborhood of the dealer. Both *neighborhood* and *victim* triangles are less likely to involve a stranger.

The differences with *offender* triangles involve mostly victim characteristics although *victim* triangles are more likely to have an African-American offender than *offender* triangles. When compared with *offender* triangles, *victim* triangles are less likely to have an African-American victim but more likely to have a male victim. They are also less likely to involve victims in the 18 - 35 age group. Although they are more likely to involve strangers than are *offender* mobility homicides. As far as motive, *victim* triangles are less likely to be retaliation-related than *offender* triangles. There were no significant differences on firearms use between *victim* and *offender* triangles. However, *victim* triangles are less likely to involve a firearm than *total* mobility triangles. On the whole these findings differ from the Pittsburgh study in that more variables differentiated between the spatial classifications and the identities of those

variables were not consistent across the two studies. Relationship was the only characteristic that discriminated consistently.

Offender Mobility Triangles

Offender mobility homicides also differ on victim, offender and event characteristics. They are less likely to involve male victims than any other type of triangle. Victims are more likely to be African-American than in either *victim* or *total* mobility triangles but less likely than *offense* mobility triangles. In general, the age of victims in *offender* triangles is more likely to be between 18 and 35 years of age than *neighborhood* or *victim* mobility triangles but more likely to be less than 25 in *offense* triangles and between 18 and 34 in *total* mobility triangles.

Offender characteristics also differ although the differences are not as consistent for victims. *Offender* mobility offenders are less likely to be African-American than *neighborhood* or *victim* mobility triangles. Offenders in *offender* mobility triangles are also less likely to be between 18 and 34 than *neighborhood* triangles and less likely to be under 25 years old than *total* mobility triangles.

Event characteristics differentiate *offender* mobility triangles too. As far as motive for the homicide, *offender* triangles are more likely to be retaliation-related than *neighborhood* triangles but less likely than *victim* triangles. They are less likely to be domestic violence related than *victim* mobility triangles. Finally, *offender* mobility triangles are more likely to be argument or drug-related than *total* mobility and more likely to be gang-related than *offense* mobility triangles. Relationships also differ significantly between *offender* triangles. *Offender* mobility triangles are less likely to be intimate or acquaintance than *neighborhood* triangles but more likely than *victim* triangles and *total* mobility triangles. These results are somewhat puzzling especially the relationship between *victim* mobility and *offender* mobility as it relates to offender/victim relationship and motive. On the one hand, *offender* mobility tends to be less likely to have a domestic violence motive but more likely to be acquaintance or intimate relationship.

As compared to the Pittsburgh study, there are only two common characteristics. *Offender* mobility triangle homicides are more likely to involve female victims and to result from some predatory activity. In the case of Washington, D.C., it is retaliation-related. In Pittsburgh, gang felony and drug motives are often involved.

Offense Mobility

Offense mobility triangles are the only type for which no significant relationships are identified by both mobility triangle classifications. This may be due in part to the small number of triads classified as *offense* mobility. Thus the results should be interpreted with care and are not further elaborated upon to develop a separate profile.

Total Mobility

Total mobility triangles have significant differences as compared to *neighborhood*, *victim* and *offender* triangles. As far as victim characteristics, both sex and race differ. *Total* mobility triangles are more likely to have a male victim than *neighborhood* triangles but less likely than *offender* triangles. African-Americans are less likely to be victims in a *total* mobility triangle than *neighborhood*, *victim* or *offender* triangle homicides. The victims are less likely to be 18-34 years of age than *neighborhood* or *offender* homicides.

Offenders however, are universally less likely to be African-American in *total* mobility triangles. They are also more likely to be male than *neighborhood* or *offender* triangles. Their ages are less likely to be between 18 and 34 than *neighborhood* or *offense* triangles but more likely to be under 25 than *offender* homicides.

Related to event characteristics *total* mobility triangles their motives are less likely to be drug-related than *victim* or *offender*. *Total* mobility triangles are also less likely to be argument than *neighborhood* or *offender*. Firearms are more likely to be involved than in *neighborhood* or *victim* mobility triangles. The relationship between offender and victim is less likely to be acquaintance or intimate than *neighborhood*, *offender* or *offense* triangles. This finding also fits with routine activity spaces since no spatial coincidence often equates to no prior familiarity.

Exhibit 4-29: Multinomial Logistic Regression Results for Traditional and Distance Mobility Triangle Typologies

Variable	Neigh. versus Victim	Neigh. versus Offender	Neigh. versus Offense	Neigh. versus Total	Victim versus Offender	Victim versus Offense	Victim versus Total	Offender versus Offense	Offender versus Total	Offense versus Total
Victim Variables										
African-American					-.53** **-.48***				.55** **.47***	
Male	-.39* **-.66*****	.31* **.30***	-1.06**	**-.47****	.70*** **.95*****			-1.37***	-.61*** **-.77*****	
Age										
<18 years old	**.65*****	**.48****	.90**	**.47*****				.70*		-.87**
18 – 24 years old	.43** **.43****		.89***	.49*** **.61*****	-.35**			.81***	.41** **.44*****	
25 – 34 years old	.72*** **.91*****			.56*** **.69*****	-.67*** **-.69*****	**-.99****			.50*** **.48*****	**.77***
Offender Variables										
African-American		**.71***		.66* **.79****	.74* **.74***	-1.11*	.81** **.82****			
Age										
<18 years old									-.53**	
18 – 24 years old	.56** **.49****	.75*** **.58*****	.95*	**.40***					-.47**	
25 – 34 years old	.53** **.59****	.88*** **.83*****	1.03**	.50* **.63*****						

NOTE: 1. For Victim and Offender's Age, the reference category is 35 years or older.
2. Significant variables are in plain text for Traditional typology and bold text for Distance typology.

Exhibit 4-29: Multinomial Logistic Results for Traditional and Distance Mobility Triangle Typologies (Cont.)

Variable	Neigh. versus Victim	Neigh. versus Offender	Neigh. versus Offense	Neigh. versus Total	Victim versus Offender	Victim versus Offense	Victim versus Total	Offender versus Offense	Offender versus Total	Offense versus Total
Motives										
Argument				.28** **.32****					.31** **.25****	
Domestic violence					.58*					
Drug-related	**-.31****					**-.55***	.34** **.29****		.29**	
Gang-related			**-.68****			**-.64***		**-.58***		
Retaliation		-.32** **-.37*****			-.26* **-.34****					
Robbery										
Firearm used		-.45*** **-.43*****	**-.90****	.56*** **-.56*****		**-.70***	-.35** **-.35****			
Relationship										
Acquaintance	1.27*** **1.41*****	.83*** **1.03*****	1.22***	1.18*** **1.47*****	-.44*** **-.38****	**-.74***			.35** **.43*****	**.80****
Intimate	2.23*** **2.27*****	.85*** **1.20*****	.99*	2.54*** **2.48*****	-1.39*** **-1.07*****	-1.24** **1.97*****			1.69*** **1.28*****	-1.55** **2.18*****

NOTE: 1. For Relationship, the reference category is Stranger-to-Stranger.
2. Significant variables are in plain text for Traditional typology and bold text for Distance typology.

Exhibit 4-30: Multinomial Logistic Regression Summary

	Victim	Offender	Offense	Total
Neighborhood	**Less likely to be male victim.** More likely victim is 18-34 years old. *More likely victim is less than 35 years old.* **More likely offender is 18-34 years old.** *Less likely to be drug-related motive.* **More likely to be acquaintance or intimate relationship.**	**More likely to be male victim.** *More likely victim is < 18 years old.* *More likely offender is African-American* **More likely offender is 18-34 years old.** **Less likely to be retaliation motive.** **Less likely to involve firearm.** **More likely to be acquaintance or intimate relationship.**	Less likely to be male victim. More likely victim is less than 25 years old. More likely offender is 25-34 years old. *Less likely to be gang-related.* *Less likely to involve firearm.* More likely to be acquaintance Or intimate relationship.	*Less likely victim is male.* More likely victim 18-34 years old. *More likely victim is less than 35 years old.* **More likely African-American offender**. More likely offender is 25-34 years old. *More likely offender is 18-34 years old.* **More likely to be argument motive**. **Less likely to involve firearm.** **More likely to be acquaintance or intimate relationship**.
Victim	N/A	**Less likely victim is African-American.** **More likely victim is male.** Less likely victim is 18-34 years old. *Less likely victim is 25-34 years old.* **More likely offender is African-American**. More likely domestic violence motive. **Less likely retaliation motive.** **Less likely to be acquaintance or intimate relationship.**	*Less likely victim is 25-34 years old.* Less likely offender is African-American. *Less likely to be drug-related motive.* *Less likely to be gang-related motive.* *Less likely to involve firearm.* Less likely to be intimate relationship. *Less likely to be acquaintance or intimate relationship.*	**More likely offender is African-American.** **More likely drug-related motive.** **Less likely to involve firearm**.
Offender		N/A	Less likely to be male victim. More likely victim is less than 25 years old. *Less likely to be gang-related motive.*	**More likely victim is African-American.** **Less likely victim is male**. **More likely victim is 18-34 years old**. Less likely offender is less than 25 years old. More likely to be argument or drug-related motive. *More likely to be argument motive.* **More likely to be acquaintance or intimate relationship.**
Offense			N/A	Less likely victim is less than 18 years old. *More likely to be 25-34 years old.* More likely to be intimate relationship. *More likely to be acquaintance or intimate relationship.*

NOTE: 1. Significant variables at the .10 level for Traditional typology only are shown in plain text.
2. Significant variables at the .10 level for Distance typology only are shown in *italic text*.
3. Significant variables at the.10 level for both typologies are shown in **bold text**.

Chapter 5

Conclusions

Due to the exploratory nature of this research we have covered quite a bit of ground in our endeavor to quantify the spatial relationships among offender home, victim home, and the location where the homicide occurs. While many studies have examined the distances that offenders' travel to commit crime, only a few studies have incorporated victim travel and examined the joint mobility involved in criminal events. Our research builds on and extends the existing body of work in several ways. First, we use an expanded study area for offenders' and victims' residences to get a better picture of cross-jurisdictional flows. Second, we disaggregate homicides to provide a more nuanced view of the dynamics involved in different types of homicide events. Third, we develop a new mobility triangle typology based on distance rather than social areas effectively addressing previous criticism directed at traditional mobility triangles because of their susceptibility to the modifiable area unit problem.

This section provides a summary and discussion of the results of the study. The first part discusses the distances between each of the components separately. Then the geometry of the configuration of all three locations is examined. Finally, we recap our attempts to identify characteristics of participants and events that vary by the type of joint distribution observed.

Travel Distances Between Primary Locations in Homicide Events

Quantifying the distances between each of three known locations revealed a number of relationships that contribute to the theoretical literature. First, as with other crimes, the distribution of distances for victims and offenders is skewed. That is, both victims and offenders tend to be involved in homicide incidents when they are relatively close to their residences. As reported, victims had median distances of .06 miles and offenders .69 miles from their homes. On average, both victims and offenders tend to be close to home when the homicide occurs. This quality of the spatial distribution of crime stems from the daily activities of both victims and offenders noted in the introduction. People, in general, tend to frequent familiar areas. Both victims and offenders use their knowledge in their decisions about where to work, shop, recreate

and in the case of offenders commit crimes. These decisions are in turn, shaped by the urban structure (Rhodes & Conly, 1981).

The expected age and sex differences for both victims and offenders were verified. On average, males travel farther than females regardless of role (i.e. victim or offender). Age differences were observed for both victims and offenders. Victims under 18 years of age have the shortest distances and averaged 1.57 miles from home. Victim distances increased until age 35 and then began to decrease. Among offenders, it is the older offenders who traveled the shortest distances, followed by those under 24 years of age. In the case of drug- and robbery-related homicides, the longer travel distances for individuals under the age of 18 may have been facilitated by the extensive public transportation system in the Washington, D.C. area. The Metro makes it easier for individuals to travel relatively long distances from their homes without a vehicle. The longest average distances were once again for those ages 25 to 34. These findings are in line with the expected distances based on the variation of the size of activity space with age (Chapin & Brazil, 1969; Harries, 1999). Activity spaces tend to increase in size through middle age and then get smaller again.

As expected, the average distances were larger than reported in other studies of offender and victim travel to crime. We believe this was due to our inclusion of homicide events in which the victim and/or offender lived outside of the District. This decision made the study area larger and increased the potential distance to the incident location in the District. On a related note regarding the study area, the research reported here was based on homicides that occurred within the boundaries of Washington, D.C. The extent to which these homicides and their associated distance distributions are representative of other cities cannot, of course, be determined. Replication of this research by other researchers—especially on the distances that victims travel to homicides—is encouraged. As it stands, we are unable to generalize our findings to a larger universe.

Several researchers have pointed out that the disaggregation of homicide events by their characteristics is an important step in order to better understanding them (Flewelling & Williams, 1999; Zahn & Jamieson, 1997). We chose to use motive as one way of breaking out different types of homicides. However, the analysis was complicated by the fact that almost half of all

homicides had more than one motive checked. About16 percent of those involved three or more motives. Thus our results that are disaggregated by motive must be interpreted cautiously.

In order to identify whether the type of homicide might affect the distance traveled, we disaggregated the homicide events by motive. Both victim and offender travel distances varied significantly by motive for the homicide. Offenders in drug-related homicides had the longest travel distances and those involved in domestic violence incidents had the shortest. In contrast victims of robbery-related homicides were further from home than any other type of homicide with drug-related homicides a close second. As with offenders, domestic violence incidents occurred closer to home than any other type of homicide.

One of the most intriguing findings concerned the relationship of firearms use and distance from home. Offenders with firearms tend to be further from their residences when they committed their crimes than offenders with other weapons. Victims were also farther from home when killed if a firearm was involved. Following Capone and Nichols (1976) we note that these individuals may be committing crimes that involve specific targets, significant planning and a vehicle. We also conjecture that offenders feel more confident to venture further from their homes when they are carrying a firearm. More research is needed to determine offender's reasons for carrying firearms and the role that firearms play in their daily routines.

Two other homicide characteristics were examined — relationship to offender and case status. Distances from home varied by the type of relationship between victim and offender, the closer the relationship; the closer the incident was to the home of the offender. For instance, domestic violence homicides have a median distance of zero, meaning that the majority of these homicides took place in a shared residence. In contrast, we found no significant relationship between case status and victim's distance from their home. Previous research had found that victims in closed cases were victimized closer to home than victims in open cases (Block et al., 2004). Our finding that victims travel about the same in open cases (2.74 miles) as in closed cases (2.64) is in the same direction as Block, Galary and Brice's (2004) finding but in this study, the difference was only a tenth of a mile.[23] The differences found by Block et al. for rape, noncommercial robbery and aggravated assault were much larger. They speculated that the cases

[23] The difference in victim travel distance between closed and open cases was not significant at the p <= .05 level in Washington, D.C. Significance tests were not provided from the Chicago data.

in which the offender and victim knew each other were the first to be solved and that those cases tended to involve a high degree of spatial proximity. In other words, the victim and offender may have some familiarity with one another just by virtue of sharing the same activity space. Our finding of no difference between the two for homicide may reflect different forces at work. For example, it is reasonable to expect that homicide cases are allotted additional resources (e.g. forensics, number of detectives, rapid response) that counteract the effect of being able to interview victims and find out the identify of offenders.

Because of the skewness in the distances measuring both offender and victim travel, we split the observations into three groups: home homicides, middle-distance homicides and long-distance homicides. Approximately twenty percent of victims were killed in or just outside their home. Another five percent were more than ten miles from home. The other three quarters of victims were classified as middle-distance distances (i.e. between .01 miles and 10 miles from home).

A general picture of homicide victims killed at home emerges from the data. In keeping with their shorter travel distances in general, women were also much more likely to be killed at home than men (46 percent versus 16.7 percent). Victims killed at home were also older than the average homicide victim and their crime was more likely to be solved. Police closed 66 percent of home homicides compared to only 56 percent of middle- and long-distance homicides.

An interesting profile of offenders who killed in or very near their home emerged from the findings on home homicides; almost 80 percent were males, who used a weapon other than a firearm (57.3 percent). At an average age of thirty years, home offenders were older than the overall average and the other distance categories. The majority of offenders were acquainted (50.8 percent) or intimate (41.7 percent) with the victim prior to the homicide. Arguments (60.1 percent) were the most frequent impetus for the homicide followed by domestic violence.

One aim of the research was to determine whether the distance an offender travels to commit a homicide is significantly different by motive. This question was tested using the middle-distance homicides having only one motive. The distance from home for offenders was significantly different for argument-related homicides as compared to domestic violence and drug-related homicides. Distance from home also differed significantly between domestic violence and drug-related, retaliation, and robbery homicides. Finally, distances from home

were significantly different for drug-related and robbery homicides. Unexpectedly, the domestic violence homicide trips are significantly longer than all other trips except gang-related homicides. Argument homicides involve significantly shorter trips than drug-related homicides. Somewhat surprisingly, offenders traveled significantly farther to be involved in drug-related homicides than they did for robbery homicides.

A more in-depth analysis of the middle distance homicides involved fitting several statistical distributions to examine distance decay in victim and offender travel to the scene of the homicide. The Pareto-exponential function was found to provide the best fit for all the motives and both types of participants except for offender travel related to drug-related homicides that required an exponential distribution. Across the board, these distributions indicate strong distance decay in the behavior of victims and offenders regardless of motive. In addition, the distributions provide no evidence of the existence of a buffer zone for homicide —- regardless of type of motive.

Finally, our examination of the relationships among the three distances and the characteristics of the participants and the events themselves revealed that victim travel distance is highly correlated with the distance between the offender and victim home address but uncorrelated with the distance from the offender's home to the homicide. Further exploration using a multiple regression analysis revealed the following factors are associated with diminished distance between offender and victim residence: 1) shorter victim to homicide distance; 2) victim residence within the District; 3) older victims; 4) older offenders; 5) retaliation or robbery motives; and 6) event is part of *neighborhood* mobility, *victim* mobility, or an *offense* mobility triangle. Gang-related homicide motives have a positive relationship with increased distance between offender and victim home addresses. These findings have direct implications for offender identification in homicide investigations because they use a known factor, in this case distance between victim home and homicide location and use it to predict an unknown factor, the probable distance between the offender's home and the location of the homicide.

The comparison of different measurement techniques demonstrated that a strong and consistent linear relationship that exists between Euclidean distance and street network distance even in an area without a uniform, grid street network. Both measurement techniques have their

advantages and disadvantages. Selection of a technique should depend on the particular problem at hand and the resources available to address it. Crime analysts may want to depend on the more easily measured Euclidean distance, while investigators may want to use the formulas provided to estimate the distance actually traveled by offender and victim. Our research on homicides shows there is such a close relationship between the two that knowing one virtually ensures good information about the other assuming the acceptance of regression results. In other words, crime analysts in Washington, D.C. can measure Euclidean distance using GIS and then use the formula provided to calculate probable street distance traveled. We propose that crime analysts consider using both measures to create an envelope representing the most probable area of offender residence. However, this suggestion requires additional empirical tests to validate its utility.

Future research should examine a third type of distance measure, travel time. Travel time has the advantage of more accurately reflecting the 'cost' of a trip. It also offers a perceptually different measurement of distance. Ideally, such travel time would be generated from the speed limits on the roads and include friction values that reflect traffic congestion. These variables were not available as attributes of the street centerline we used. However, the inclusion of travel time would offer an important additional dimension.

Application of Mobility Triangles to Homicide

The spatial configuration of the anchor locations was examined using geometry and two mobility triangle typologies. Simple geometry classified an event according to the level of coincidence among the locations. Total spatial coincidence formed a dot (i.e. the three anchors share a common location). If any two of the locations were coincident, a line was formed. Locations with no coincidence resemble a triangle with the shape of the triangle dependent on the angles between the points. In order to replicate previous studies and extend the notion of mobility triangles we explored the use of traditional, distance and a hybrid form of mobility triangle classification. The hybrid typology proved too complex and was dropped from further consideration. Finally, a multinomial logistic regression was used to determine which of the event and person characteristics differentiated among the different types of mobility triangles.

The geometric configurations of the anchors provide an interesting framework from which to approach the relationships among offender home, victim home and the location of the homicide. First, in order to ensure the sample of triad events was comparable to the population of homicides we evaluated the two and found them equivalent.

An examination of the distances for triads revealed some interesting characteristics of the sample. First, regardless of motive, on average the distance between offender home and victim home is always the longest. For most motives, offender to homicide is the next longest and victim to homicide is the shortest. The case of robbery homicides is the one exception, victims' travel farther to the scene of the crime than do offenders. Since our data is limited to home address, we cannot capture whether the work place is the dominant anchor point in robbery and the victims are robbed close to where they work but far from where they live. On average, both victims and offenders involved in gang-related, retaliation and robbery homicides are farther from home when the homicide occurs than other types of homicide. Robbery homicides have the highest total distance for all three locations. We believe this reflects commuting patterns that bring suburban residents into the urban area to work and subsequently become victims of crime. The longer travel distances for gang-related and retaliation homicides may be a sign of the spatial dispersion of rival gangs in the city or they may be the result of aggressive trips made to exact retaliation but end with the aggressor being killed.

Using a spatial geometry of homicides enables us to uncover additional insights into homicide. About three–quarters of triads are triangles, with the other quarter distributed among lines (20 percent) and dots (4 percent). The characteristics of the homicides were significantly different by geometry. Domestic violence (34 percent) and arguments (5.8 percent) had the highest proportion of dots while robbery (23.3 percent), argument (21.5) and drug-related (20.7 percent) homicides had the most lines. Triangles dominated all the motives but were highest for gang-related (86.6 percent) and retaliation (83.6) homicides. Offenders and victims have similar patterns by geometry. Males are more likely to be part of triangles but females are more likely to be involved in line homicides. Two areas where differences exist are among white offenders and over 50-age category. White offenders are more likely than either African-American offenders or white victims to be part of line (55 percent) rather than a triangle (45 percent). Older offenders tend to be part of dots (35 percent) while older victims are more likely to be part of lines. In keeping with earlier observations, these findings reflect what is known about how

activity spaces vary with age and sex and lend empirical support for the validity of using routine activities to explain crime patterns.

Our replication of Tita and Griffiths (2006) research using Pittsburgh homicides yielded remarkably similar results with just a few differences. Despite different time periods, study areas sizes and durations (all of which contributed to very different numbers of observations between the two studies), the proportions of *neighborhood* and *offense* mobility triangles were almost identical. Washington, D.C. had more *offender* and *victim* mobility homicides while Pittsburgh had more *total* mobility triangles. Although not directly addressed in this research, the size of the social areas used as boundaries will affect the triangle classification. Larger social areas will produce more *neighborhood* triangles and fewer *total* mobility triangles while smaller social areas will produce the inverse. Rather than test different sizes of social areas we chose to develop a new classification scheme, based on the conceptual definitions of traditional mobility triangles but using distance as the classification mechanism.

Our experiments with distance mobility triangles clearly showed the sensitivity of classification scheme changes in distance cut-offs. We tested four different distances, quarter mile, half mile, three-quarter mile and 1 mile. Of those, the half mile scheme yielded results roughly comparable to traditional triangles. The distance mobility triangles still had fewer *neighborhood* triangles and more *total* mobility triangles than the traditional triangles. *Neighborhood* mobility and *total* mobility classifications were the most sensitive to distance although in opposite directions. As the distance increased, the proportion of *neighborhood* triangles increased and the proportion of *total* triangles decreased. The proportion of *offense* mobility triangles is insensitive to changes in the size of the distance bands reflecting the longer distance that offenders tend to travel to the location of the homicide. *Victim* mobility triangles show an increase between one-quarter and one-half miles but are stable at one-half mile and above. Similarly, this may be a function of the shorter distances most victims travel. Finally, *offense* mobility triangles made up a smaller proportion, at all distances, than was observed in the traditional typology and their proportion increased with increasing distance. Thus, the use of distance triangles provides a more nuanced view of relationships between the anchor points but the variations between the two typologies were not extreme. In addition, distance triangles are flexible and can be aggregated to any boundary for display purposes (e.g. to summarize

neighborhood homicide problems) or shown as points by type of triangle to examine their relationship to neighborhood boundaries (e.g. a point map of all *neighborhood* triangles).

A Closer Look at the Characteristics of Mobility Triangles

Our application of multinomial logistic regression to identify person and event characteristics that differentiated among the spatial types was illuminating but ultimately unsatisfying from a policy view. Related to the comparison of *traditional* and *distance* typologies, they perform about equally as far as identifying significant differences between triangle types with a high level of agreement between the two techniques. They disagreed in sign only two times and often had very similar values. The conflicting signs involved the relationship variable, specifically intimate relationships. In both cases, the traditional typology predicted it was less likely to be an intimate relationship for *victim* mobility vs. *offense* mobility and for *offense* mobility vs. *total* mobility. While the distance typology predicted it was more likely that they would involve intimates in *victim* mobility vs. *offense* mobility and for *offense* mobility vs. *total* mobility. These results could be due to the small number of *offense* mobility triangles. Further study is necessary to determine whether the differences between the two typologies are significant enough to advocate for the use of one typology over the other.

The research we had originally proposed would have included an examination of rape, robbery and aggravated assault as well as homicide and provided the first in-depth exploration of anchor points as they relate to violent crime. One particularly interesting line of research that could have been undertaken with those data involves the examination of the relationship between homicides and aggravated assaults. Other researchers have noted that homicides may be thought of as aggravated assaults in which the victim died rather than premeditated attacks with the specific goal of death. Unfortunately, we were not able to obtain the data so these questions remain to be answered by future research endeavors.

Chapter 6:

Implications for Practice

Much attention has been focused on the crime of homicide because of its severity for the victim, impact on victim's family and friends, and its affect on the ability to maintain a viable community (Wilson, 1975). These factors make the results of this research endeavor important to police, community members and violence prevention practitioners. While the ability of police to prevent homicide has been hotly debated, results of a recent quasi-experimental study show a link between the implementation of problem oriented policing strategies and dramatic reductions in homicides (White, Fyfe, Campbell, & Goldkamp, 2003). Along the same lines, we now suggest how the advances in basic knowledge that were discussed in the previous section can be translated into recommendations for changes in policy and practice.

We anticipate two major uses of these insights: 1) informing the problem solving activities of patrol and 2) aiding in homicide investigations. One of the most fundamental aspects of problem solving is to disaggregate the problem and look intensely at its various facets (Eck & Spelman, 1987; Goldstein, 1990). In this research, we disaggregated homicides into event, victim and offender characteristics. We then combined that analysis with another that focused on the spatial configuration of known locations. By treating both space and characteristics simultaneously we can detect new information underlying homicide problems. This work also offers a starting point for detectives as they begin to create offender lists for the crime. By combining the detectives known facts concerning the characteristics of the victim, event and offender (if available) the detective will be able to ascertain the likely distance and direction traveled by an offender.

Applications to Problem Solving

Identification of the spatial typology at work in neighborhoods is essential to achieving a better understanding of the crime problem. The relatively simple classification scheme used by mobility triangles offers a handy tool to quantify the relationships between victim, offender and incident. In addition, situating offenders and victims within their resident neighborhood and the incident within a crime neighborhood sets the stage for further explorations to identify which

neighborhoods are generating the offenders and victims that kill and are killed in the crime neighborhood (McEwen & Groff, 2005).

The characteristics of neighborhoods offer important information regarding the motivations for victims and offenders to be at the same place. One key attribute is the existence of facilities that attract people (Brantingham & Brantingham, 1995; Rengert, 1988). Work by the Brantinghams identified two major types of places, crime generators and crime attractors (Brantingham & Brantingham, 1995). Crime generators are places that attract large numbers of people, not necessarily for criminal activities (e.g. malls, sporting arenas, etc.). Crime attractors, on the other hand, are places that are known for their criminal opportunities (e.g. entertainment districts, drug markets, etc.). By taking into account the presence of crime generators and crime attractors police personnel can enhance their understanding of the processes underlying mobility triangles. For example, neighborhoods, in which the predominant type of triangle is *neighborhood* or *offender* mobility, may have problems with incivilities or crime attractors such as drug markets. Once the underlying problem is identified, proven strategies can be implemented. In the case of drug markets, one proven strategy involves the use of civil remedies to force owners to clean up nuisance properties and in doing so, deprive drug buyers and sellers of a receptive environment (Mazerolle, Price, & Roel, 2000).

One clear-cut application of this technique would be to include the spatial typology of crime when homicide profiles are developed by neighborhood. As demonstrated by the pie chart map of the distribution of mobility triangles, it is possible to determine the general type of homicide problem present. A simple table could also be used to identify neighborhoods in which there are high percentages of specific types of homicide triangles.

Different types of homicide triangles suggest different intervention and prevention strategies. In neighborhoods with high proportions of *neighborhood* triangles, violence reduction strategies could be organized that would concentrate on the residents of the neighborhood. Neighborhoods in which residents are killing each other in the neighborhood also require the application of strategies addressing both victims and offenders. Previous research has indicated that offenders and victims are often very similar (Kennedy & Forde, 1990). Thus it is probable that any homicide prevention efforts will impact both groups. Strategies such as enforcement of existing warrants and vehicle license checks have the potential to get violent

individuals off the street so they will not become murderers or victims. Comprehensive strategies such as 'pulling levers' require intensive support by a wide range of agencies but have provided impressive results and strategies need to be targeted there as well as strategies that focus on the physical environment to reduce the opportunity for violence (Kennedy, 1997; Kennedy, 1998; Kennedy & Braga, 1998a). The term 'pulling levers' was coined by David Kennedy and refers to a comprehensive strategy that coordinates both negative levers such as enforcement (e.g., police and parole officers) and positive levers (e.g., jobs programs, church-sponsored programs and drug treatment programs) to give target populations (e.g., gang members, ex-offenders etc.) the impetus and the tools to become law-abiding citizens.

Examining the neighborhood profile of homicide events provides a first view of the overall distribution of homicide triangle types. In order to better understand the particular situation in a neighborhood, it is necessary to drill down to the next level of specificity in the data. For example, if a neighborhood has a large proportion of *offender* triangles then the offenders are traveling in from other neighborhoods. The next logical question is which other neighborhoods? The answer to this question would identify specific areas that are supplying offenders and could be display graphically[24]. These areas would be natural foci for both enforcement and prevention efforts. Enforcement efforts such as warrant enforcement could be focused in the supplier neighborhood to reduce the number of potential offenders. Social programs could be targeted to reduce violent behavior and increase opportunities for legal means of earning money. The same process could be applied to identify sources of victims in neighborhoods with a large proportion of victim mobility triangles. A possible response to prevent additional victimization might involve a public relations campaign to inform residents of the situation. As mentioned earlier, stepped up warrant enforcement is effective in reducing both the number of potential victims and potential offenders by getting crime-prone individuals off the street.

The physical environment of these neighborhoods is another potential intervention point that could be targeted to decrease the incidence of homicide depending on the particular situation. For instance, a problem with domestic violence homicides would not be very amenable to changes in the physical environment. *Victim* mobility homicides are another matter.

If further analysis of the *victim* mobility homicides reveals the victims had traveled to that particular neighborhood in search of drugs, a variety of strategies are available to implement depending on the nature of the drug trade. If abandoned buildings are havens for drug dealing and drug use, then partnerships with code enforcement officials will aid in securing those buildings. Routine police tools such as license check points and drug task forces may be used to reduce both demand and supply. The license checkpoints deter both potential customers and dealers while the drug task force reduces supply by arresting dealers.

In the case of a problem typified by *total* mobility triangle homicides, the overwhelming spatial commonality is the neighborhood in which the homicide occurs. Further analysis of the whole set of offender residence and victim residence neighborhoods may reveal significant overlap. If quite a few homicides also turn out to have gang-related motives the problem may be that the neighborhood is disputed area that intersects two different gang territories. In this case, special gang task forces with coordinated, multi-agency partnerships have been successful in reducing gang activity (Kennedy & Braga, 1998a). Whatever the initial type of triangle identified, it is critical that further analysis of the character of the homicides is conducted before deciding on a strategy.

Homicide Investigations

Combining spatial analysis with more traditional forms of crime analysis has the potential to provide important information to homicide detectives. This is especially true when they are investigating homicides with no witnesses, where there is no prior relationship between the victim and the offender, and when there is very little physical evidence. These cases are particularly challenging to solve.

Development of offender lists is a primary area where the geographic analysis of homicide case information may be particularly helpful. Most geographic analyses stop at the coarsest of levels. For example, a quick and dirty analysis of all homicides in Washington, D.C. revealed that there was a little less than a fifty percent chance the offender lived in the neighborhood where the homicide took place. This fact would not be very helpful to homicide

[24] The companion report to this document provides an in-depth examination of cartographic techniques related to the visualization of mobility data (McEwen & Groff, 2005).

investigators since it represent odds of 50/50 that an offender lives in the same neighborhood. However, by undertaking additional analyses we can generate more specific information.

Examining spatial typologies involves using information about victims, relative locations and event characteristics to narrow offender lists. There are several findings that can inform this process. First, the relationship discovered between victim travel to crime and distance between the two homes will enable investigators to predict the likely distance the offender traveled to commit the crime. This relationship is particularly valuable because it uses two known pieces of information and thus can be applied to open cases. Investigators can use the projected distance to prioritize offender lists based on whether the home address of the offender falls within that distance.

Finally, the results of the multinomial logistic regression offer some interesting insights regarding the relationship of the joint mobility pattern in closed cases and the associated characteristics of victims and events. For example, homicides with female victims who are killed in their own neighborhood are likely part of a *neighborhood* triangle so the offender may live in the same neighborhood. The age of the victim is also an important discriminator. Homicides with victims over the age of 35 are more likely to be *victim* or *offense* mobility triangles. Both of which involve an offender who resides nearby the homicide location. The distance of the victim's home to the location of the homicide can be used determine which type of triangle it is.

In sum, there is a whole host of potential applications for both investigations and problem-oriented policing from data generated to look at the joint mobility patterns of victims and offenders. A companion report goes into those applications and illustrates how the visual display of data can be used to better understand both offender and victim behavior and the role of places (Groff & McEwen, 2005a).

Appendix 1: Computer Programs

As mentioned in Chapter 2, the large number of records involved in this research necessitated automation of two of the most labor-intensive tasks, distance measurement and typology assignment. Three computer programs were created to facilitate the research process. These programs are described here.

The first of the two programs automated the distance measurement between related points. The program is written in Avenue® rather than Visual Basic® because the network analysis extension only is available in Arcview 3.x®[25]. This research required that a measurement be produced for both the street distance and Euclidean distance between addresses in different files that had a common field. While an existing script called pt2pt_distance.ave was available to calculate Euclidean distances, no such script existed for street network distances. The new script capable of providing both Euclidean and street distances is available on the Arcscripts website (http://support.esri.com) under 'Calculate Network and Euclidean Distance'. To use the script just download it from the website and add it into your current Arcview® project. The script has windows that guide you through the process. You must have the network analyst extension to measure street distances.

The second program written for the research can be edited to assign a mobility triangle typology based on either distance or traditional definitions. This program is written in Visual Basic® and is for use with ArcGIS® 9.x products. The program is available from NIJ.

The third program automated the drawing of lines between origin and destination areas to facilitate flow mapping within ArcGIS. The program exists as a .dll file and is available from NIJ. To use the program you must download it to your hard drive and then register the dll. There are several ways to register a dll. Two example methods are provided below:

1. Open two file explorer windows. In the first one browse to c:\windows\system32 and scroll down till you see regsvr32.exe. In the second window open it to where your GenerateLines.dll is located. Drag and drop the generatelines.dll onto regsvr32.dll.

[25] ArcGIS® 9.1 will have a network analyst extension when it is released in summer of 2005.

2. Open a command prompt and cd to the directory that contains the generatelines.dll. At the command prompt type regsvr32 generatelines.dll.

With either method you should get a message that the dll registered successfully.

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