Charles P. O'Brien, M.D., Ph.D.
Professor and Vice Chair
Department of Psychiatry
University of Pennsylvania
Philadelphia, PA 19104

Paul Trusiani, B.A.
Research Associate
Political Science Department
University of Pennsylvania
Philadelphia, PA 19104

A Comparison of Drug Use Networks Across Three Cities

Mark L. Williams, Zhangqing Zhuo, Harvey A. Siegal, Rafaela R. Robles, Robert T. Trotter II, and Adelbert Jones

INTRODUCTION

The risk of acquired immunodeficiency syndrome (AIDS) among injecting drug users (IDUs) and their sexual partners remains one of the most critical health problems facing the United States. The proportion of the national AIDS caseload composed of individuals who have acquired the human immunodeficiency virus (HIV) through the use of contaminated syringes or as the result of having sex with an IDU continues to grow. In some major metropolitan areas, the number of AIDS patients who have acquired the disease through behaviors associated with intravenous drug use now exceeds the number of individuals who became infected as the result of male-to-male sexual transmission. The risk of HIV infection either directly or indirectly as the result of intravenous drug use is greatest among those in American society least able to cope with the consequences of disease. Minority poor residing in the Nation's urban centers are most at risk of succumbing to AIDS (Curran et al. 1988; Hahn et al. 1989; Lange et al. 1988; Newmeyer 1988). A number of behavioral or sociodemographic variables have been found to be associated with a higher risk of HIV infection due to drug injection. Among the behaviors and conditions implicated are frequency of drug injection, years of injection, use of only injected drugs, use of a shooting gallery, the use of cocaine, and homelessness (Chaisson et al. 1989; Chitwood et al. 1990; Des Jarlais 1992; Kahlsa et al. 1992; Marmar et al. 1987; McCusker et al. 1992; Schoenbaum et al. 1989; Siegal et al. 1991).

Variation in the risk of HIV infection associated with injecting drug use demonstrates that not all IDUs are at equal risk of infection. Some injectors are more likely to become infected than others. Drug injection is a not a simple act. Studies have found that the injection of drugs, not to mention the lifestyle of an IDU, is a complex set of behaviors and interactions (Grund et al. 1991; Singer et al. 1992; Watters 1988, 1989). The circumstances of the drug injection scene and those who are present when drugs are injected can influence the dynamics of disease

transmission (Battjes et al. 1989; Grund et al. 1991; van den Hoek et al. 1992). If the act of injecting involves more than one person, there are a number of behavioral norms and customs associated (Williams and Johnson 1993). Who injects, how much each participant injects, the order of injection, and whether a needle is cleaned are regulated by a complex set of rules recognized by most injectors. Each can have an effect on the transmission of HIV.

Increasing knowledge of the factors and circumstances associated with HIV infection does not increase the macrolevel understanding of the dynamics of transmission or of risk (Samuels et al. 1992). Lack of understanding is, to a large degree, due to the absence of a strong theoretical perspective from which to evaluate knowledge of microlevel factors associated with HIV infection and to understand the macrolevel dynamics of the epidemic. Without a macrolevel theory that can put microlevel behaviors and circumstances of injecting drug use into a meaningful perspective, researchers are unable to evaluate the relationships among behaviors and circumstances or to explain how variations in these factors influence the rate of infection for a population. A theory of social networks holds some promise as a theory that can accommodate the translation of microlevel behaviors into macrolevel understanding. A social network is the sum of interpersonal linkages within a population. Put another way, a social network is the sum of personal network interactions (Klovdahl 1985). Linkages among people can vary in length of interaction, frequency of contact, number of contacts, heterogeneity of contacts, and strength of emotional ties (Auslander and Litwin 1987; Granovetter 1973; Pilisuk and Froland 1978; Saulnier and Rowland 1985). The sum of linkages across these network variables produce patterns of social networks that can have consequences for the transmission of disease within individual network structures.

The purpose of this chapter is to present the result of an investigation of the drug use network structures of intravenous drug users in two cities in the United States and one in Puerto Rico. One city involved in the study had a high rate of HIV infection among intravenous drug users and, by comparison, the other two cities had low rates of HIV infection (Robles et al. 1992; Siegal et al. 1991; Williams 1990). The drug use networks in each of the three cities were evaluated for differences in number of contacts, frequency of contacts, length of interactions, heterogeneity of interactions, and strength of emotional ties. Only intravenous drug use linkages between individuals were investigated in the analysis. Although

other interpersonal linkages may be significant in the transmission of HIV infection from one individual to another, the focus of this study was on the structures of social networks related to intravenous drug use only. It was expected, given the differences in rates of HIV transmission among the three sites, that there would be significant differences among the network structures.

METHODOLOGY

Data Collection

Data for this analysis were abstracted from a larger data set of out-of-treatment drug users collected in the United States and Puerto Rico. Data were collected in Dayton/Columbus, OH, Houston, TX, and Rio Piedras, PR. To be eligible to participate in data collection activities, respondents were required to have injected a drug or smoked crack cocaine at least once during the 30 days before participation, have a positive urine screen for cocaine or opiates or show evidence or recent track marking, and not have been in drug treatment during the month preceding participation. In addition to these requirements, participants were required to be 18 years of age, recruited from selected targeted geographic areas, and to have signed an informed consent form (see Kaplan et al. 1987; Lee 1993). All study participants were provided the opportunity to participate in HIV prevention programs and to be tested free of charge for HIV infection.

Data used for analysis were collected using the Risk Behavior Assessment (RBA) and the Social Network Questionnaire (SNQ). The RBA was developed for the National Institute on Drug Abuse as a method for collecting HIV-infection risk data related to drug abuse and sexual behaviors at the community level. The instrument was designed to collect demographic, drug use, needle-sharing, sexual behaviors, and medical and drug treatment history data. The reliability and validity of the RBA has been found to be quite high (see Needle et al., unpublished manuscript). The SNQ was developed as a supplement to the RBA to assess the strength and characteristics of drug use linkages among chronic drug users and the context in which their drug use occurs. Questions developed to assess the linkages among drug users include the number, characteristics, and types of drug use relationships of the questionnaire respondent. To be consistent with the RBA, the timeframe of the SNQ was limited to the 30 days before the interview. Since the SNQ was

developed as a supplement to the RBA, data about networks were collected from the perspective of the respondent. No attempt was made to link data collected from respondents or to data collected from all members of a network. The SNQ also asked respondents about their drug use relationships and the context of drug use the last time that they used drugs, but those data are not presented in this study.

All data for this study were collected in private settings by trained interviewers. Most interviews took place at locations convenient to the respondent. Interviewers were trained to use both the RBA and the SNQ. Although the SNQ was developed as a supplement to the RBA, time of administration varied from site to site. Some sites chose to administer the SNQ immediately after the RBA. Others chose to collect data using the SNQ during a separate session, usually 1 week after the administration of the RBA. It is not known whether the timing of administration had any consequence for the data being collected. However, any effect of the timing of data collection using the SNQ is likely to be small. Respondents were paid for the time spent responding to both questionnaires, although method and amount of payment varied from site to site.

Data Analysis

Data collected for this study were unlinked; that is, data collected from one respondent were not linked to data collected from other respondents. Unless otherwise indicated, the level of analysis for this study was the network. Data presented by the respondent on drug use contacts during the previous 30 days were aggregated to the network level. Specifically, the analysis sought to characterize the number and frequency, strength, and heterogeneity of linkages within networks. Only drug use relationships are presented. The data do not include relationships the respondent may have with others with whom he or she did not use drugs in the 30 days before data collection. Heterogeneity was assessed by gender, age groups, race/ethnicity, and drug use. Number and frequency of linkages was assessed by the number of drug use contacts reported by the respondent and the frequency of drug use within the network. Strength of linkages was measured by the length of time that members of the network had used with each other. In addition to these variables, the level of needle sharing and sex within the drug use network was measured.

Four variables were constructed to investigate the heterogeneity of the networks within the data set. Networks were assessed to determine if members of a network were the same gender, within one or two age

groups, in the same racial/ethnic group, and used only intravenous drugs together. Gender of a network was measured by composition: all male, all female, or male and female members. Age groups were categorized into broad groups: 30 years and younger, 31 to 40, 41 to 50, and 51 years or older. Because the exact ages of a respondent's drug use contacts were not requested, a network's age group was assessed to be the same if the age groups of the members were within one group. Race/ethnicity of a network was measured to be the same if all members belonged to the same racial/ethnic group. Drug use of the network was measured by the drugs, either intravenous drugs or crack cocaine, used by the respondent with other members of the network. Variables measuring the homogeneity of networks were measured by nominal variables where the network either matched or did not match a criterion.

The number and frequency of drug use linkages were measured by two variables. The number of linkages within a network was measured by the number of contacts reported by a respondent plus one. The number of network members was measured by a categorical variable ranging from one, indicating a drug use network of only the respondent, to five or more members. The frequency of drug use linkages was measured by the average frequency that the respondent reported using drugs with each contact within the network. Frequency of drug use contact was measured by a categorical variable ranging from less than or equal to three times a month to four or more times daily. Frequency of drug use also was measured by the absolute frequency of drug use between the respondent and each network contact. (Absolute frequency of use was measured by a categorical variable ranging from three or fewer times per month to twice or more daily.) Strength of drug use links was measured by the average duration of time the respondent reported having used drugs with each network member. Duration of time was measured by a categorical variable ranging from 6 or fewer months to greater than 4 years.

Three HIV-risk variables were also analyzed for the networks: receiving a used needle from a network contact, giving a needle to a network contact, and having sex with a network contact. Unfortunately, the questionnaire asked only if the respondent had given or received a needle or had sex with a network member. Although a respondent reporting a risk behavior does provide evidence of the behavior occurring within a network, it is an inadequate measure of the true level of a behavior within a network. All three risk variables were measured as categorical variables ranging from zero to greater than or equal to two contacts within the network.

All sample characteristic and network variables were investigated, controlling for site. Preliminary analysis had shown that there were significant variations in the data by site where the data were collected. Sample and network characteristic data were analyzed using contingency tables and chi-square tests of significance. The interrelationship of network characteristics was investigated using Pearson correlation coefficients. The site where data were collected was not controlled for in the correlational analysis.

Respondent Characteristics

The sample used for this analysis was limited to respondents who had injected a drug at least once during the previous 30 days. The sample included 192 respondents reporting 275 drug use contacts. As shown in table 1, demographic characteristics of the respondents in the sample varied across most variables by site. There was no statistically significant differences among the sites as to the gender of the respondents. Thirty percent of the sample was female, and 70 percent was male. On the remainder of the demographic variables presented in table 1 (race/ethnicity, age, education, marital status, current living arrangement, and injected drug use), the sample varied depending on the city where the data were collected. All respondents in Rio Piedras were Hispanic. Two-thirds of the sample collected in Dayton/Columbus were African American and one-third was white. Sixty-four percent of the Houston respondents were African American, 19 percent Hispanic, and 17 percent white.

The average age of respondents in the study was 34.2 years in Rio Piedras (standard deviation [SD] = 7.0), 38.2 years in Houston (SD = 7.8), and 39.8 years in Dayton/Columbus (SD = 8.7). The largest number of respondents in Rio Piedras and Dayton/Columbus were between the ages of 31 and 40 years. The greatest proportion of respondents in Houston were between the ages of 41 and 50 years. The level of educational attainment was highest among participants in Dayton/Columbus. Almost two-thirds of the Dayton/Columbus sample had completed high school, a GED program, or continued their education after high school. Forty-six percent of the Houston sample, and 40 percent of the Rio Piedras sample reported having a high school education or greater. Forty-six percent of the Houston sample reported less than a high school but more than an eighth-grade education. Forty percent of the Rio Piedras sample had less than an eighth-grade education.

TABLE 1. *Demographic characteristics.*

	D/C	H	RP
Gender			
Male	.74	.62	.76
Female	.26	.38	.24
	p<0.13		
Race/Ethnicity			
African American	.67	.64	—
Hispanic	—	.19	1.0
White	.31	.17	—
	p<0.000		
Age			
≤30	.13	19	.34
31-40	.47	38	.50
41-50	.29	40	.13
≥51	.11	04	.03
	p<0.000		
Education			
<8th grade	.06	.08	.40
<High school	.31	.46	.20
High school	.30	.31	.27
> High school	.33	.15	.13
	p<0.000		
Marital Status			
Single	.33	.44	26
Married	.30	.20	20
Separated	.10	.18	43
Divorced	.24	.12	10
Widowed	.03	.06	01
	p<0.000		
Current Living Arrangement			
Own house or apartment	.47	.24	57
Someone else's house/apartment	.37	.57	34

TABLE 1. *Demographic characteristics (continued).*

	D/C	H	RP
Current Living Arrangement (continued)			
Hotel, halfway house, shelter	.13	.15	—
Streets	.03	.05	.07
	p<0.000		
Homeless			
No	.77	.79	.91
Yes	.23	.21	.09
	p<0.051		
Injected Drug Use			
Cocaine	.18	70	.04
Heroin	.27	13	.09
Heroin/cocaine	.55	17	.87
	p<0.000		

KEY: D/C = Dayton/Columbus; H = Houston; RP = Rio Piedras.

Most respondents at all three sites reported that they were not married at the time of the interview. However, how respondents classified their marital status varied significantly among the three cities. The greatest number of respondents in Houston and Dayton/Columbus reported that they were single at the time of the interview. The largest proportion of respondents in Rio Piedras reported that they were separated. The majority of respondents in Dayton/Columbus and Rio Piedras reported living in their own house or apartment, 47 percent and 57 percent, respectively. The majority of respondents in Houston (57 percent) reported living in someone else's house or apartment. The Rio Piedras sample had the greatest proportion of participants reporting that they lived on the streets (7 percent). Yet, only 9 percent of the Rio Piedras sample considered themselves homeless, compared to 21 percent in Houston and 23 percent in Dayton/Columbus.

Injecting drug use in the 30 days before the study was fairly limited to either heroin, cocaine, or heroin and cocaine in all three cities. However, the patterns of cocaine or heroin injection varied significantly between the sites. The primary drug injected in Houston was cocaine, used by 70 percent of participants. About one-fifth of the respondents in Houston reported injecting heroin and cocaine mixed together, and approximately one-tenth reported injecting heroin by itself. Few respondents in Rio Piedras reported injecting heroin (9 percent) or cocaine (9 percent). Most respondents in the Puerto Rico sample reported injecting heroin and cocaine mixed together. Twenty-seven percent of the sample in Dayton/Columbus reported injecting heroin. Yet, like the sample in Rio Piedras, the majority of respondents in Ohio (55 percent) reported injecting heroin and cocaine mixed together. Seventeen percent reported injecting cocaine.

ANALYSIS

Network Characteristics

The average size of the networks reported by participants in the 30 days before being interviewed was 2.43 persons. As shown in table 2, network size did not vary among the sites ($p < 0.066$). Approximately 15 percent of the sample reported injecting drugs with no other persons and, therefore, had a network size of one. Twenty-eight percent reported a network size of two people, 20 percent a network size of three people, 17 percent a network size of four to five people, and 17 percent a network size of six or more people. Individuals who reported a network size of one were deleted from the remainder of the analysis.

The homogeneity of networks did vary significantly by gender, race/ethnicity, and drug use by site. Only the age groups of those involved in the networks did not vary significantly between the samples ($p < 0.370$). Approximately one-third of those interviewed reported networks composed of individuals within the same age groups. The remainder reported that the network was composed of members from at least two age categories. A higher proportion of networks in Dayton/Columbus and Houston were composed of both men and women than in the Rio Piedras sample ($p < 0.001$). Fifty-three percent of the networks in Rio Piedras were single-gender networks, compared with 22 percent in the Ohio sample and 30 percent in the Texas sample. Networks in which both intravenous drug and crack cocaine use was reported were high in

TABLE 2. *Characteristics of drug use contacts.*

	D/C	H	RP
Network Size			
1	0.16	0.11	0.19
2	0.21	0.24	0.39
3	0.17	0.18	0.21
4-5	0.24	0.27	0.11
≥6	0.21	0.20	0.10
	p<0.066		
Age			
Same age group	0.20	0.25	0.32
Mixed age group	0.80	0.75	0.68
	p<0.37		
Gender			
Single gender	0.22	0.33	0.47
Mixed gender	0.78	0.67	0.53
	p <0.001		
Race/Ethnicity			
Same racial group	0.78	0.76	0.98
Mixed racial group	0.22	0.24	0.02
	p<0.001		
Drug Use			
IV only	0.31	0.25	0.51
IV and crack	0.70	0.75	0.49
	p<0.000		

TABLE 2. *Characteristics of drug use contacts (continued).*

	D/C	H	RP
Average Time Respondent Used With Others			
≤6 Months	0.22	0.20	0.40
7-12 Months	0.15	0.13	0.14
1- 2 Years	0.12	0.17	0.11
Average Time Respondent Used With Others			
2-4 Years	0.12	0.18	0.12
> 4 Years	0.39	0.32	0.23
	p<0.21		
Average Time (as a dichotomous variable)			
≤6 Months	0.22	0.20	0.40
>6 Months	0.78	0.80	0.60
	p<0.018		
Average Frequency of Drug Use With Network			
≤ Monthly	0.15	0.17	0.02
Weekly	0.46	0.50	0.14
Daily	0.22	0.24	0.28
2-3 times daily	0.10	0.07	0.39
≥4 times daily	0.02	0.03	0.18
	p<0.000		

TABLE 2. *Characteristics of drug use contacts (continued).*

	D/C	H	RP
Absolute Frequency of Interactions With Others			
≤ Monthly	0.29	0.26	0.04
Weekly	0.39	0.41	0.18
Daily	0.18	0.20	0.24
>Daily	0.14	0.13	0.54
	p<0.001		
Received a Needle From a Network Member			
No	0.71	0.68	0.70
1	0.17	0.11	0.23
≥2	0.12	0.21	0.07
	p<0.092		
Gave a Needle to a Network Member			
No	0.66	0.65	0.63
	0.19	0.11	0.26
≥2	0.15	0.25	0.11
	p<0.066		
Sexual Relationships With Network Members			
None	0.46	0.49	0.84
	0.49	0.38	0.12
≥2	0.05	0.13	0.04
	p<0.000		

KEY: D/C = Dayton/Columbus; H = Houston; RP = Rio Piedras.

Dayton/Columbus (70 percent) and Houston (75 percent), compared to 49 percent in the Rio Piedras sample ($p < 0.000$). The proportion of networks reporting only intravenous drug use in Rio Piedras was 51 percent.

There was no statistically significant difference among the three sites in the average time that respondents reported using drugs with their networks ($p < 0.210$). Twenty-seven percent of respondents reported using with network members an average of 6 months or less. Fourteen percent reported using with their network 7 to 12 months, 14 percent 1 to 2 years, and 15 percent an average of 2 to 4 years. Thirty-one percent of respondents reported using with their network for more than 4 years. Although there was no statistically significant difference in the average time a respondent reported using with his or her network among the three sites when average time was investigated as a categorical variable, when average time was coded as a dichotomous variable ranging from 6 months or less to greater than 6 months, a significant difference among the sites did emerge ($p < 0.000$). Forty percent of the network members in Rio Piedras reported using drugs with their networks an average of 6 months or less, compared to 22 percent in Dayton/Columbus and 20 percent in Houston.

The average frequency of drug use within a network varied significantly by site ($p < 0.000$). The majority of networks in Rio Piedras (57 percent) reported using together an average of two or more times daily. The majority of networks in Dayton/Columbus and Houston reported using together an average of weekly or less, 61 percent and 67 percent, respectively. The differences in average frequency of network drug use is reflected in the frequency of drug use interaction between the respondent and individual members of the network. The majority of interactions in Rio Piedras occurred twice or more daily. The majority of interactions between respondents and individuals within their networks in the Ohio and Texas samples occurred weekly or less, 68 percent and 67 percent, respectively.

There was no statistically significant difference among networks at the three sites in regard to the respondent reporting that he or she received a needle in the previous 30 days from another network member ($p < 0.092$). Approximately 30 percent of respondents reported receiving at least one needle from another network member. There was no statistically significant difference in the number of networks in which the respondent reported giving a needle to another network member

($p < 0.066$). About two-thirds of the networks did not involve the respondent giving a needle to another network member. Seventeen percent of the networks involved the respondent giving a needle to at least one other network member and 17 percent to two other network members. There was a statistically significant difference among the sites in regard to the number of networks where the respondent reported having sex with one or more network members ($p < 0.018$). The majority of networks in Dayton/Columbus (54 percent) and Houston (51 percent) involved a sexual relationship between the respondent and at least one other network member. Only 16 percent of the networks in Rio Piedras involved a reported sexual relationship between the respondent and another network member.

As shown in table 3, a number of network characteristics investigated were intercorrelated. A network of mixed gender was positively correlated with a network of members from more than one age group ($r = 0.22$, $p < 0.01$) and more than one racial/ethnic group ($r = 0.19$, $p < 0.01$). However, a network with both men and women was negatively correlated with network size ($r = -0.19$, $p < 0.01$). Mixed-gender networks were positively correlated with all three HIV-risk behaviors investigated, the respondent giving needles to another network member ($r = 0.19$, $p < 0.01$), the respondent receiving needles from another network member ($r = 0.27$, $p < 0.001$), and the respondent having a sexual relationship with another member of the network ($r = 0.51$, $p < 0.001$). Network size was negatively correlated with networks composed of more than one age group ($r = 0.24$, $p < 0.001$). Networks composed of more than one racial/ethnic group were positively correlated with a respondent reporting he or she gave needles to ($r = 0.26$, $p < 0.001$) and had a sexual relationship with another network member ($r = 0.20$, $p < 0.01$). Giving and receiving needles within a network were very highly interrelated. Giving a needle to another network member and receiving a needle from another network member had a correlation coefficient of 0.82 ($p < 0.001$). Although having a sexual relationship with a network member was not correlated with giving a needle to another network member, having a sexual relationship and receiving needles from another network member were positively correlated ($r = 0.23$, $p < 0.001$). Two variables, the average time network members had been using with each other and the average frequency network members used drugs together, were not found to be significantly related to any other variable in the analysis.

TABLE 3. *Correlation of network characteristics.*

	G	A	R/E	NS	AT	AF	GN	RN
Gender								
Age	0.22*							
Race/ethnicity	0.19*	.14						
Network size	-0.19*	-.24**	-.06					
Average time	-0.08	.06	.09	-.11				
Average frequency	-0.17	.04	-.10	-.08	.01			
Gave needles	0.19*	.17	.26**	-.07	.04	-.01		
Received needles	0.27**	.18	.17	-.06	.04	-.06	82**	
Sexual relationship	0.51**	.17	.20*	-.10	-.03	-.14	12	.23**

KEY: * $p < 0.01$; ** $p < 0.001$; G = Gender; A = Age; R/E = Race/Ethnicity; NS = Network Size; AT = Average Time; AF = Average Frequency; GN = Gave Needles; RN = Received Needles; SR = Sexual Relationship.

SUMMARY AND DISCUSSION

This study presented drug use network data collected in three cities in the United States and Puerto Rico. Respondents in the study were out-of-treatment intravenous drug injectors at risk for HIV infection. All respondents in the study had injected at least once during the previous 30 days. There were significant differences among the respondents related to the site where the data were collected. The racial/ethnic composition of the samples varied according to the city in which respondents were interviewed. Not surprisingly, all respondents in the Rio Piedras sample reported that they were Hispanic. About two-thirds of the respondents in the Houston and Dayton/Columbus samples were African American. In addition, respondents in the Puerto Rico sample were more likely to have been younger and to have injected heroin and cocaine mixed together. Respondents from the Houston site were more likely to have been older, considered themselves homeless, and to have injected cocaine. Given these significant differences in the samples, the number, heterogeneity, strength, and frequency of network linkages were investigated, controlling for site.

The number of drug use linkages reported by study participants did not vary significantly by site. Respondents at the three sites reported having

slightly over two drug use linkages or, put another way, a drug use network size of slightly over three people. However, there were significant differences in network characteristics among the sites in regard to heterogeneity, strength of linkages, and frequency of linkages. Respondents in Puerto Rico were more likely to be involved in networks that were relatively homogeneous, with relatively weak ties and frequent drug use interactions. Networks in Rio Piedras were much more likely to be all Hispanic, all male, use only injectable drugs, to have used drugs with each other a short period of time, and to use together multiple times daily. Injectors in the Dayton/Columbus and Houston samples, on the other hand, were more likely to be involved in heterogeneous networks, with comparatively stronger ties and less frequent drug use interactions. Networks in Houston and Dayton/Columbus were much more likely to be of mixed gender or race/ethnicity, to use both injectable drugs and crack cocaine, to have used drugs together a comparatively long time, and to use together once a week or less. Although these differences in network characteristics did emerge, there was no significant difference between the sites in a respondent reporting that he or she received or gave a needle to another member of the network. There was a significant difference, however, in reported sexual relationships. Respondents in Dayton/ Columbus and Houston were more likely to have reported a sexual relationship with one or more network members.

Some network characteristics were found to be significantly correlated. Networks with mixed genders were related mixed-age groups, with the respondent giving needles to or receiving needles from one or more network contacts and the respondent reporting having sex with one or more network contacts. However, networks with mixed genders were negatively related to the size of the network. In addition, network size was negatively related to more than one age group in a network. Networks with members of more than one racial/ethnic group were significantly related to the respondent reporting that he or she gave one or more network contacts a needle and had a sexual relationship with one or more contacts. Networks in which the respondent reported giving a needle were highly correlated with the respondent receiving a needle. Receiving a needle from a network member was correlated with reported sex with a network member.

There are a number of limitations to this study and, as a result, the findings must be interpreted with caution. The sample used was not derived using a random sampling procedure. The degree to which the sample is representative of drug injectors in the three cities can be only

estimated vaguely. Therefore, the generalizability of the findings is unknown. The requirements of the larger study to which this study was a supplemental effort, especially the need to relocate study participants after 6 months, may have served to bias the sample toward individuals who were less likely to be involved in risky behaviors. The relative age of the respondents in this sample would suggest that participants were more likely to have been more settled than younger drug injectors. Since the respondents in the study were unlinked, the degree to which the respondents were reporting the same networks is unknown. However, it is possible individuals may be reporting data on the same networks. Relying on egocentric unlinked data may also present another bias. Individuals included in the sample may be limited to those who are relatively stable in their living arrangements and lifestyle. Others with whom the respondents may be linked, but who were not recruited to participate in the study, may be less stable and far more likely to have drug use interactions with a larger number of more varied people. The timeframe of data collection, 30 days before the interview, may have had the effect of obscuring relationships or behaviors that are relatively rare. However, given these limitations, the study does provide some worthwhile information and suggest some potentially meaningful avenues for further investigation.

The differences in network characteristics between the Rio Piedras and the other two samples, given the significantly different rates of HIV infection among drug injectors in Puerto Rico, Ohio, and Texas, would suggest that network structures are related to rates of infection (Robles et al. 1992; Siegal et al. 1991; Williams 1990). The homogeneity of networks in Rio Piedras may have the effect of removing barriers that inhibit forming weak drug use linkages. The heterogeneity of networks in Texas and Ohio may have the opposite effect. African Americans may be reluctant to inject with whites or Hispanics. Hispanics may be reluctant to inject with whites or African Americans. Men and women, particularly if they have a sexual relationship, may be reluctant to inject with someone who is not a current network member (see Williams and Johnson, in press). For example, it would be expected that there would be far less sexual tension in single-gender than in mixed-gender drug use networks. The lack of sexual tension within single-gender networks may act to facilitate the formation of new drug use contacts outside the network. The larger number of drug use relationships of 6 months or less in the Rio Piedras sample would support such a speculation. In addition, the frequency of drug use interaction within the network in Rio Piedras would also tend to support the formation of new, weak-link relationships.

Injecting one or more times daily may present a situation in which it is much more difficult to coordinate drug use activities with others and far easier to use with whomever is present. Although it requires more analysis to assess, homogeneity of network structures may actually facilitate the formation of weak drug use relationships and, thereby, once introduced into a social network, the transmission of HIV.

The greater proportion of weak contacts and frequency of drug-using interactions in the Puerto Rico sample suggest that there may be a multiplicative effect among these two network measures. The chances for the transmission of HIV are increased if the number of contacts between drug injectors who have used only a short amount of time together is high, as suggested by the number of short-term relationships in the data from Puerto Rico. The chances for transmission would also seem to be increased if the frequency of injections is high. If duration is short and frequency high, the effect of each would seem to be multiplied by the other. There are a number of ways to assess this possibility controlling for the duration of drug use among injectors within a network and the frequency of injection using a multisite sample. The use of a multisite sample would be necessary to control for the effect of local circumstances and conditions.

Intercorrelation among some of the network measures suggests that some types of risk behaviors may be interrelated and related to network structure. For example, respondent reports of receiving and giving needles and a sexual relationship between network members were intercorrelated with measures of network heterogeneity. This would suggest that the risks of infection in a heterogeneous network may be more related to the strength of the relationships in the network as measured by duration of drug use rather than weakness. For example, it is not uncommon for those investigating risk behaviors to hear of needle sharing between sexual intimates. Such sharing, because of the emotional bond involved, is not usually considered sharing by the respondent (Williams and Johnson, in press). Therefore, risk in this situation would be related to the strength of the relationship. In addition, the intercorrelation between giving and receiving needles and sexual relationships would suggest that sex may be an equally, if not more, important means of HIV transmission in strong-link networks.

A social network theory of HIV infection may prove a useful mechanism for understanding rates of infection in different populations. Although respondents in all samples reported sharing needles, the rate of HIV

infection is far higher in Rio Piedras than in either Houston or Dayton/Columbus. One place to begin looking for differences, if behaviors are the same, is in the structure of the networks. Several significant differences were found. Although linked HIV data were not available for this study, an analysis of linked HIV social network data would be the next logical step. Such an analysis could show that, rather than one social network structure evident at a site, multiple structures related to HIV serostatus are evident. Multiple structures are possible. For example, in Houston, independent social network structures were found to be related to race/ethnicity (Williams and Johnson, in press). Whatever avenue of research is followed, social network theory does seem to have promise as a means for understanding the macrolevel implications of microlevel behaviors.

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AUTHORS

Mark L. Williams, Ph.D.
Principal Investigator
NOVA Research Company
Bethesda, MD 20814

Zhangqing Zhuo, Ph.D.
Research Scientist
University of Minnesota
Minneapolis, MN 55455

Harvey A. Siegal, Ph.D.
Principal Investigator
Wright State University
3640 Colonel Glen Highway
Dayton, OH 45435

Rafaela R. Robles, Ed.D.
Principal Investigator
Department of Anti-Addiction Services
P.O. Box 21414, Rio Piedras Station
Rio Piedras, PR 00917

Robert T. Trotter II, Ph.D.
Principal Investigator
Northern Arizona University
Campus Box 15200
Flagstaff, AZ 86011

Adelbert Jones, Ph.D.
Principal Investigator
Desire Narcotic Rehabilitation Center
2037 Orleans Drive
New Orleans, LA 70126

Ethical and Legal Issues in Social Network Research: The Real and the Ideal

Donald E. Woodhouse, John J. Potterat, Richard B. Rothenberg, William W. Darrow, Alden S. Klovdahl, and Stephen Q. Muth

INTRODUCTION

The sine qua non of social network research is identifying "nodes" and describing the connections between them. When the nodes are people and the connections are intimate activities, ethical questions are inevitable. Ideal answers are relatively easy and emanate from the general principles of bioethics. The reality is more complex: When the people are "criminals" and their activities are illegal (such as injecting narcotics or buying and selling sex), legal and ethical dilemmas frequently arise and practical solutions are elusive.

To describe social network structures and their influence on the spread of human immunodeficiency virus (HIV), it is necessary to collect detailed information about people at risk, their behaviors, and how they connect to others. There are many obstacles to collecting information about sexual activity, drug use, and social connections. Beyond social and political resistance to investigating intimate aspects of human behavior, a fundamental obstacle that remains is ignorance about how to measure such things. These are methodological problems. More pressing issues concern researchers' obligations to society at large and to the people they study.

Behavioral researchers in the United States are guided both by express requirements for protecting human subjects in federally funded research, promulgated by the Office for Protection from Research Risks (OPRR), Department of Health and Human Services (DHHS) (45 CFR 46), and by general principles of biomedical ethics. These principles include respect for persons (a duty to respect others, to respect their autonomy, and to protect those with diminished autonomy), beneficence (the duty to maximize benefits to the subjects of research and to society at large), nonmaleficence (the duty to prevent harm to subjects), and justice