Using Network Sampling and Recruitment Data to Understand Social Structures Related to Community Health in a Population of People Who Inject Drugs in Rural Puerto Rico

Mayra Coronado-García*; Courtney R. Thrash, MA†; Melissa Welch-Lazoritz, MA†; Robin Gauthier, PhD†; Juan Carlos Reyes, EdD‡; Bilal Khan, PhD†; Kirk Dombrowski, PhD†

Objective: This research examined the social network and recruitment patterns of a sample of people who inject drugs (PWIDs) in rural Puerto Rico, in an attempt to uncover systematic clustering and between-group social boundaries that potentially influence disease spread.

Methods: Respondent driven sampling was utilized to obtain a sample of PWID in rural Puerto Rico. Through eight initial "seeds", 317 injection drug users were recruited. Using recruitment patterns of this sample, estimates of homophily and affiliation were calculated using RDSAT.

Results: Analyses showed clustering within the social network of PWID in rural Puerto Rico. In particular, females showed a very high tendency to recruit male PWID, which suggests low social cohesion among female PWID. Results for (believed) HCV status at the time of interview indicate that HCV+ individuals were less likely to interact with HCV- individuals or those who were unaware of their status, and may be acting as "gatekeepers" to prevent disease spread. Individuals who participated in a substance use program were more likely to affiliate with one another. The use of speedballs was related to clustering within the network, in which individuals who injected this mixture were more likely to affiliate with other speedball users.

Conclusion: Social clustering based on several characteristics and behaviors were found within the IDU population in rural Puerto Rico. RDS was effective in not only garnering a sample of PWID in rural Puerto Rico, but also in uncovering social clustering that can potentially influence disease spread among this population. [*P R Health Sci J 2017;36:77-83*]

Key words: Puerto Rico, HIV, HCV, RDS

The use of illicit drugs affects every region of the United States, but most of our information about drug use comes from large urban areas (1). This is true despite two decades of increasingly visible rural drug use and its related harms (2,3). Information on drug use in Puerto Rico follows a similar pattern. While CDC surveillance efforts and past studies have focused on the San Juan metropolitan area (4–6), little focus has been given to rural areas (7,8).

Although much research has been conducted to further understand populations of people who inject drugs (PWID), research is limited due to the stigmatization of drug use/users and illegal behaviors, as well as geographic spread, making rural PWID a classic "hard-to-reach" research population (9). One highly used and well-studied method that has been adopted to recruit members of hard-to-reach populations is Respondent Driven Sampling (RDS; (10,11)). Pioneered in the 1990s by Heckathorn (12,13) and extended since (14), RDS uses chain-referral sampling to make use of social connections among hidden or hard-to-reach groups, with an emphasis on long referral chains and a rigorous analysis of recruitment biases to correct for common problems associated with "snowball" techniques. The RDS data discussed below were collected as part of a larger project aimed at characterizing HIV and HCV propagation dynamics in rural drug-user networks in central Puerto Rico. The objective was to obtain statistical data on population characteristics of PWID (including demographics, infection prevalence, and behavior) for an initial "equilibrium" sample that could later be compared to data on urban PWID collected elsewhere in Puerto Rico.

---

*Regis University, Denver Colorado, USA; †University of Nebraska-Lincoln, United States of America; ‡University of Puerto Rico Medical Sciences Campus, San Juan, Puerto Rico

Address correspondence to: Melissa Welch-Lazoritz, MA, Department of Sociology, University of Nebraska- Lincoln, 206 Benton Hall, Lincoln, NE 68588-0324. Email: mwelch2@unl.edu

This paper discusses the results of the initial RDS sampling, but goes beyond this to provide an analysis of the recruitment data that reflects on clustering and social boundaries that can be discerned from the biases in the recruitment process. Here we follow Wejnert (15) and others (16) who have argued that RDS analysis can be used for general social network analysis (RDS-SN). As Wejnert notes, "RDS data provide a wealth of information and potential for social network analysis by shifting the unit of analysis from nodes to ties in the network" (15). By examining patterns in these ties, and comparing them to what we might expect from random distributions of the same data, we uncover systematic clustering and between-group social boundaries that potentially influence disease spread among PWID. In this effort, we seek to add to recent work that stresses the importance of non-random (i.e. network) mixing patterns in the spread of HIV and related infections (17,18).

Risk networks are now widely recognized as a critical construct in understanding drug related viral and disease infection patterns, as social networks, as much as the human bodies in which infection happens, represent the natural environment in which transmission takes place and through which infection propagates (19,20). Since the early 1990s, social network research among PWID has produced considerable data on infection profiles and equally detailed data on the broad demographic and behavioral profiles of injecting communities and their risk behavior (21–23). Risk networks—graphs whose vertices are individuals and edges are social connections bearing disease transmission risk—necessarily shifts our view of risk away from individual behaviors to collective, social bodies as the carriers and transmitters of infections (24–26). Modeling risk networks as dynamical systems provides an opportunity to understand the long-term behavior of PWID risk networks themselves—well beyond what can be seen by considering their constituent individuals in isolation (27). Critical to this task is an understanding of how individuals "mix" via patterns of injection equipment sharing. The basic building blocks for this include patterns of affiliation based on both drug use behaviors and user social factors (such as ordinary demographic variables).

Homophily, or the tendency for actors to associate with similar others (28), has been documented across a wide range of personal and demographic characteristics (29). A familiar example, in the context of drug use, is serosorting around equipment -sharing, as when those who have never received a positive diagnosis avoid sharing with those who have received one and with people who have never been tested. In this example it is easy to see that the level of homophily has direct implications for infection potential with a risk setting. More generally, it has been shown that the potential for infection to spread across groups of people with similar behaviors or characteristics is limited in high homophily settings (30), however high homophily also provides an efficient vehicle for within-group diffusion if infection reaches the group (31). A homophily score provides the researcher with an easily interpretable measure of within versus across group contact, which in turn can be used

as a gauge for the disease risk potential of each group, and the whole community.

Throughout this paper, we use the homophily index proposed by Heckathorn (13). The mixing patterns found in the recruitment chain are transformed into a measure ranging from -1 to 1 where 1 indicates all referrals are sent to people within the same group, 0.3 indicates that 30% of referrals are sent within group and -1 indicates that all referrals are sent outside the group. The measure is adjusted for relative group size and reflects the degree of contact between groups. If the number of in-group ties matches what would be expected based on the relative size of the group alone, the homophily score is 0. Sometimes, however, it is also useful to decompose the homophily score into its two component parts: affiliation homophily (Ha) and degree homophily (Hd). In this rendering, generalized homophily (Hx) measures in-group contact and Ha is a measure of in-group contact adjusted for the differential contact generated by differences in degree alone (Hd). Thus if females have more partners on average than males, we would expect to find more female-female ties in a group than male-male ties, even if the connections were placed entirely by chance. This is the effect measured by Hd. On the other hand, if females actually preferred to associate with other females rather than males (Ha), the overall homophily effect (Hx) would be even higher. Throughout the duration of the paper we will refer to Hx as homophily, because it is our primary measure of in-group contact, and because, regardless of underlying cause, differential patterns of risk are our primary concern.

The concept of between group affiliation, is an extension of the concept of homophily. Affiliation describes the recruitment patterns between all groups, adjusted for the number of in each group. Because it measures the recruitment patterns between all groups, affiliation can be used to measure homophily (the affiliation of a group with itself), or it can measure the extent of affiliation between one group and specific others. Groups have a strong affiliation with another if connections occur between them frequently. Heterosexual (male-female) equipment sharing is one possible example of cross-group affiliation, equipment sharing between people with non-concordant infection statuses is another. Potential for infection across groups that partner with each other is increased in a setting defined by cross-group affiliation (32).

The alternative to both homophilous settings and settings that exhibit cross-group affiliation is implicitly one where relationships occur at random, based on the relative sizes of each group without consideration of personal behaviors and attributes. According to a random mixing model, recruitment is simply a function of the group's prevalence (33). Prior work has shown that the closer a population conforms to a random mixing model, the more easily infections spread across groups. In contrast, the greater the in group clustering in such a context, the more quickly local contacts are depleted and the infection has nowhere to spread (34). As such, a random mixing scenario is the baseline comparison against which network effects on disease spread are measured.

Materials and Methods

The Injection Risk Networks in Rural Puerto Rico (IRN-RPR) project sought to recruit active adult injection drug users. Recruitment began with two RDS "seeds" in each of four study communities, contacted with the assistance of project staff from the local syringe exchange program. Participants completed a personal interview, then HIV and HCV rapid antibody tests, and then provided with three referral coupons that she/he could distribute to other injection drug users in their social networks. Data collection continued in this manner until the desired sample size (n>300) was obtained. These 317 interviews provided extensive data regarding injection and sexual risk behaviors, perceived HIV/HCV status and testing history (prior to involvement in our study), movement patterns between communities, access to health and social services, and injection drug use network contacts. The study received IRB approval through the University of Nebraska-Lincoln (IRB# 20131113844FB) and the University of Puerto Rico, Medical Sciences Campus (IRB# A8480115).

A description of the resulting sample is available in Table 1. The sample was largely composed of males (90.48%) with an average age of 40.78 years. More than one-fifth (21.90%) of respondents reported current homelessness. Most individuals (80.06%) reported household incomes of less than $5,000 dollars per year. Nearly 47% of respondents were single. Additional descriptive statistics can be found in Table 1.

Population estimates were calculated using the software package RDS Analyst (35). Based on knowledge of the area and the number of individuals who have utilized needle exchange programs in rural Puerto Rico, we estimated that the area in which the study took place has a top population of no more than 2,000 PWID. Based on this estimate, RDS Analyst finds a potential discoverable population estimate for our sample of 1,032 PWID (mean), with a 95% confidence interval of (420, 1913). While this can serve as a loose estimate, a lack of firm regional boundaries, differential access to transportation, high mobility, and a number of related problems associated with firmly defining a fluid study area require that we approach this figure with caution.

Results

Homophily and Affiliation in Social networks

As introduced above, one advantage of the RDS recruitment method is that the estimates of homophily used to correct for sampling bias can also be used to understand some of the network tendencies of the population from which the sample is derived. Inter- and intragroup tendencies to association are of particular interest to public health researchers and policy makers, as social structural factors can play a significant role in determining disease spread (18). Where RDS can be used to successfully sample from a community, it can also provide us with the means to examine these tendencies in a form in which

Table 1. Descriptive characteristics of sample

	Mean/%	SD	Range
Demographics			
Gender (n=315)			
Male	90.48		
Female	9.21		
Transgender	0.32		
Age (n=315)	40.78	10.07	18-70
Born in Puerto Rico (n=315)	93.02		
Currently homeless (n=315)	21.90		
Income (n=311)			
Less than $5000 per year	80.06		
More than $5000 per year	19.94		
Marital Status (n=315)			
Single	46.98		
Married/Cohabiting	22.22		
Separated, divorced, widowed	30.80		
Education (n=315)			
Less than High school	47.62		
Completed High school or GED	33.65		
College	18.73		
Sexual orientation (n=314)			
Heterosexual	96.18		
Gay/Lesbian	1.27		
Bisexual	2.55		
Hepatitis C (n=303)			
Unknown status	22.77		
Negative	27.06		
Positive	50.17		
HIV (n=315)			
Unknown status	13.97		
Negative	81.90		
Positive	4.13		
Injection drug use			
Age at first use (n=315)	21.91	8.22	10-58
Frequency of use (n=315)			
1-3 x/month	5.71		
1-6 x/week	9.52		
1-3 x/day	45.08		
4 or more x/day	39.69		
Speedball (Heroin & Cocaine) Use (n=314)	91.08		
Drug/Alcohol treatment			
Alcohol treatment (n=314)	10.19		
Drug treatment (n=315)	81.27		

they can be measured for relative strength and compared for relative importance. This section examines elements of social structure, role, or social status that could potentially influence the recruitment process. In each case the issue at stake is the extent to which elements of an underlying social structure reflected in the affiliation patterns of the respondents is likely to influence the health risks associated with injection drug use in rural Puerto Rico.

To do this, RDSAT measures homophily within groups on a scale from −1 to 1 (15), with a score of H=0 indicating no preference for in-group association, H=1 indicating the highest possible preference for in-group association (implied, for example, if all men recruited to the project in turn recruited only other men), and a score of H= −1 indicating the highest possible preference to connect with those outside of the group

(implied, again in a situation where all of the men recruited to the project in turn recruited only women). A homophily score of 0.3 (or -0.3) was referred to as "substantial" in-group contact by Heckathorn (2002) and it has since been used as an heuristic to assess substantial magnitude (for examples, see (11,36)). RDSTAT also provides estimates of affiliation homophily (Ha) and degree homphily (Hd): the homophily attributable to preferential in-group nominations, adjusted for degree differences across groups, and the extent of in-group preference attributable to differences in degree across groups respectively.

The same scale used to provide estimates of homophily can also be used to measure the level of association between groups (16), labeled here as "affiliation". Thus while "homophily" tracks the tendency of a group to connect only with others in the same group, "affiliation", tracks the tendency of members of one group to connect with those of a specified other group (again, at a rate higher than that predicted by a random mixing of ties within the overall population). Like homophily, affiliation is scored on a scale of −1 to 1, with a positive score indicating a tendency for intergroup association, and a negative score indicating intergroup disassociation (13). Here too, we use a 0.3 (or -0.3) cutoff to indicate a substantial degree of association or disassociation.

Table 2 examines the IRN-RPR RDS sample and social network characteristics by gender. The recruitment sample consisted of 278 male recruits and 28 female recruits (excluding our initial "seeds", and one respondent self-identified as transgender). Using the Gile and Handcock sequential sampling estimator (37), the estimated population proportions (Estimated Pop. Prop.) show that ~90.4% of the PWID population in rural Puerto Rico is male, while ~9.6% is estimated to be female. These represent only a small adjustment from the raw sample (shown as "Sample prop."), suggesting that gender appears to have little role in biasing the final sample.

Next we examine gender homophily in recruitment patterns. Different levels of homophily are apparent within the two genders, which is likely influenced by the small proportion of female injection drug users. Male PWIDs showed no gender preference (H=0.00) when recruiting a peer in the study, while female PWIDs recruiting patterns showed a significantly high preference for recruiting male PWIDs (H=-0.601). Even when the separate sources of this homophily are examined and differential recruitment based on degree is accounted for (Hd in Table 2), the remaining Affiliation Homophily (Ha) for female respondents remains highly negative (-0.578). This indicates a very high tendency among female respondents to recruit male PWID, rather than female PWID, into the study. The Affiliation Matrix in Table 2 shows that while male PWID affiliate freely with both male and female PWID (scores ~0), female PWID show a much greater tendency to affiliate with male PWID (0.601) than with female PWID (-0.601). This is unsurprising, considering women make up such a small percentage of rural Puerto Rican PWID both in our sample and in the estimated population.

Table 2. RDS sample and Social network

Characteristics by gender			
	Male	**Female**	**Total**
Distribution of recruits	278	28	306
Estimated Pop. Prop.	0.904	0.096	1.0
Sample Prop.	0.908	0.092	1.0
Homophily	0.000	-0.601	
Affiliation homophily (Ha)	-0.006	-0.578	
Degree homophily (Hd)	0.054	-0.055	
Affiliation matrix			
Male	0.0	0.0	
Female	0.601	-0.601	

Hepatitis C and HIV status

We examined the association between perceived HCV/HIV statuses with recruitment patterns from the RDS referrals. The results (Table 3) suggest that recruits who reported unknown HCV status or HCV- status showed little preference for recruiting PWID with the same HCV status (affiliation matrix values ~0), and equally little preference for recruitment based on positive or unknown HCV status. However, those who perceived themselves to be HCV+ prior to testing do show a low but important tendency to affiliate with those of the same perceived status (0.249), and a tendency to avoid those who believe themselves to be HCV- (-0.335). Although these homophily and affiliation levels remain low, the results for this analysis do present an interesting finding. Based on the affiliation matrix, individuals who believed they were HCV+ were less likely to nominate both those who believed they were HCV- and those who were unaware of their status. In contrast, those who were unaware of their status and those who believed that they were negative do not appear to be avoiding those who believe that they are HCV+. Therefore, it is those who believe that they are HCV+ who are acting as the gatekeepers for the disease. The same analyses were conducted on believed HIV status, however these were hampered by low cell counts as very few respondents believed themselves to be HIV+. Respondents who were unaware of their HIV status or believed they were HIV negative showed no preference when recruiting other PWIDs in the social network.

Table 3. RDS sample and social network characteristics by believed HCV status

	Unknown	**Negative**	**Positive**	**Total**
Distribution of recruits	67	76	144	287
Estimated Pop. Prop.	0.243	0.341	0.416	1.0
Sample Prop.	0.228	0.271	0.502	1.0
Homophily	0.041	-0.038	0.249	
Affiliation homophily (Ha)	0.049	0.084	0.129	
Degree homophily (Hd)	-0.026	-0.217	0.140	
Affiliation matrix				
Unknown	0.041	-0.173	0.047	
Negative	0.009	-0.038	0.010	
Positive	-0.129	-0.335	0.249	

Drug treatment participation

Participation in drug treatment programs showed signs causing significant clustering behavior among respondents (Table 4). The responses collected from recruits during the interview suggests that approximately 72.1% of the population is estimated to have participated in a drug treatment program (compared with 81.3% of the actual sample). This suggests 1) that we oversampled treatment participants, and 2) that treatment participation provides substantial clustering in the social lives of rural PWID in Puerto Rico (H=0.423), and perhaps indicates social bonding on the basis of similar experiences with treatment.

Table 4. RDS sample and Social network characteristics by Drug treatment participation

	No	Yes	Total
Distribution of recruits	58	249	307
Estimated Pop. Prop.	0.279	0.721	1.0
Sample Prop.	0.187	0.813	1.0
Homophily	0.018	0.423	
Affiliation homophily (Ha)	0.131	0.131	
Degree homophily (Hd)	-0.336	0.331	
Affiliation matrix			
No treatment	0.018	-0.018	
Yes treatment	-0.423	0.423	

Speedball

As seen in Table 5, PWID who used speedball (a mixture of heroin and cocaine) displayed high levels of homophily (H=0.446), while recruits who did not showed low-moderate levels (H=0.225). These results suggest that speedball use is causing clustering in the social networks of PWID in rural Puerto Rico. We can note, in looking at the breakdown of the overall homophily score, that affiliation homophily—here the tendency to cluster based entirely on similarity of drug choice—of both those who speedball and those who do not are, in fact, similar (0.251), and that much of the clustering is due to degree homophily—the tendency of groups with higher average personal network size to wind up with more people who have high numbers of connections in their own personal networks than groups with a tendency to have small personal network sizes. In this case we can see from the degree homophily scores in Table 5 that those PWID who do not use speedball have a negative degree homophily (-0.260) when compared to those who do (0.270).

Factors unrelated to clustering

Another aspect of using an RDS-SN approach is that we can determine where clustering did not occur. In the interview, recruits were asked about the use of various injection drugs other than speedball, including non-injection drugs and alcohol. None of the aspects of drug use showed much influence on the clustering of the network. These scores suggest that PWID in rural Puerto Rico do not form social

relationships on the basis of shared drug preferences other than speedball. The lack of clustering here and with other substances suggests that injection and non-injection drugs are not being used for social reasons, as has been found elsewhere (38). Other variables that did not impact clustering in the network were (1) age, (2) type of sex partners, (3) number of sex partners, (4) geographic location, (5) frequency of binge drinking, (6) number of focal towns in which the respondent reported injecting in, (7) homelessness in the past year, and (8) age the respondent first injected a drug.

Table 5. RDS sample and Social network

Characteristics by speedball use			
	No	**Yes**	**Total**
Distribution of Recruits	26	280	306
Estimated Pop. Prop.	0.121	0.879	1.0
Sample Prop.	0.089	0.911	1.0
Homophily	0.225	0.446	
Affiliation homophily (Ha)	0.251	0.251	
Degree homophily (Hd)	-0.260	0.270	
Affiliation matrix			
No	0.225	-0.225	
Yes	-0.446	0.446	

Discussion

This is one of the first studies to explore injection drug use in rural areas and provide knowledge about social networks of PWIDs within these communities. Overall, the results of this RDS analysis indicate clustering within the social network of rural Puerto Rican injection drug users.

These data produce an insight into the way that gender is reflected in relationships among PWID. Specifically, the high level of "heterophily" of females in the population suggest that there is a significantly low social cohesion among the female PWID, likely due to the small percentage of female PWID in rural Puerto Rico and points to a critical "bridging" role for their male partners. A study of IDU in Albania showed similar results, that females exclusively recruited males for inclusion in the study, while males showed slight preferential recruitment of other males (39). However, studies conducted in rural Ohio (40), Sydney (41), and St. Petersburg (39) show a different pattern for gender clustering within the social networks of injection drug users. Both Wang et al. (40) and Stormer et al. (39) find that females showed slight preferential recruitment for females, while males showed near-neutral recruitment patterns by gender. Paquette, Bryant, and De Wit (41) found that both males and females preferentially recruited in-group, but homophily levels were quite low (0.13 for males and 0.19 for females).

Interestingly, our results indicate that individuals who believe that they are HCV+ are less likely to affiliate with (or give an RDS coupon to) others who are unaware of their status or believe that

they are HCV-. Therefore, it appears that those who believe that they are HCV+ may be acting as "gatekeepers" and helping to prevent the spread of HCV throughout the network. In contrast, those who believe that they are negative or are unaware of their status seem to be affiliating with others regardless of potential HCV status. The extent that these recruitment affiliations reflect risk relationships for the spread of HCV is unknown, yet still provides a useful starting point for interventions aimed at lowering HCV incidence in rural Puerto Rico.

Additionally, results for speedball (heroin and cocaine) use show that there is significant clustering in the network based on the use of this drug combination, though not with others substances alone or in combination. Those who inject speedballs are more likely to associate with others who also inject speedballs, which seems to provide evidence for the type of partnership sharing referred to locally as "caballo", or the process of two PWID pooling resources to purchase both heroin and cocaine and then sharing the mixture. This understanding is preliminary, however, and more research needs to be done in order to understand why this particular use pattern is causing clustering in the network while other kinds of drug use do not. The question of whether this clustering actually results from the practice of drug users pooling resources in an effort to obtain both drugs is unclear. Degree-based sources of homophily would seem to indicate that PWID who use speedball have higher average numbers of social connections (and thus perhaps more risk partners), than those who do not, which would account for much of the clustering seen here (42). To the extent that caballo necessitates or provides for maintaining a higher number of partners, then the practice may still be involved. This issue requires further study and data that go beyond the recruitment data considered here.

Finally, those who have attended a drug treatment program are more likely to associate with others who have also attended a similar program. Currently, there is no evidence of clustering based on drug treatment participation elsewhere in the IDU literature. Given that this sample included current injection drug users only, such a finding would suggest that social bonds made during treatment continue afterwards, even when the overall goals of the treatment are not achieved.

This analysis applies a novel method for discovering features of social structure among PWID, which in turn can prompt novel and important questions about injection related risk. These findings are limited by the use of recruitment patterns as stand-ins for risk network patterns. In the next phase of research, direct ethnographic observation of the risk networks will allow us to evaluate the extent to which this is true. Those results will help further explore and contextualize the patterns observed here.

Despite these limits and the formative nature of the results shown here, RDS has been shown to be a vital method in recruiting PWID. This analysis is one of the first to address recruitment patterns and social network characteristics among a sample of PWID in rural Puerto Rico. The analysis of this recruitment process provides evidence of social clustering based on several characteristics, including gender, believed HCV status, speedball use, and drug treatment participation. This analysis informs not only future use of RDS for the recruitment of PWID, but also provides valuable insight on the social network characteristics for those attempting to implement interventions for such populations.

Resumen

Objetivo: Esta investigación examinó las redes sociales y patrones de reclutamiento en una muestra de personas que se inyectan drogas en zonas rurales (PQID) de Puerto Rico, en un intento de descubrir la agrupación sistemática y los limites sociales entre grupos que potencialmente influyen en la propagación de la enfermedad. Métodos: Se utilizó la técnica de Respondent Driven Sampling (RDS) para obtener una muestra de personas que se inyectan drogas en el área rural de Puerto Rico. A través de ocho "semillas" se reclutaron 317 participantes. En base a los patrones de reclutamiento de esta muestra empleamos RDSAT para calcular el grado de semejanza y afiliación en esta población. Resultados: Nuestro análisis mostró agrupación dentro de la red social de las PQIDs en zonas rurales de Puerto Rico. En particular, las mujeres mostraron una alta tendencia a reclutar hombres, PQID, lo que sugiere baja cohesión social entre las mujeres, PQID. Resultados para su estado percibido de infección con HCV durante la entrevista indica que individuos HCV+ eran menos propensos a interactuar con individuos HCV- o con aquellos que no estaban al tanto de su estado y podrían actuar como "barreras" para prevenir la propagación de enfermedades. Las personas que participaron en un programa de abuso de sustancias eran más propensos a afiliarse entre ellos. El uso de speedballs estaba relacionado con la agrupación dentro de la red, en la cual usuarios de esta mezcla de drogas tenían más probabilidad de afiliarse entre ellos. Conclusión: Se identificó agrupación social basada en varias características y comportamiento dentro de la población PQIDs en la zona rural de Puerto Rico. RDS fue eficaz, no solamente para obtener una muestra de PQID en zonas rurales de Puerto Rico, sino también en el descubrimiento de la agrupación social que potencialmente puede influir la propagación de la enfermedad en esta población.

References

1. Lansky A, Finlayson T, Johnson C, Holtzman D, Wejnert C, Mitsch A, et al. Estimating the Number of Persons Who Inject Drugs in the United States by Meta-Analysis to Calculate National Rates of HIV and Hepatitis C Virus Infections. PLoS ONE 2014;9:1–9.

2. Gfroerer JC, Larson SL, Colliver JD. Drug Use Patterns and Trends in Rural Communities. J Rural Health 2007;23:10–5.

3. Dombrowski K, Crawford D, Khan B, et al. Current Rural Drug Use in the US Midwest. J Drug Abuse 2016;2:3.

4. Colon HM, Deren S, Robles RR, Kang S-Y, Cabassa M, Sahai H. A Comparative Study of Mortality Among Puerto Rican Injection Drug Users in East Harlem, New York, and Bayamon, Puerto Rico. J Urban Health Bull N Y Acad Med 2006;83:1114–26.

5. Finlinson HA, Oliver-Vélez D, Deren S, Cant JGH, Colón HM, Robles RR, et al. A longitudinal study of syringe acquisition by Puerto Rican injection drug users in New York and Puerto Rico: implications for syringe exchange and distribution programs. Subst Use Misuse 2006;41:1313–36.

6. Mino M, Deren S, Colón HM. HIV and Drug Use in Puerto Rico: Findings from the ARIBBA Study. J Int Assoc Physicians AIDS Care Chic Ill 2002. 2011;10:248–59.

7. Löytönen M, Arbona SI. Forecasting the AIDS epidemic in Puerto Rico. Soc Sci Med 1996;42:997–1010.

8. López LM, de Saxe Zerden L, Bourgois P, Hansen H, Abadie R, Dombrowski K, et al. HIV/AIDS in Puerto Rican People Who Inject Drugs: Policy Considerations. Am J Public Health 2015;105:e3–e3.

9. Johnston LG, Whitehead S, Simic-Lawson M, Kendall C. Formative research to optimize respondent-driven sampling surveys among hard-to-reach populations in HIV behavioral and biological surveillance: lessons learned from four case studies. AIDS Care 2010;22:784–792.

10. Wejnert C. An Empirical Test of Respondent-Driven Sampling: Point Estimates, Variance, Degree Measures, and Out-of-Equilibrium Data. Sociol Methodol 2009;39:73–116.

11. Dombrowski K, Khan B, Moses J, Channell E, Misshula E. Assessing Respondent Driven Sampling for Network Studies in Ethnographic Contexts. Adv Anthropol 2013;3:1–9.

12. Heckathorn DD. Respondent-Driven Sampling: A New Approach to the Study of Hidden Populations. Soc Probl 1997;44:174–99.

13. Heckathorn DD. Respondent-Driven Sampling II: Deriving Valid Population Estimates from Chain-Referral Samples of Hidden Populations. Soc Probl 2002;49:11–34.

14. Gile KJ, Handcock MS. Respondent-Driven Sampling: An Assessment of Current Methodology. Sociol Methodol 2010;40:285–327.

15. Wejnert C. Social network analysis with respondent-driven sampling data: A study of racial integration on campus. Soc Netw 2010;32:112–24.

16. Dombrowski K, Khan B, Moses J, Channell E, Dombrowski N. Network sampling of social divisions in a rural Inuit community. Identities 2014;21:134–51.

17. Goodreau SM. A decade of modelling research yields considerable evidence for the importance of concurrency: a response to Sawers and Stillwaggon. J Int AIDS Soc 2011;14:12–12.

18. Goodreau SM. Assessing the Effects of Human Mixing Patterns on Human Immunodeficiency Virus-1 Interhost Phylogenetics Through Social Network Simulation. Genetics 2006;172:2033–45.

19. Valente TW. Social Networks and Health: Models, Methods, and Applications: Models, Methods, and Applications. Oxford University Press, USA; 2010.

20. Dombrowski K, Khan B, McLean K, Curtis R, Wendel T, Misshula E, et al. A Reexamination of Connectivity Trends via Exponential Random Graph Modeling in Two IDU Risk Networks. Subst Use Misuse 2013;48:1485–97.

21. Altmann M, Wee BC, Willard K, Peterson D, Gatewood LC. Network analytic methods for epidemiological risk assessment. Stat Med 1994;13:53–60.

22. Curtis R, Friedman SR, Neaigus A, Jose B, Goldstein M, Ildefonso G. Street-level drug markets: Network structure and HIV risk. Soc Netw 1995;17:229–49.

23. Friedman SR, Neaigus A, Jose B, Curtis R, Des Jarlais D. Networks and HIV risk: an introduction to social network analysis for harm reductionists. Int J Drug Policy 1998;9:461–9.

24. Kottiri BJ, Friedman SR, Neaigus A, Curtis R, Des Jarlais DC. Risk networks and racial/ethnic differences in the prevalence of HIV infection among injection drug users. J Acquir Immune Defic Syndr 1999. 2002;30:95–104.

25. Friedman SR, Curtis R, Neaigus A, Jose B, Jarlais DCD. Social Networks, Drug Injectors' Lives, and HIV/AIDS. 1st ed. Softcover of ed. 1999. Springer; 2010.

26. Dombrowski K. Topological and Historical Considerations for Infectious Disease Transmission among Injecting Drug Users in Bushwick, Brooklyn (USA). World J AIDS 2013;3:1–9.

27. Khan B, Dombrowski K, Saad M. A stochastic agent-based model of pathogen propagation in dynamic multi-relational social networks. Simul Trans Soc Model Simul Int 2014;90:460–84.

28. McPherson M, Smith-Lovin L, Cook JM. Birds of a Feather: Homophily in Social Networks. Annu Rev Sociol 2001;27:415–44.

29. Smith JA, McPherson M, Smith-Lovin L. Social Distance in the United States Sex, Race, Religion, Age, and Education Homophily among Confidants, 1985 to 2004. Am Sociol Rev 2014;79:432–56.

30. Merli MG, Moody J, Mendelsohn J, Gauthier R. Sexual mixing in Shanghai: Are heterosexual contact patterns compatible with an HIV/AIDS epidemic? Demography 2015;52:919–942.

31. Del Valle SY, Hyman JM, Hethcote HW, Eubank SG. Mixing patterns between age groups in social networks. Soc Netw 2007;29:539–554.

32. Heckathorn DD, Broadhead RS, Anthony DL, Weakliem DL. AIDS and social networks: HIV prevention through network mobilization. Sociol Focus 1999;32:159–179.

33. Blau PM. A macrosociological theory of social structure. Am J Sociol 1977;26–54.

34. Keeling MJ, Eames KT. Networks and epidemic models. J R Soc Interface 2005;2:295–307.

35. Handcock MS, Gile KJ, Fellows IE, Neely WW. Package "RDS." 2015; Available from: ftp://204.45.81.82/cran/web/packages/RDS/RDS.pdf

36. Greiner AL, Albutt K, Rouhani SA, Scott J, Dombrowski K, VanRooyen MJ, et al. Respondent-driven sampling to assess outcomes of sexual violence: a methodological assessment. Am J Epidemiol 2014;180:536–544.

37. Handcock MS, Gile KJ. Modeling social networks from sampled data. Ann Appl Stat 2010;4:5–25.

38. Hopfer S, Tan X, Wylie JL. A social network–informed latent class analysis of patterns of substance use, sexual behavior, and mental health: Social Network Study III, Winnipeg, Manitoba, Canada. Am J Public Health 2014;104:834–839.

39. Stormer A, Tun W, Guli L, Harxhi A, Bodanovskaia Z, Yakovleva A, et al. An Analysis of Respondent Driven Sampling with Injection Drug Users (IDU) in Albania and the Russian Federation. J Urban Health Bull N Y Acad Med 2006;83:i73–82.

40. Wang J, Falck RS, Li L, Rahman A, Carlson RG. Respondent-driven sampling in the recruitment of illicit stimulant drug users in a rural setting: Findings and technical issues. Addict Behav 2007;32:924–37.

41. Paquette DM, Bryant J, De Wit J. Use of respondent-driven sampling to enhance understanding of injecting networks: A study of people who inject drugs in Sydney, Australia. Int J Drug Policy 2011;22:267–73.

42. Wejnert C. Extensions Of Respondent-Driven Sampling: Web-Based RDS, Empirical Validation, And The Dual Homophily Model. PhD Dissertation 2009 Aug 19; Available from: Url: http://ecommons.library.cornell.edu/handle/1813/13472