Network Exposure and Homicide Victimization in an African American Community

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Objectives. We estimated the association of an individual's exposure to homicide in a social network and the risk of individual homicide victimization across a high-crime African American community.

Methods. Combining 5 years of homicide and police records, we analyzed a network of 3718 high-risk individuals that was created by instances of co-offending. We used logistic regression to model the odds of being a gunshot homicide victim by individual characteristics, network position, and indirect exposure to homicide.

Results. Forty-one percent of all gun homicides occurred within a network component containing less than 4% of the neighborhood's population. Network-level indicators reduced the association between individual risk factors and homicide victimization and improved the overall prediction of individual victimization. Network exposure to homicide was strongly associated with victimization: the closer one is to a homicide victim, the greater the risk of victimization. Regression models show that exposure diminished with social distance: each social tie removed from a homicide victim decreased one's odds of being a homicide victim by 57%.

Conclusions. Risk of homicide in urban areas is even more highly concentrated than previously thought. We found that most of the risk of gun violence was concentrated in networks of identifiable individuals. Understanding these networks may improve prediction of individual homicide victimization within disadvantaged communities. (*Am J Public Health.* Published online ahead of print November 14, 2013: e1–e8. doi:10.2105/AJPH.2013.301441)

More than 10 000 people are killed by firearms each year, and another 40 000 are hospitalized or treated for gunshot injuries.[1] Homicide victimization, however, is not evenly distributed across populations or places. Young people are more likely to be murdered than the elderly, African Americans are more likely to be murdered than whites, men are more likely to be murdered than women, gang members are more likely to be murdered than non-gang members, and individuals living in socially and economically disadvantaged neighborhoods are more likely to be murdered than individuals living in more advantaged neighborhoods.[2–7]

Yet, despite decades of research into why certain characteristics and behaviors place individuals at greater risk for homicide, the social and health sciences have not fared as well in explaining why specific individuals within high-risk populations become victims of homicide. Although we know that risk factors such as age, race, gender, gang membership, and living in a poor neighborhood increase one's risk of being a homicide victim, we cannot explain why a specific young African American male gang member in a high crime neighborhood becomes a murder victim while another young man with the identical risk factors does not. In this article, we argue that one's position in a distinctive type of risky social network—a co-offending network—and exposure to violence in that network is essential to understanding individual victimization within high-risk populations.

Understanding the topographies of risky networks and individuals' placement within them illuminates analyses of violent victimization in at least 2 important ways. First, a network approach can offer new insight into the uneven distribution of homicide within high-risk communities. Like other social and health behaviors,[8–12] homicides cluster within networks.[13] Additionally, such networks tend to be fairly homogenous with respect to traditional individual-level risk factors. For example, a recent study of a high-crime community in Boston found that 85% of all gunshot injuries occurred entirely within a network of 763 young minority men (<2% of the community population), a third of whom were gang members and a third of whom had previous police contact.[13] In much the same way, geographic exposure to neighborhood violence is associated with a range of negative outcomes such as posttraumatic stress disorder, depression, and decreased cognitive functioning.[14–18] But, like other risk factors, the spatial exposure to homicide in many high crime communities might be quite uniform. In the present study, for example, 40% of the individuals in the sample lived within 350 feet from where a homicide occurred, and 75% lived within roughly 1 city block (690 feet) from where a homicide occurred (see supplemental material, available as a supplement to the online version of this article at http://www.ajph.org). A network approach suggests that victimization is not simply a function of spatial proximity or of individual risk factors such as age, race, gender, or gang affiliation, but also of how people are connected, the structure of the overall network, the types of behaviors occurring in the network, and an individual's position in the overall structure.

Second, social network analysis extends the analysis of violent victimization by providing a means to quantify and measure more precisely the behaviors that are the proximate determinants of homicidal encounters. In most instances, risk factors act as proxies for more dynamic processes, situational dynamics, and risky behaviors. For example, gang membership—typically treated as a binary indicator where one is or is not a gang member—is frequently shown to increase one's odds of being a victim or perpetrator of a violent crime.[3,7,19,20] Yet, qualitative and ethnographic work demonstrates that gang participation is fluid and often changes within the situational contexts of particular interactions.[21–23] The true effect of being a gang member is not about a binary label, but about whom one hangs around with, the structure of the network, and group processes within the gang. Network analysis can directly model such processes and structures.

The present study investigates how exposure to homicide in one's network contributes to one's own probability of victimization. Rather than rely only on risk factors, this study directly measures the contours of a risky network in a high-crime African American community in Chicago, Illinois. The focus is on social distance to a victim—how many handshakes removed one is from a homicide victim in their network. Our hypothesis is that there is a strong association between one's own risky behaviors (in this study, co-offending arrest) and the risky behavior of one's associates. The stronger that association—the socially closer one is to a homicide victim—the greater the influence on one's own victimization. In this sense, homicide is socially contagious, and associating with people engaged in risky behaviors—like carrying a firearm and engaging in criminal activities —increases the probability of victimization. Like needle sharing or unprotected sex in the spread of HIV,[24–26] co-offending exposes an individual to situations, behaviors, and people that elevate the probability of homicide victimization. Although we are unable to ascertain the precise mechanisms of transmission in the case of homicide, we maintain that such transmission is heightened as individuals engage in risky behaviors such as, in this case, co-offending.

METHODS

We examined individual homicide victimization within a high-risk network of co-offending in a high-crime African American community in Chicago between 2006 and 2011. Data were derived from 2 sources provided by the Chicago Police Department: (1) homicide records containing detailed information on the incident and participants and (2) records of all arrests among residents in the community during the observation period. Homicide data were used to determine our dependent variable, whether an individual was shot and killed (1 = yes, 0 = no). Arrest records, as we describe in "Co-offending Networks," were used to determine the networks created by patterns of co-offending.

The Study Community and Population

The study community consisted of approximately 82 000 residents living within a 6-square mile area. By nearly all socioeconomic indictors, the community displayed a severe concentration of homicide risk factors: the population was 92% African American, 33% of all households lived below the poverty line, 52% of all households were headed by a single female, and 43% of the population had less than a high school education.[27] It is not surprising, therefore, that the study community also had some of the highest rates of homicide in the city. The yearly homicide rate between 2006 and 2011 was, on average, 55.2 per 100 000, roughly 4 times higher than the average of all other areas of the city (14.7 per 100 000). During the study period, 307 homicides occurred in the study area, of which 81% (n = 249) involved a firearm.

An examination of homicide data revealed that, within the study community, homicide was highly concentrated within the population of criminal offenders; a finding consistent with previous cross-sectional and cohort studies that demonstrate the overlap between victims and offenders of violent crime.[7,13,28–32] In other words, our data indicate that both the perpetrators and victims of homicide during our study period can be situated within the population of individuals arrested during that same interval. Indeed, 85% of all gunshot homicide victims in the community had at least 1 previous arrest, and 42% of all homicide victims during the observation period were arrested at least once in the 5 years before their victimization. This pattern suggests that risk of homicide victimization is most highly concentrated within the offending population of the community, and, conversely, that those in the non-offending population are at a lower risk. Therefore, focusing the analysis on individuals with a criminal record yields an extremely high proportion of the population at risk for homicide victimization.

As such, the sample for the present analysis was restricted to any individual who lived in the community and was arrested between the years 2006 to 2011. This was done for 2 reasons. First, as just described, doing so captures a high proportion of homicide victims in the community—81%. Second, and perhaps more importantly, investigating criminal histories and arrest records offers an inroad into a set of behaviors that can be used to recreate the risky networks underlying patterns of homicide. That is, rather than simply treating previous arrest as a risk factor itself, this study explored how previous patterns of arrest generate a network conducive for the spread of homicide.

Co-offending Networks

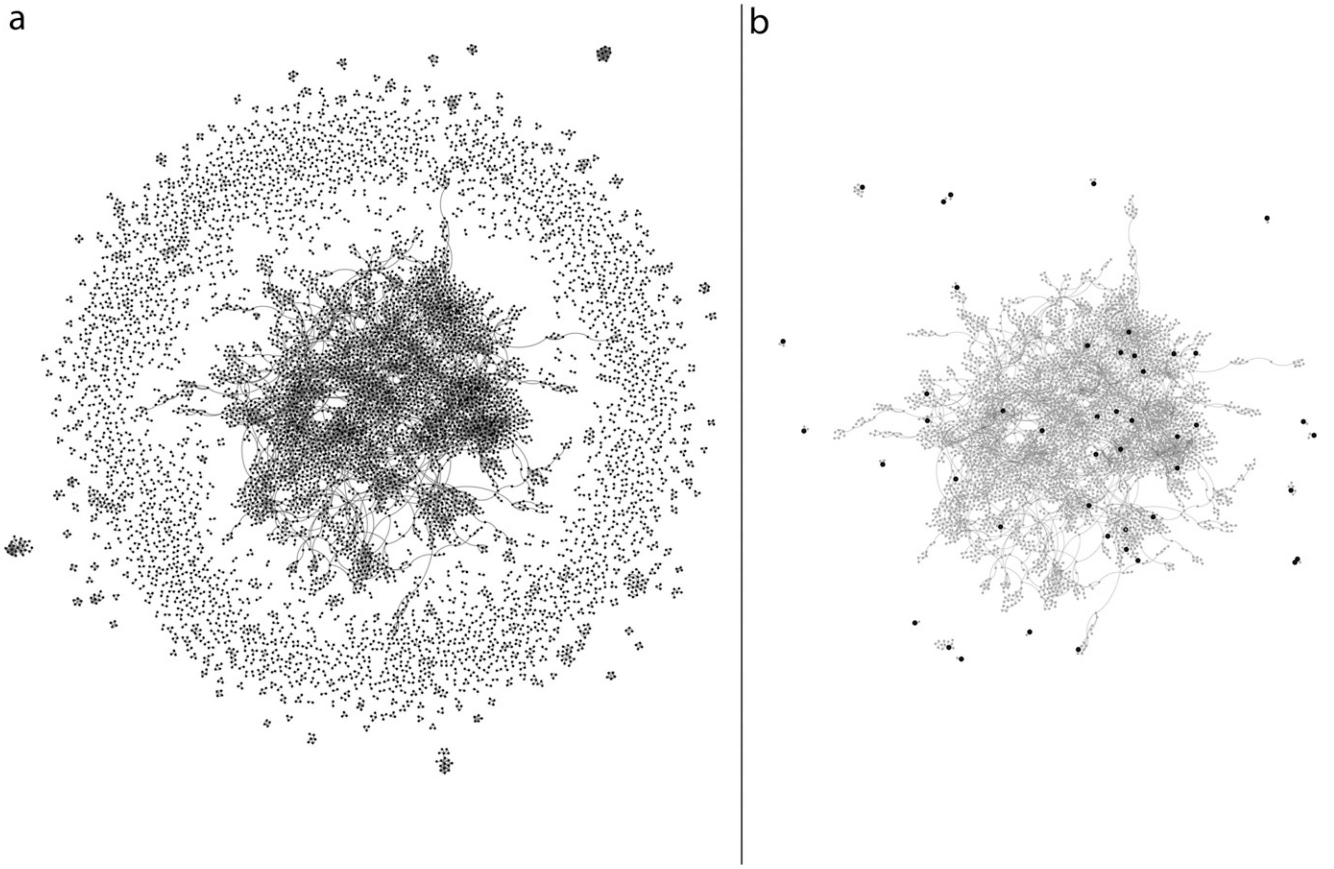
To establish these networks, we examined patterns of co-offending—instances in which 2 or more people were arrested together for the same crime.[33–35] Approximately 53% of the co-arrests in our data involved 2 people, and the remaining 47% involved groups of 3 or more. Fewer than 4% of all of these ties represented repeat offenses between the same 2 individuals. The underlying assumptions are that people who are arrested together (1) know each other and (2) engage in risky behaviors together, in this case, illegal behavior. Akin to network studies of other risky behavior such as intravenous drug use and unprotected sex,[24,25] creating social ties in this way focuses on the network formed by types of behavior that increase one's risk of exposure. Given the overlap between victim and offender populations more generally,[7,13,28–32] our construction of co-offending networks further captured exposure to potential perpetrators of violence (although our data did not allow us to identify them) as well as the events (arrests) indicative of risky behavior. Our construction of co-offending networks in this way was quite conservative, recognizing the fact that only a small portion of all crimes are detected by the police and an even smaller portion lead to an arrest.

The resulting co-offending network contained 24 110 unique individuals—roughly 30% of the community's total population. That is, almost one third of the community's total population was arrested during the 5-year study period. These profoundly high arrest rates are consistent with the spatial concentration of incarceration in Chicago—and urban centers in the United States more broadly.[36] Of the 24 110 individuals arrested in this community, 34% (n = 8222) had a co-offending tie to at least 1 other person. This network was overwhelmingly young, African American, and male: 98% were African American, 89% were male, and the average age was 27.4 years (SD = 9.68 years). Police identified approximately 35% of the sample as being members of street gangs.

Figure 1 displays the co-offending network where each of the nodes represents a unique individual and each of the ties represents a unique co-offending dyad. Figure 1a shows the entire observed network, and Figure 1b depicts the sample used in our regression analyses. The ties among this population created 1732 unique components that ranged in size from 2 individuals to 3601 individuals.

The victims in 41% (n = 103) of all gun homicides in the study community were located in this co-offending network. However, in the entire network, homicides were even further concentrated, occurring in only 75 of the 1732 components in the co-offending network, which contain only 3718 of the 82 000 individuals living in the community. In other words, 41% of all gun homicides occurred in a network component consisting of approximately 4% of the population of the community. Even by itself, this concentration of homicides redefines the notion of individual victimization in this community. If one considers the population of the community that was not arrested during the study period, the 5-year homicide rate drops from 55.2 to 39.7 (per 100 000)—roughly one third lower than the estimate including the offender population but still higher than the city average. Simply being arrested during this period increases the aggregate homicide rate by nearly 50%, but being in a network component with a homicide victim increases the homicide rate by a staggering 900% (from 55.2 to 554.1).

In the ensuing analyses, we restricted our sample to only those components of the co-offending network that experienced at least 1 homicide during the observation period. This can be seen in Figure 1b where homicide victims are represented by the larger darker nodes. The distribution of ties in the network is highly skewed, indicating that the majority of individuals had a small number of ties and a handful of individuals had a large number of ties (see supplemental material). On average,



Note. The total sample includes all individuals involved in an incident of coarrest from 2006–2011. The analytic sample includes all components from the total network that contain at least 1 homicide victim. Darker and larger nodes represent homicide victims.

FIGURE 1—Co-offending network in an African American community for (a) the total sample and (b) the analytic sample: Chicago, IL, 2006–2011.

TABLE 1—Sample Characteristics and Descriptive Statistics of Variables Used in Analytic Sample and Regression Analyses of an African American Community: Chicago, IL, 2006–2011.

Characteristics	Mean (SD)	Range
Individual		
Age: age in y	27.42 (9.68)	13–71
Race: whether individual is African American	0.987 (0.111)	1 = African American, 0 = non–African American
Gender: whether individual is male	0.892 (0.301)	1 = male, 0 = female
Gang member: whether individual is identified by the police as a gang member	0.347 (0.472)	1 = yes, 0 = no
Network		
Degree: total no. of co-offending ties an individual has in the network	2.291 (2.063)	1–20
Ego-density: percentage of an individual's network associates who are also tied to each other	0.352 (0.400)	0–1
Geodesic distance to victim: the mean shortest distance between an individual and all homicide victims in the network	5.400 (2.518)	1–16
Geographic distance to victim: shortest spatial distance to a homicide victim in ft	153.00 (112.078)	0.415–2067
Member of largest network: whether an individual is part of the largest co-offending network	0.968 (0.174)	1 = yes, 0 = no

an individual had 2.29 ties to other individuals in the network (SD = 2.06), ranging from a minimum of 1 (because our sample required at least 1 coarrest) to a maximum of 20. Furthermore, Figure 1b shows that homicides tended to cluster even further within this high-risk network. Notice, for example, how homicide victims clustered in particular segments of the network and in many cases multiple victims were but a few ties away from each other (see also supplemental material). Conversely, there were large segments of the network without a single homicide victim.

Modeling Strategy

The present analysis employed logistic regression models to predict whether an individual is the victim of a gun homicide (1 = yes, 0 = no), although we refer the reader to the supplemental material for further discussion of alternative modeling strategies that also have great potential in this and related instances. All models include controls for traditional risk factors including: age (in years), age-squared, whether an individual was African American (1 = yes, 0 = no), whether an individual was male (1 = yes, 0 = no), and whether the individual was identified by the police as being a member of a street gang (1 = yes, 0 = no; Table 1). We also explored alternative modeling strategies, in particular a 2-stage network autocorrelation model, which produced similar results; unfortunately, such models are generally not well suited for binary outcomes (see supplemental material).

Social Distance to a Homicide Victim

Our objective was to assess the association between an individual's probability of victimization and exposure to homicide within the co-offending network. Although we cannot adjudicate the mechanisms with the available data, we contend that the risky behaviors leading to an arrest increase one's exposure to individuals, situations, and behaviors conducive to gun violence. We hypothesize that greater exposure to homicide victims in one's social network increases one's own probability of victimization. Similar to previous network research, we conceive of this as social distance[8,9,11] (i.e., how many steps removed one is from a homicide victim). Formally, we measured social distance as the mean geodesic distance between each individual and all gun homicide victims in the network. The geodesic distance refers to the shortest path between 2 nodes, n_i and n_j, where the distance is simply $d(i, j)$.[37] The shortest distance is the smallest value of $d(i, j)$. A geodesic of 1 means that the closest homicide victim was an immediate associate, a geodesic of 2 means the closest homicide victim was an associate's associate, and so on. On average, any individual in the network was 5.4 ties away from a homicide victim, ranging from 1 tie away to 16 ties away.

Furthermore, people can be indirectly connected to multiple victims (i.e., any individual might be a few ties away from multiple homicide victims, each of whom may affect an individual's probability of victimization). We therefore measured the mean geodesic of all geodesics to all homicide victims, allowing us to capture all indirect avenues of exposure. The average shortest path of all possible shortest paths was 10.53 (SD = 2.591). Distance measures were calculated separately for disconnected parts of the network (see supplemental material).

Covariates

Regression models also considered network properties in addition to social distance that might affect individual victimization. These variables included: (1) network degree, the total number of co-offending ties; (2) ego-density, the proportion of all of an individual's associates who were also tied to each other; and (3) whether an individual was part of the largest component (1 = yes, 0 = no; see supplemental material).

Finally, models included a measure of geographic distance (in feet) of an individual to the nearest homicide victim. We considered this measure for 2 reasons: (1) to assess the direct effects of spatial proximity to a homicide victim and (2) to control for our measure of social distance that might be confounded with spatial distance (i.e., people are socially closer to those who are geographically closer). Homicides were geographically located in nearly every part of the study community (see supplemental material), which made the spatial distance from any individual victim quite small. On average, an individual in the network lived approximately 501 feet from the location of a homicide, with 75% of the sample living within 632 feet from a fallen victim (< 1 city block). Put another way, nearly all individuals in the sample lived within

TABLE 2—Logistic Regression of Gun Homicide Victimization on Individual and Network Characteristics in an Analytic Sample From an African American Community: Chicago, IL, 2006–2011.

Variables	Model 1 (Individual), OR (95% CI)	Model 2 (Individual + Network), OR (95% CI)	Model 3 (Individual + Network + Neighborhood), OR (95% CI)
Individual			
Age	1.430*** (1.230, 1.693)	1.097 (0.897, 1.365)	1.095 (0.915, 1.312)
Age^2	0.995*** (0.993, 0.997)	0.999 (0.995, 1.001)	0.998 (0.996, 1.001)
Race	0.305* (0.117, 1.043)	1.120 (0.191, 7.228)	1.445 (0.335, 6.225)
Gender	5.974* (1.850, 36.608)	6.643* (1.570, 48.036)	6.166*** (2.016, 18.581)
Gang member	1.211 (0.806, 1.805)	1.501 (0.800, 2.825)	1.532 (0.834, 2.813)
Network variables			
Degree		0.595*** (0.456, 0.745)	0.600*** (0.453, 0.795)
Density		0.709 (0.286, 1.630)	0.632 (0.249, 1.602)
Member of largest network		31.338* (2.015, 608.945)	35.608*** (0.575, 2203.845)
Geographic distance to victim (min)		0.997 (0.9988, 1.0004)	0.999 (0.998, 1.000)
Geodesic distance to victim (mean)		0.430*** (0.314, 0.572)	0.415*** (0.268, 0.645)
AIC	909.52	415.08	439.03
No.	3718	3718	3704

*$P < .05$; ***$P < .001$.

a single city-block of where a homicide occurred during the study period.

RESULTS

Table 2 reports the results from 3 logistic regression models: an individual-level risk factors model (model 1), a model including network-level variables (model 2), and a model including neighborhood-level fixed effects (model 3).

Model 1 confirms previous research on risk factors. The age and gender terms indicate that younger people and men were significantly more likely to be murdered than older people and women. The odds ratio on the race variable suggests that African Americans had 70% lower odds of being homicide victims than non-African Americans (OR = 0.305). However, as virtually the entire sample was African American, it is more accurate to state the risk was higher for those small numbers of non-African Americans in this predominately African American network. The gang member variable, although positive, did not achieve statistical significance ($P = .191$). Thus, within this network, being identified by the police as a gang member did not significantly increase the risk of victimization. This finding runs counter to some past research, especially on self-reported gang membership,[3] and may be an artifact of underestimation of gang membership by police.

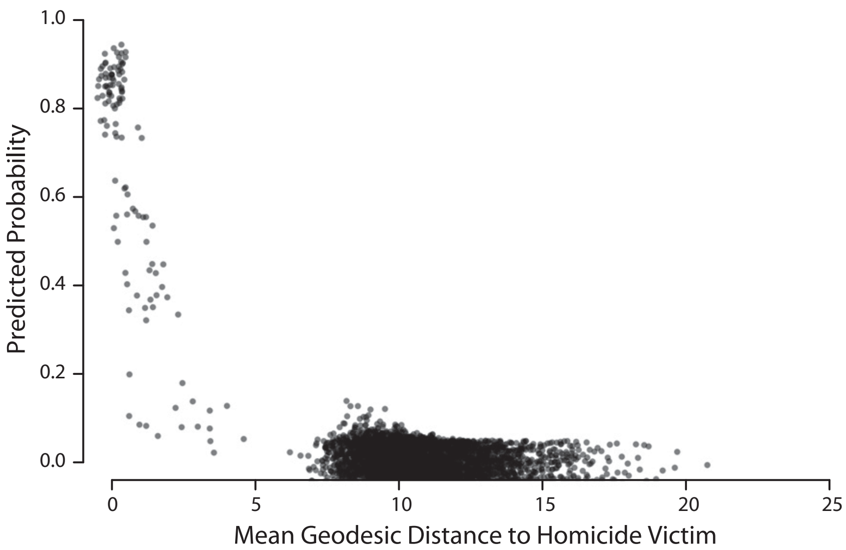
Model 2 adds the network variables. Doing so (1) reduces the statistical significance of all of the individual level variables except gender and (2) improves the overall model fit (AIC decreases from 909.52 to 425.08). This suggests, as we maintain, that many of the effects associated with individual risk factors might be acting as proxies for more dynamic social processes. Thus, considering properties of the co-offending network greatly increases the accuracy of individual victimization models beyond what the traditional risk factors model can do.

Three of the network-level variables attained significance in model 2: (1) degree centrality, (2) largest component membership, and (3) mean geodesic distance to homicide victims. Although one might expect being involved with a greater number of co-offenders to increase one's probability of victimization, the observed effect of degree decreased one's probability of victimization (OR = 0.595). However, because ties were co-offending arrests, it is safe to assume that those with a greater number of arrests with co-offenders most likely experienced incarceration during the observation period. Incarceration removes individuals from these risky networks, if only temporarily, and thereby reduces the risk of homicide victimization on the street. Such an interpretation is consistent with research that finds incarceration is associated with significant declines in the risk of mortality that are especially profound for African American men.[38–40]

Although having more network ties was protective, being a member of the largest component of the network was associated with a 3080% increase in the odds of being a homicide victim (OR = 31.338), a tremendously large (although expected) effect because the majority of the observed homicides occur in this single component.

Consistent with our hypothesis, the social distance measure was negatively associated with victimization: the further one is from a homicide victim, the lower the risk of victimization. Each social tie removed from a homicide victim decreased one's odds of being a homicide victim by 57% (OR = 0.430). Conversely, the closer one is to a homicide victim, the greater the risk of victimization. Figure 2 highlights this point by plotting the predicted probabilities from model 2 against the mean geodesic distance to a homicide victim. This finding suggests that the effect is more pronounced the closer one is to a victim and diminishes quickly beyond 4 or 5 ties away from a victim.

Two of the network terms in model 2 did not obtain statistical significance: ego-density (OR = 0.709) and geographic distance to a shooting victim (OR = 0.999). Of particular interest is the geographic distance measure. Although previous research suggests that geographic exposure to homicide is associated with a host of negative outcomes,[14,15] our models suggest this effect does not extend to the victimization of offenders in the observed network. This might be because of the fact that, as described earlier, virtually everyone in this sample lived within a close distance to



Note. The geodesic distance refers to the shortest path between 2 nodes, n_i and n_j, where the distance is simply $d(i, j)$.[37]

FIGURE 2—Predicted Probability of Homicide Victimization in an African American Community and Mean Geodesic Distance to a Homicide Victim: Chicago, IL, 2006–2011.

a homicide victim (see supplemental material), or it might be because these previous studies did not include measures for social distance. Additional models discerned no interaction between the geographic distance and social distance (see supplemental material), and the correlation was low ($r = 0.006$).

Finally, model 3 adds neighborhood fixed effects to assess how robust the individual and network-level parameters are to unobserved variation in neighborhood structural conditions. Following recent research on Chicago neighborhoods,[41,42] we geocoded the residence of each individual in the sample to 1 of 20 neighborhood clusters within the study community (see supplemental material). Six out of the nineteen dummy variables (with 1 neighborhood used as a reference) in model 3 were statistically significant (ORs ranged from 4.69 to 9.40) indicating the presence of unmeasured neighborhood conditions that contribute to homicide victimization beyond our other parameters (full models presented in the supplemental material). These statistically significant neighborhoods were, not surprisingly, those with the highest total counts of homicide. However, and in support of our main hypothesis, controlling for neighborhood fixed effects did not change the overall magnitude, direction, or significance of the network parameters, suggesting that the findings are robust to neighborhood variation. Future research would do well to investigate the relationship between co-offending networks and neighborhood conditions in further detail.

DISCUSSION

Taken together, these results demonstrate the importance of social networks, defined here as co-offending networks, in shaping homicide victimization. This pattern is consistent with the literature on social network effects on health behaviors,[8,10,12,24,25] and social contagion more generally,[43–45] which demonstrates how the contours and composition of individuals' networks influence behaviors, opinions, and attitudes. The present study provides evidence that patterns of individual homicide victimization are influenced by social proximity to homicide victims. An individual who associates with or is in close social proximity to other homicide victims exists (and acts) in a social world where risky people, situations, and behaviors are present. Furthermore, the results demonstrate that social networks exert an important indirect effect (i.e., one's homicide victimization is influenced not only by one's friends but also by one's friends' friends). The effect of social distance is pronounced with each handshake removed from a victim being associated with a 57% decrease in the odds of victimization. Similar diminishing effects of social distance are found in relation to other health behaviors.[8,9]

This study is not without limitations, however. First, although our findings demonstrate the importance of networks for homicide victimization, we are unable to differentiate selection into high-risk networks from a direct causal effect of being in a high-risk network. That our sample was quite homogenous on individual and geographic risk factors lends some support to a process greater than selection, but the present study can provide only indirect evidence to support a causal interpretation.

Second, although our findings suggest that a contagion process is at work, further research is needed to specify the actual contagion mechanisms. In particular, attention should be directed toward the types of interactions, behaviors, and situations within these networks that lead to victimization.[46–48]

Third, these networks were constructed using a specific behavior, co-offending.[33–35] To date, most research on networks and health focus on either social networks (e.g., friendship or kinship) or behavior networks (e.g., needle-sharing or sexual relations). Though co-offending is technically an example of the latter, crime itself is typically a social phenomenon,[49] and violence is most likely to occur between people who know each other before the event.[32] Furthermore, the types of behaviors that result in a coarrest imply that these individuals know each other outside of a single event (i.e., one does not engage in criminal activities with a stranger but rather with someone with whom they have regular interactions).[30,49] As case in point, a recent network survey of active offenders in Chicago found that, on average, 42% of all reported criminal ties (such as co-offending) extended to noncriminal social activities including social, financial, and emotional support and activities.[50] Unfortunately, we are unable to ascertain the extent to which individuals in the present study know each other outside of the specified coarrest, suggesting that our estimates of the true underlying social network are conservative. Future research should consider how our assessment of risky networks intersect or diverge from larger social networks.

These results have considerable implications for our understanding of homicide reduction and prevention strategies. These findings imply that homicide spreads through specific types of behaviors and in specific segments of the population. Although long-term homicide reduction strategies must address the fundamental inequalities that drive racial and socioeconomic disparities in violence,[4] network analysis can guide immediate homicide reduction efforts by identifying specific points of intervention involved in crime epidemics. By mapping the terrain within high-risk social networks and analyzing shooting patterns, network analysis offers a more direct road map for interventions. Thus, the approach advanced here would argue against sweeping policies and practices based on categorical distinctions such as gang membership or race and, instead, focus on intervention and prevention efforts that consider the observable and risky behavior of individuals. This project suggests that using network techniques to pinpoint groups and individuals at risk for victimization might provide more useful points of intervention, and a more efficacious use of limited resources. ■

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Contributors

A. V. Papachristos designed the study, collected the data, conducted all social network analysis, implemented all statistical models, and cowrote the article. C. Wildeman consulted and assisted on study design and statistical modeling and cowrote the article.

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Human Participant Protection

This study was an analysis of secondary data and was deemed exempt by Harvard and Yale institutional review boards.

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