Six-Degrees of Violent Victimization: Social Networks and the Risk of Gunshot Injury

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ABSTRACT

Objectives. This study investigates the relationship between an individual's position in a social network and the probability of being a victim of a fatal or non-fatal gunshot wound.

Methods. This study combines detailed observational data from the police with records of fatal and non-fatal gunshot injuries among 763 individuals in Boston's Cape Verdean community. After creating the social networks of these high-risk individuals, logistic regression is used to uncover the relationship between the odds of being a victim of a gunshot injury and various network characteristics.

Results. The probability of gunshot victimization is directly related to one's network distance to other gunshot victims—i.e., the closer someone is to a gunshot victim, the more likely that person is to also be a gunshot victim. This social distance to gunshot victims operates above and beyond other types of exposure to gun violence. Younger individuals, gang members, and individuals with a high density of gang members in their interpersonal networks are also at increased risk of being a gunshot victim.

Conclusions. Risk of gunshot injuries in urban areas is more greatly concentrated than previously thought. While individual and neighborhood level risk factors contribute to the aggregate rates of violence, this study suggests that most of the actual risk of gun violence is concentrated in a small social network of identifiable individuals.

INTRODUCTION

Gun violence remains a serious public health and safety problem in the United States. In 2009, a total of 9,146 people were murdered with firearms, and it is estimated another 48,158 were treated in hospitals for gunshot wounds received in assaults.[1, 2] Leading social scientific examinations of homicide victimization and offending generally focus on understanding "risk factors" at the *individual-level* (e.g. age, gender, race, and socioeconomic status), at the *situational-level* (e.g. the presence and type of weapon, the presence of drugs or alcohol, and the role of bystanders or third parties during violent events), and at the *community-level* (e.g. residential mobility, population density, and income inequality).[3-8] This research suggests that serious violent victimization and offending is concentrated among young minority males who are engaged in criminal activity, use violent means to settle disputes, have easy access to firearms and other weapons, and reside in socially and economically disadvantaged neighborhoods.[3, 9-12] Furthermore, indirect exposure to gun violence—such as living in a high-violent neighborhood—is also associated with a host of negative health outcomes, including PTSD, depression, psychobiological distress, anxiety, cognitive functioning, and suicide, as well as other negative social behaviors such as school dropout, increased sexual activity, running away from home, and engagement in criminal and deviant behaviors.[13-17]

Although the risk factors approach to gun violence helps describe its distribution across populations, it overlooks the fact that the vast majority of people exposed to such risk factors never become a victim or perpetrator of a violent gun injury. Moreover, a growing amount of empirical evidence suggests exposure to

serious gun violence and risk of violent victimization is highly concentrated in extremely small geographic locations and within highly circumscribed social networks. For example, a recent study in Boston found that from 1980 to 2008 only five percent of city block faces and street corners experienced 74 percent of gun assault incidents.[18] Another Boston study finds that about 50 percent of homicide and nearly 75 percent of gun assaults were driven by less than one percent of the city's youth population (aged 15-24), most of whom were gang-involved and chronic offenders.[19] Yet, how and why gun violence clusters geographically and within specific social networks is not well known. Thus, although a risk factor approach may accurately predict why *certain characteristics* put individuals at greater risk for gunshot victimization, it does not explain why *specific individuals* are involved in a gun-related violence.

This limitation of the risk factor approach to gun violence stems, in part, from the failure to consider—and, more importantly, *measure*—the ways in which an individual's social network might influence his or her risk of gunshot victimization. The fact that more than two-thirds of all homicide victims and offenders know each other[20-22] suggests that the ways in which people are connected is essential to understanding how violence occurs.

To address this shortcoming, the present study analyzes the salience of social networks on differential risks of gunshot injury. Recent studies on the health effects of social networks suggest that the clustering of certain health behaviors—such as obesity, smoking, and depression—is related to contours of one's social network.[23-28] One of the key findings of this research is that health outcomes are related not

only to close friends and family members, but also to one's more distant associates—one's friends' friends and other relations more than a few handshakes away. Given that gun violence is highly concentrated in circumscribed networks, we hypothesize that the structure and composition of an individual's social network will exert an influence on one's exposure to and risk of gunshot injury. More specifically, we hypothesize that one's risk of gunshot injury increases the greater their direct and indirect connections to individuals who have received gunshot injuries.

METHODS

Setting

The present study examines violent victimization among a network of individuals from Boston's Cape Verdean community. Cape Verde is an archipelago of islands located off the West Coast of Africa that was a colony of Portugal until 1975. Cape Verdeans represent a diverse mix of African (especially West African), European (especially Portuguese), and even some Asian peoples. Although the Cape Verdean population in New England dates to the 19th century, Boston's Cape Verdean population has grown steadily since 1965 immigration reform. As of 2000, Boston is home to an estimated 35,000 to 50,000 persons of Cape Verdean descent.[26] Boston's Cape Verdean population is heavily concentrated in two communities—the Bowdoin-Geneva and Upham's Corner neighborhoods—that are associated with many traditional violent crime "risk factors." For example, in the Bowdoin-Geneva neighborhood 20 percent of the population lives below the federal

poverty line (as compared to 12 percent nationally), 52 percent live in a single-family household (as compared to 23 percent nationally), and 42 percent of the population has less than a high-school diploma (as compared to 20 percent nationally).[29]

In terms of levels of gun violence, these two Cape Verdean neighborhoods closely resemble other disadvantaged neighborhoods in Boston that struggle with street gang and violence problems. The Boston Police Department (BPD) estimates that some ten street gangs comprised of approximately 220 members are involved in ongoing violent conflicts that adversely affect the well-being of the Cape Verdean community in Boston. A recent analysis estimated that fatal and non-fatal shootings involving Cape Verdean gang youth more than tripled from 12 shootings in 1999 to 47 shootings in 2005.[30]

Data Collection

Data come from two sources provided by the BPD: Field Intelligence Observation (FIOs) cards and records of fatal and non-fatal gunshot injuries. FIOs are records of non-criminal encounters or observations made by the police; these reports include information such as: reason for the encounter, location, and the names of all individuals involved. Since these data include only social ties observed by the police, the FIO data provide an extremely conservative measure of one's social networks as individuals likely have many more friends and associates whom the police do *not* observe.

FIO data were extracted for all known gang members in the two neighborhoods studied. "Ties" between individuals were derived for all situations in

which two or more individuals were observed in each other's presence by the police. Extant qualitative research in sociology, anthropology, and criminology suggests that "hanging out"—standing on street corners while associating with one's friends—is an important social behavior among young urban males as well as a key mechanism driving street-level violence.[31-34]

To generate the social networks of high risk individuals in the study communities, we employed a two-step respondent driven sampling method frequently used in the study of other high-risk and hidden populations such as drug users and sex workers.[35, 36] The initial sampling seeds consisted of the entire population of Cape Verdean gang members known to the police (N = 238). Step 1 entailed pulling all FIOs in the year 2008 for these 238 individuals to generate a list of their immediate associates. This step was repeated (Step 2) to gather the "friends' friends" of the original seeds to create a final social network of 763 individuals. While this sampling method could be repeated for additional steps, previous research suggests that such a two-step approach adequately captures the vast majority of information necessary to understand the underling social processes.[37, 38]

The FIO data were then merged with data on all known fatal and non-fatal gunshot injuries reported to the police in the city of Boston. This enables us to determine which individuals in our social network were the victims of gunshot violence in the years 2008-2009. Since 2006, Harvard researchers and BPD analysts and gang experts have reviewed every shooting event in the city, categorizing them on the basis of motive and gang involvement. During the study time period, there

were 2 fatal and 38 non-fatal shootings in the final social network of 763 individuals.

Models

We use logistic regression to model the determinates of gunshot victimization in the sample population. Two sets of models are presented. The first set presents the results on the entire population of 763 individuals, while the second set presents the results of a subsample of 579 of the population that comprise a single larger network. To account for temporal ordering, the network variables are constructed using data from 2008 and regressed on the victimization data for 2008-9. Network calculations and visualizations were conducted using the "statnet" software in the statistical package, R.[39] Regression analyses were conducted using Stata 10.[40]

Variables

Table 1 shows the mean, standard deviation, and range for all variables used in our analysis.

Dependent Variable

Our dependent variable is a binary indicator of whether or not an individual was the victim of either a fatal or non-fatal gunshot wound in 2008-9. Approximately 5 percent were victims of fatal or non-fatal gun violence. The current study combines fatal and non-fatal injuries; analysis of only non-fatal shooting found no discernible differences in the results.

Independent Variables

Individual Level Covariates. Our models include several individual-level control variables commonly associated with gun violence: age, gender, race/ethnicity, and whether or not the individual has ever been arrested. *Age* is consistently one of the strongest predictor of violent victimization: rates of homicide victimization peak between 18 and 24, and decline steadily thereafter.[41] We square age (in years) to capture this non-linear relationship. *Gender*, another important covariate in research on crime and violence, is measured as a binary variable (1 = female, 0 = male).[42] The vast majority of network members are male (94 percent). *Ethnicity* is measured as a binary variable indicating whether or not the subject was of Cape Verdean ancestry (1 = yes, 0 = no). Half of the study population is of Cape Verdean decent and the remainder is mainly African-American and Latino. Finally, we include a binary dummy variable to indicate whether or not the subject has at *least one prior arrest* with the Boston Police Department (1 = yes, 0 = no). A full third of the sample has at least one prior arrest.

Network Measures

On average, any individual in the network has ties to approximately three associates, though the standard deviation is equally large. This distribution of ties in the network—presented in Appendix A—is consistent with other research that finds that most individuals in networks have a small number of ties, while a small number of individuals have an exceedingly large number of ties.[25, 43, 44] It is often argued, in fact, that such a distribution of social ties in a network (degree distribution) is a common property of most social networks and foundational to many of the observed effects networks have on behavior.[45] In the present data, however, some

caution is in order as the ties themselves are based on observations made by the police. Thus, the number of ties may be influenced how police go about their duties and investigations.[46] As such, we weight our sample according to the distribution of ties in order to account for any bias attributable to policing efforts (Appendix A).

Four social network measures are included in the analyses: network density, the percentage of associates who are known gang members, the percentage of one's associates who have been gunshot victims, and the average "shortest distance" (geodesic distance) from the subject to another shooting victim.

Network density is a basic property that reflects the overall intensity of the connected actors: the more connected the networks, the greater the density.[47] Most often, dense networks are associated with cohesive subgroupings and cliques.[48] Formally, the density is measured as the sum of ties that are present in the network divided by the possible number of ties.[35] In the present study, we measure the *ego-network density*, or the density of ties in the immediate social network surrounding each individual. Several studies of school-aged youth have found a positive relationship between being in a dense social network with a large number of delinquents and self-reported delinquency.[49-51] We anticipate a similar result.

The percentage of associates who are gang members is measured as the proportion of an individual's immediate associates who are gang members (as identified by the police). This measure extends the prior research on the negative consequences of gang membership[52, 53] by capturing a saturation effect: greater exposure to gang members in one's social network should also increase one's level of risk of gunshot injury.

Exposure to gunshot violence is measured in two ways. First, we measure the effect of exposure to gunshot violence in one's *immediate* social network as the *percentage of an individual's immediate associates who were gunshot victims*. In essence, this variable captures the injury or death of a direct associate, someone whom they were observed associating with in public during the previous year.

We extend this exposure idea to include a measure of *indirect exposure* to gunshot victims, measured as the *average number of shortest paths* (geodesic distance) from the subject and all gunshot victims in the social network.[47] In large social networks, individuals can be connected indirectly in many different ways. The geodesic distance refers to the shortest path (the number of handshakes) between any two actors in a network. To create this measure, we calculated all possible paths between all pairs of connected individuals and then computed the shortest paths between each subject and all of the gunshot victims in the social network. To simplify, a geodesic of 1 means that the subject has an immediate friend who has been shot, a geodesic of 2 means that the subject has a friend-of-a-friend who has been shot, and so forth. Research demonstrates that a wide variety of health and social behaviors are affected by people in the our social networks who are a few handshakes removed.[23, 54]

RESULTS

The network of 763 individuals generated from the respondent driven sampling method is presented in Figure 1. Each of the nodes represents a unique individual and each of the ties linking two nodes indicates at least one observation

of two individuals observed socializing together. A total of 1,869 ties were extracted from the FIOs. Gunshot victims are represented as the larger red nodes in the network.

Two important characteristics of this network are worth noting. First, although Figure 1 is comprised of 57 unique subnetworks (components), 76 percent of individuals are connected in the single large network consisting of 579 individuals (large component). The presence of a single large component is quite common in studies of other social networks, suggesting that our method of reconstructing this social network offers an accurate—albeit, conservative—representation of social patterns found in other types of friendship networks.[25, 55] Second, visual inspection of the network clearly shows the clustering of gunshot victims. And, as might be expected, 85 percent of the shooting victims are found in this large component indicating that those in the largest component have the greatest exposure to gun violence. The average geodesic distance between any individual in the network and a gunshot victim is 4.7. Thus, on average, individuals in this network are less than 'six-degrees' removed from a gunshot victim.

Predicting Gunshot Victimization

Table 2 shows the Odds Ratios and 95% Confidence Intervals for models that regressed gunshot victimization on the full set of explanatory variables on both the entire network and the largest component. Examination of the individual-level predictors for both models show that, consistent with prior research, the odds of being a gunshot victim decreases with age and increases with prior contact with the criminal justice system. As expected, females in the network are considerably less

likely to be gunshot victims. Those of Cape Verdean decent are more likely to be gunshot victims, although this variable does not quite attain statistical significance in either model.

Contrary to some (but not all) previous research,[49, 54] ego-network density in both models is *negatively* related to gunshot victimization suggesting that density may, in fact, be protective of victimization; the p-value of this variable, however, suggests that this effect is not significantly different than zero. When considering only the complete network, the saturation of gang members substantially increases one's odds of being shot (OR = 1.65), although the statistical significance of this effect drops when considering only the large component (OR = 1.39).

The two variables of network exposure to gunshot injuries also differ slightly when considering the whole network as compared to only the large component. In the complete network model, the percentage of immediate alters who have been shot greatly increases one's odds of also being a gunshot victim (OR = 2.49): a one percent increase in the number of one's friends who are gunshot victims increases one's own odds of victimization by approximately 149 percent. Thus, it appears that having one's immediate associates getting shot does indeed increase one's own risk of gun victimization. However, this effect diminishes in the model for only the large network (OR = 1.38) and loses its statistical significance (p-value = 0.481). In part, this loss of statistical significance highlights the fact that individuals who are in the smaller disconnected network (i.e., not members of the larger component) have fewer potential avenues of indirect exposure and, therefore, might only experience exposure through an immediate social tie.

Both models in Table 2 support our main hypothesis that social distance is related to gun victimization: *the closer one is to a gunshot victim, the greater the probability of one's own victimization* net of individual and other network characteristics. In the whole network model, every one network connection away from a shooting victim decreases the odds of getting shot by 8.8 percent (OR = 0.912). In the large component, the effect is even greater: every one network connection removed from a gunshot victim decreasing one's odds of getting shot by approximately 25 percent (OR = 0.754). This relationship between distance to a shooting victim and probability of gunshot victimization is summarized in Figure 2, where the x-axis indicates the average distance to a shooting victim and the y-axis indicates the predicted probability of gunshot injury from the complete network model in Table 2. Of note, the effects of social distance to a shooting on probability of being shot begins to level off after approximately five steps removed.

CONCLUSIONS

Our data on the Cape Verdean population in two Boston neighborhoods reveals a social network of young men with a highly elevated risk of gunshot victimizations. Descriptive network analysis shows the existence of a social network consisting of 763 individuals, the majority of whom are all connected in a single large network. On average, individuals in this network are less than five handshakes away from the victim of a gun homicide or non-fatal shooting. Our findings demonstrate that the effect of this distance to a shooting victim greatly increases an individual's own odds of becoming a subsequent gunshot victim. The closer one is to

a gunshot victim, the greater the probability that person will be shot. Indeed, each network step away from a gunshot victim increases one's odds of getting shot by approximately 25 percent. This suggests that like other health and social outcomes, *indirect exposure* to gun violence can have significant effects on one's health.

The findings of this study are limited in three ways. First, while the RDS sampling method has performed well in other high-risk samples, it clearly does not identify *all* individuals at risk of gunshot victimization. For instance, situations not visible to police investigation—such as unreported domestic violence incidents—would not be captured in our data. Second, the use of FIO data circumscribes our measurement of social networks to those ties witnessed firsthand by police and, therefore, we most likely underestimate the scope and extent of individuals' social networks. Third, our findings may also be confined to the unique character of Boston's Cape Verdean neighborhoods. However, these communities share many similarities with other high-crime and socially disadvantaged urban neighborhoods and recent research suggests that the network patterns described here extend to gang-level violence in Boston and Chicago.[56, 57]

These limitations not withstanding, these results imply that the risk of gunshot injuries in urban areas is more greatly concentrated than previously thought. While research continues to document the high levels of geographic and social concentration of crime,[17-21] our findings suggest that research must also consider how the *ways* in which people are connected to affects violent victimization. Risk factors and direct exposure to violence, while important, are not enough. The contours of our social networks—even when we cannot see them—

affects our behavior.[55] Furthermore, our findings suggest that the risk of gunshot victimization is not evenly distributed within high-risk populations. In the present study, those individuals who live within the largest social network, for instance, are at a much greater risk of gunshot victimization than either those in the smaller disconnected networks or the general neighborhood population. How and why such networks affect the ways in which we assess the real risk of gunshot injury is vital importance for future research.

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TABLE 1 – Descriptive Statistics and Univariate Statistics for Each Variable used in Descriptive and Regression Analyses

	Mean (SD)	Range (Minimum, Maximum)
Dependent Variable		
Fatal or non-fatal gunshot victim	0.05 (0.22)	0 = No, 1 = Yes
Indepdent Variables		
Degree: Number of Observed Ties	2.89 (3.22)	0, 24
Age: Age in years	24.87 (6.33)	15, 53
Gender: Whether or not the individual is female (as compared to male)	0.06 (0.24)	0 = Male, 1 = Female
Cape Verdean: Whether or not the individual is of Cape Verde decent (as compared to all other races and ethnicities)	0.50 (0.50)	0 = No, 1 = Yes
Prior Arrest: Whether or not individual has at least one prior arrest	0.31 (0.46)	0 = No, 1 = Yes
Ego-Network Density: Percentage of all network ties that are present as a proportion of all possible ties.	0.23 (0.37)	0, 1
Gang Member: Individual is identified by police as a gang member.	0.311 (0.46)	0 = No, 1 = Yes
Percent of Gang Members in Network: Percent of Alters who are gang members as identified by police	0.45 (0.41)	0, 1
Percent of Network Containing Shooting Victim: The percentage of individuals immediate social network that contains shooting victims	0.08 (0.21)	0, 1
Distance to Shooting/Homicide Victim: the average shortest distance between an indiviual and a shooting/homicide victim	4.69 (2.91)	0, 10.74

TABLE 2 – Logistic Regression of Shooting/Homicide Victimization on Individual and Network Characteristics

	Probability of Gunshot Victimization Among in Boston, OR (95% CI)				
	Complete Network (N = 763)			Largest Component (N = 579)	
	OR (95% CI)	**P>|z|**		**OR (95% CI)**	**P>|z|**
Individual Level Variables					
Age^2	**0.998 (0.997, 0.998)**	**0.000**		**0.998 (0.997, 0.999)**	**0.000**
Gender	0.793 (0.278, 2.25)	0.664		1.21 (0.416, 3.56)	0.719
Cape Verdean	1.31 (0.882, 1.96)	0.177		1.04 (0.641, 1.67)	0.871
Ever Been Arrested	**1.87 (1.32, 2.65)**	**0.000**		**1.89 (1.30, 2.74)**	**0.001**
Network Variables					
Ego-Network Density	0.897 (0.499, 1.61)	0.715		0.646 (0.323, 1.29)	0.217
Percent of Gang Members in Network	**1.65 (0.991, 2.77)**	**0.054**		1.39 (0.765, 2.54)	0.276
Distnace to Shooting/Homicide Victim	**0.912 (0.884, 0.986)**	**0.020**		**0.754 (0.654, 0.869)**	**0.000**
Perent of Immediate Alters Who Have been Shot	**2.49 (1.13, 5.51)**	**0.024**		1.38 (0.557, 3.46)	0.481
Log Likelihood		-696.78			-639.76
LR Chi-Squared		98.6			105.63

FIGURE 1 – The Social Network of Cape Verdean Youth in Boston, 2008

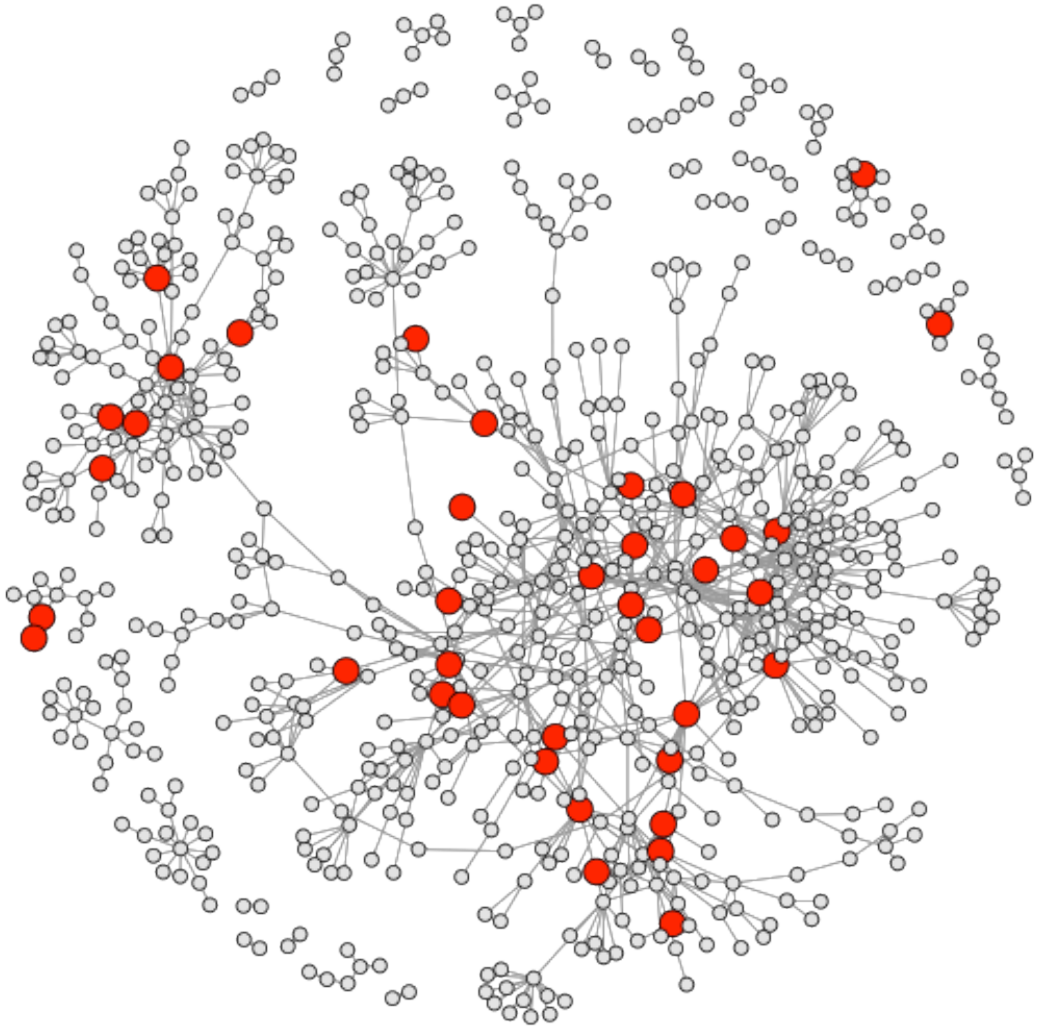
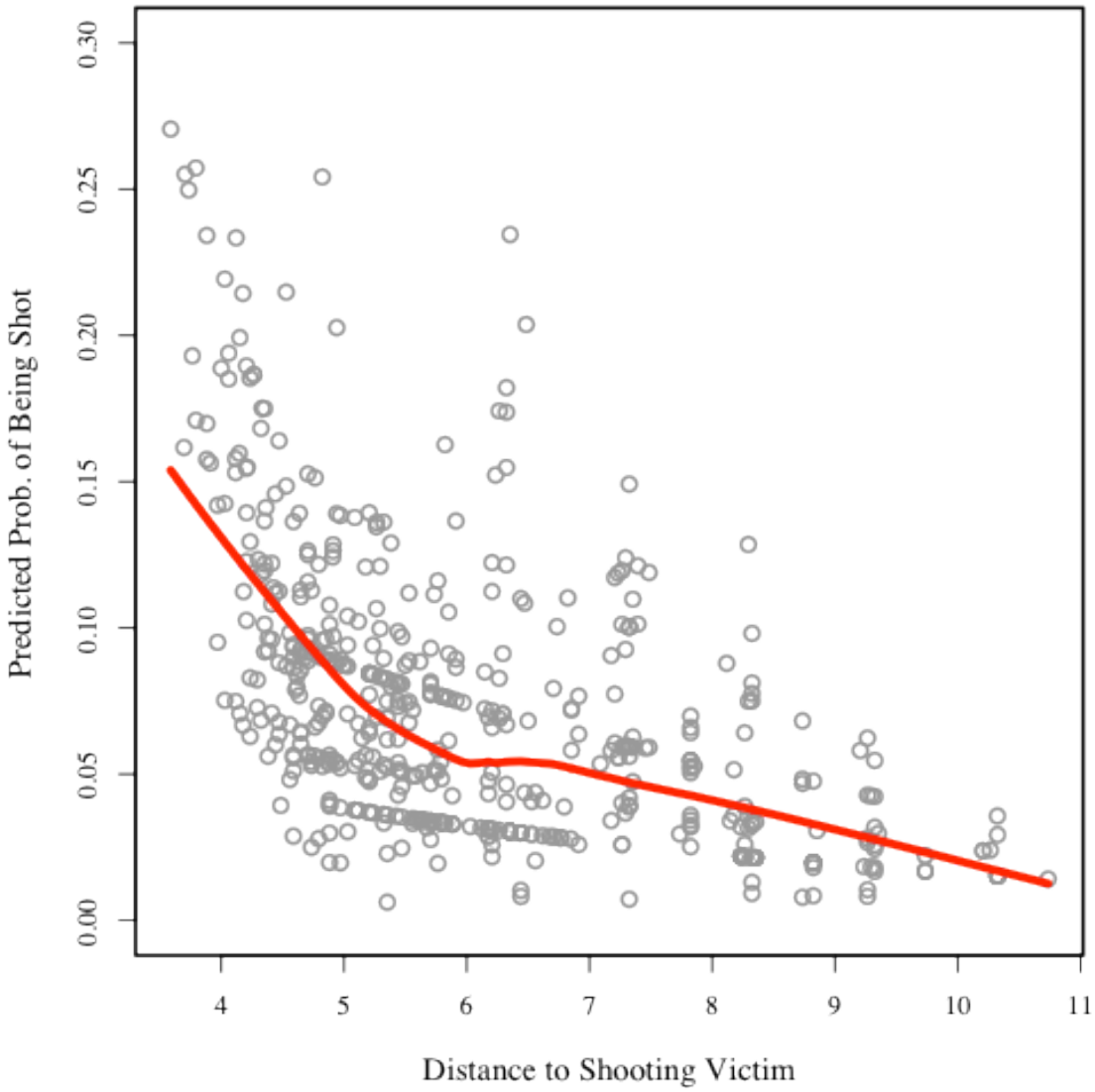


FIGURE 2 – The Relationship between the Predicted Probability of Being a Shooting/Homicide Victim and Distance to another Shooting/Homicide Victim



APPENDIX A – The Distribution of the Number of Network Ties