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Peer influence of injection drug use cessation among dyads in rural Eastern Kentucky

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Abstract

Background: This analysis aims to assess whether injection drug use cessation among peers predicts injection drug use cessation among individuals and explores whether this association varies by relationship type and strength.

Methods: Data were collected through baseline and 6-month assessments for the Social Networks among Appalachian People study (2008–2011). Interviewer-administered surveys collected sociodemographic and drug use behaviors (past 6 months and lifetime). Participants also listed sex, drug use, and social support partners (past 6 months). Listed names were cross-referenced with survey participants to identify relationships between study participants. The analytic sample was further restricted to include only those relationship pairs where both individuals reported a history of injection drug use at baseline (n=244 unique individuals and 746 dyads). We fit a generalized estimating equations logistic regression model to (1) assess the relationship between peer injection cessation and individual injection cessation and (2) determine

whether the strength of this association differs by relationship-level variables (i.e., relationship role, relationship type, relationship duration, frequency of interaction, residential proximity).

Results: Overall, those with a network member who ceased injection drug use were more likely to stop injecting over the following 6-month period (AOR=1.65). The magnitude of this association was greater for social support partners (AOR=2.95), family members (AOR=3.56), those with whom the participant interacted at least daily (AOR=2.17), and those who the participant knew longer (AOR=2.09). Further, among family members, the effect size was greater when relationships were further restricted to immediate family members (AOR=5.35).

Conclusion: Our findings suggest that in this rural community, closer, more supportive relationships, may be more influential for modeling injection cessation; however, relationship-types were not mutually exclusive so differences in effect size across strata may not be statistically significant. In this setting, social support through the recovery process (including cessation attempts with peers) may increase likelihood of injection cessation.

Keywords

Injection Drug Use; Social Network Analysis; Rural; Cessation; Peer Influence

Introduction

Rural Appalachia has been hit hard by the intersecting opioid use disorder (OUD), injection drug use, and HCV epidemics.(Zibbell et al., 2015) Between 2006 and 2012, the annual HCV incidence rates in rural areas were nearly double those in urban areas, and were particularly high in the central Appalachian region of the United States.(Zibbell et al., 2015) Following the HIV outbreak in rural Indiana, the CDC conducted a vulnerability assessment, which identified 220 counties with high rates of HCV and increased vulnerability to an HIV outbreak (if HIV were introduced) among persons who inject drugs (PWID).(Van Handel et al., 2016) Of note, 54 of these 220 counties are in Kentucky. Kentucky is also an epicenter for overdose. For example, between 2000 and 2010, Kentucky's overdose fatality rate increased by 282%. The mortality rate continued to increase between 2010 and 2016 (23.6 to 33.5 deaths per 100,000 population).(Centers for Disease Control and Prevention, 2017) In the context of the risk environment framework and the modified social ecological model, disparities in the prevalence of HCV, injection drug use, overdose, and other drug-related harms are the result of upstream social and structural factors (i.e., social, economic, political, organizational).(Baral, Logie, Grosso, Wirtz, & Beyrer, 2013; Galea, Ahern, & Vlahov, 2003; Rhodes, 2002, 2009) Although these harms are experienced at the individual-level, their relationship with upstream factors may be mediated or moderated by social networks and social support. Drug use is ultimately a "social activity, involving social interactions within particular social environments"(Rhodes et al., 2003).

At the individual-level, injection cessation has been associated with the type(s) of drug(s) used, less frequent recent injection drug use, and sociodemographic characteristics (i.e., younger age, employed, male gender) (Deren, Kang, Colón, & Robles, 2007; Evans, Hahn, Lum, Stein, & Page, 2009; Mehta et al., 2012; Nambiar, Agius, Stoové, Hickman, & Dietze, 2015; Steensma, Boivin, Blais, & Roy, 2005). Those using heroin, heroin with other drugs,

alcohol, or benzodiazepines; and those who were homeless were less likely to cease injection drug use (Evans et al., 2009; Nambiar et al., 2015; Steensma et al., 2005). Several studies noted that those who recently participated in drug detoxification, residential treatment, methadone maintenance, and 12-step programs (Evans et al., 2009), and specifically methadone maintenance (Horyniak et al., 2018; Nambiar et al., 2015), were more likely to cease injection drug use. However, one study reported that participation in methadone maintenance, outpatient treatment, residential treatment, Narcotics' Anonymous, or detoxification was not associated with cessation of injection drug use – likely due to limited access (Hadland, Wood, Nosova, Kerr, & DeBeck, 2017) and another reported that abstinence-based treatment methods like 12-step programs impeded injection cessation efforts (Boyd, Fast, Hobbins, McNeil, & Small, 2017). There have also been mixed findings with respect to the direction of the association between injection drug use cessation and recent arrest (Hadland et al., 2017; Horyniak et al., 2018; Nambiar et al., 2015), and incarceration (Deren et al., 2007; Mehta et al., 2012).

At the neighborhood level, Nandi and colleagues (2010) reported a strong association between neighborhood poverty and injection drug use cessation, with those living in neighborhoods with a greater proportion of residents living in poverty being more likely to continue injecting. (Nandi et al., 2010) Genberg and colleagues (2011) similarly found that those living in neighborhoods with greater deprivation were less likely to cease injection drug use. They also reported that those who moved neighborhoods were more likely to stop injecting drugs, but that this effect varied depending on the level of deprivation of the neighborhood that the individual was moving to; moving from a highly deprived to less deprived neighborhood had the strongest positive effect, while continuing to reside in a deprived neighborhood was most detrimental. (Genberg et al., 2011)

According to the risk environment framework and the modified social ecological model, the relationship between aspects of the physical and social environment (i.e., neighborhood disadvantage, availability of treatment for substance use and mental health disorders, access to drugs and sterile injecting equipment) may be modified by social networks and social support. Similarly, in Berkman's conceptual model for how social networks impact health, social networks (measured via network characteristics, network relationships, and structure) act at the mezzo level to provide opportunities for social support, social influence/selection, social engagement, access to resources, and person-to-person contact. These in turn influence risk and health-seeking behaviors. (Berkman & Glass, 2000; Berkman, Glass, Brissette, & Seeman, 2000) Prior studies have shown that those with larger and more dense drug use networks (i.e., structure) reported more frequent injection drug use (C. Latkin et al., 1995) and riskier injection practices. (De, Cox, Boivin, Platt, & Jolly, 2007; C. Latkin, Mandell, Vlahov, Oziemkowska, & Celentano, 1996) Another cross-sectional study reported that the odds of injection increased as the number of socially proximal peers (2 degrees of separation) who injected increased (i.e., network characteristics). (Rudolph, Young, & Havens, 2017). There have been a few longitudinal studies which have examined injection risk behaviors and changes in drug use over time. For example, one longitudinal study characterized the influence of network turnover (i.e., network characteristics) for both network members who used drugs and those who did not on injection risk behaviors. They reported an increase in riskier injection practices when individuals who injected were added

to the network, but a reduction in risk behaviors when those added to the network did not inject. They also reported a reduction in risky injection practices when individuals who injected drugs left the network.(Costenbader, Astone, & Latkin, 2006) Buchanan and colleagues similarly used longitudinal data to examine changes in one's network following drug use cessation (but not injection drug use cessation) and found that drug use cessation was positively associated with a reduction of PWUD in one's network at a later time point. (Buchanan & Latkin, 2008)

Another longitudinal study specifically aimed to examine the role of both social selection and social influence in the longitudinal association between heroin and/or cocaine use among individuals and their networks. Their findings provide support for both social influence and social selection processes among adults with persistent drug use over time. However, most longitudinal changes in drug use were due to changes in network composition rather than to changes in friends' behaviors.(Bohnert, Bradshaw, & Latkin, 2009) Compared with prior findings from studies among adolescents, this study among adults reported that social selection played a greater role.(Bohnert et al., 2009) They hypothesized that this is due to adults having greater control over who they spend their time with and having less malleable attitudes than adolescents.(Bohnert et al., 2009) The authors also explained that compared with network members with whom individuals report drinking alcohol, drug use network members may play a greater role in helping individuals to acquire drugs.(Bohnert et al., 2009)

Another study which examined the relationship between network characteristics and cessation of heroin, crack and cocaine among an urban sample of persons who injected drugs at baseline found that having a smaller proportion of PWUD in their network at baseline predicted drug use cessation at follow-up, suggesting a role for social influence on cessation of drug use.(C. A. Latkin, Knowlton, Hoover, & Mandell, 1999) These findings remained significant even after adjusting for participation in a drug treatment program, which suggests that changes in network composition are not only the result of drug treatment enrollment.(C. A. Latkin et al., 1999)

A smaller number of studies have focused on network correlates of injection drug use cessation. For example, a few prospective studies reported that injection drug use cessation was less likely for those who maintained relationships with network members who use drugs(Bouhnik et al., 2004; Buchanan & Latkin, 2008) or inject drugs.(Deren et al., 2007) Findings from a qualitative study suggest that injection cessation is more likely among those with friends, family, or care providers who could provide housing or social support.(Boyd et al., 2017)

An area that has not been extensively studied is whether *injection* drug use cessation among peers predicts *injection* drug use cessation among individuals, particularly in a rural setting and further, whether this association is modified by relationship-level factors. Because injection drug use is an observable behavior that is not necessarily transmitted through risk behaviors, it is unknown whether the behaviors of some peers are more influential than others. For example, is the relationship between peer injection cessation and individual injection cessation different for network members with whom the individual uses drugs or

has sex, or for relationships where social support is exchanged? Similarly, the extent to which the association between peer injection cessation and individual injection cessation varies by relationship duration, geographic proximity or shared environment, frequency of interaction, and closeness of the relationship has not been studied. The purpose of this analysis is to (1) assess whether having a peer who had a history of injection but who stopped injecting (i.e., injection drug use cessation) predicts injection drug use cessation within the past 6 months among individuals (all relationships considered equal) and (2) explore whether the strength of this association varies by relationship-level factors (i.e., relationship role, relationship type, duration of relationship, frequency of interaction, residential proximity) among an adult sample of PWUD in rural Eastern Kentucky.

Methods

Study Site

The Central Appalachian region, where this study was conducted, is characterized by higher levels of economic distress, with concentrated areas of extensive poverty and unemployment.(Appalachian Regional Commission, 2011b) both of which are risk factors for substance use. According to the Appalachian Regional Commission, Appalachian Kentucky had the highest poverty rate and the second highest three-year average unemployment rate in the Appalachian region. The particular county from which study participants were enrolled had a poverty rate of 29%, which is higher than the United States Average Poverty Rate (12.4%).(Appalachian Regional Commission, 2011a) This region of Eastern Kentucky is also an epicenter for prescription opioid use, overdose, and HCV and is the nation's 4th most vulnerable county to an HIV/HCV outbreak linked to injection drug use.(Brawley, Sanders, & Miracle, 2016)

Recruitment and Enrollment Procedures

The data for this analysis were collected as part of the Social Networks among Appalachian People (SNAP) study, an ongoing, longitudinal study of 503 adult PWUD in rural Eastern Kentucky. SNAP methods are described in detail elsewhere.(A. M. Young, Jonas, Mullins, Halgin, & Havens, 2012) Briefly, participants were recruited through respondent-driven sampling between 2008 and 2010.(April M Young, Rudolph, Quillen, & Havens, 2014) Questionnaires were administered at baseline and at 6-month intervals by a trained interviewer using Computer Assisted Personal Interviewing (CAPI) software (Questionnaire Development System [QDS], Nova Research Company, Bethesda, MD). The baseline survey collected residential addresses, demographic characteristics (i.e., gender, age, years living in Eastern Kentucky, months of education, monthly income from employment, and whether or not the participant spent any time in jail over the past 30 days), types of drugs used (ever and in the past 6 months) and mode of drug administration for each, and information about recent (past 6-month) network members. Follow-up study visits collected information about risk behaviors and patterns of drug use over the past 6 months. The study protocol was approved by the Institutional Review Board at the University of Kentucky and a Certificate of Confidentiality was obtained from the National Institute of Health.

This analysis uses data from the baseline and 6-month surveys, only. Because our analysis focuses on correlates of injection cessation, individuals included in the analysis must have reported injecting in the past 6 months at baseline (N=244). Further, because we were interested in the relationship between injection drug use cessation among peers and injection drug use cessation among individuals, we only included network members (peers) who self-reported ever injecting in their lifetime at baseline. This resulted in a total of 746 relationship pairs.

Network data collection and management

At baseline, participants were asked to provide the first name and first letter of the last name for recent (past 6 months) drug use partners, sex partners, and those who provided him/her with social support (i.e., emotional, financial, material, or informational support). Up to 8 names were permitted for each name generator, for a maximum of 24 unique network members. (Rudolph et al., 2017; April M Young, Rudolph, & Havens, 2018) For each network member named, demographic characteristics (i.e., age, gender) and relational data (i.e., relationship type, frequency of interaction, relationship duration in months, and roles fulfilled) were also collected. Network member names and demographic characteristics (age and gender) were cross-referenced with those of study participants to identify pairs of participants who knew one another. We assumed that individuals knew one another if at least one member of the pair reported knowing the other. This resulted in 746 relationship pairs involving 244 unique individuals. Of note, we constructed the network using only network members listed in the personal network inventory and did not rely on RDS-referrals. In other words, if a person's RDS recruiter or recruit was not confirmed as a network member through the personal network inventory (i.e., at least one member of the dyad named the other as a social support, drug use, or sex partner), the relationship was not included in this analysis. Only 27% of the relationship pairs examined here were also RDS referral ties; however, all of the 746 relationships were listed in the personal network inventory. More details on RDS recruitment, RDS diagnostics, and the network construction procedure are provided elsewhere. (Rudolph et al., 2017; Rudolph, Young, & Havens, 2019; April M Young et al., 2014; April M Young et al., 2016)

Outcome – Individual Injection Drug Use Cessation

For each of the 244 study participants included in the analysis, injection cessation was coded as 1 for those who reported injecting in the past 6 months in the baseline survey but not in the past 6 months at the first follow-up visit. Injection cessation was coded as 0 for those who reported injecting drugs in the past 6 months at both study visits (i.e., continued injection).

Primary Exposure – Peer Injection Drug Use Cessation

Because all network members included in this analysis were also study participants, we used self-reported data on injection status, rather than information about injection status reported by his/her peer. In order to ensure that peer injection drug use cessation preceded injection drug use cessation among individuals, we coded peer injection drug use cessation as 1 for those who reported ever injecting in their life but not in the past 6 months at baseline (based on their responses in the baseline survey). Peer injection cessation was coded as 0 for those

who reported ever injecting in their life and injecting in the past 6 months at baseline (i.e., continued injection).

Relational Attributes

Relational data considered for this analysis included relationship type (i.e., drug use partner, sex partner, or exchange of social support), multiplexity (i.e., drug use partnership where social support is also exchanged), network member role (i.e., family member, immediate family member, non-family member), frequency of interaction over the past 6 months, distance between residences in miles, and relationship duration in months. For reciprocal relationships (i.e., relationships where each member of the pair reported knowing the other), we used information reported about the relationship by the focal person in the dyadic analysis. For example, if A reported knowing B and B reported knowing A, we used the information about the relationship reported by A when examining A's odds of injection cessation. Similarly, when examining B's odds of injection cessation, we used the information about the relationship that was reported by B. If only one member of the pair reported knowing the other (i.e., A reports knowing B but B does not report knowing A), we used the relationship-level data reported by A for both relationships (A->B and B->A). For example, if A reports knowing B for 120 months but B does not report knowing A, we assumed that both individuals knew one another for 120 months (i.e., A knows B for 120 months and B knows A for 120 months). More details on this procedure have been described previously, with a corresponding sensitivity analysis.(Rudolph et al., 2019) To compute residential distance, we calculated the shortest road network distance between the residential addresses reported by each member of the pair. Details on this procedure have been previously described in greater detail.(Rudolph et al., 2019; April M Young et al., 2016)

Dyadic Network Analysis

The network data for this analysis included only those who listed (or were listed as a network member by) at least one other person in the study sample. Because we aimed to assess the effect of peer injection drug use cessation on individual injection drug use cessation, we restricted the analytic sample to include only those where both individuals reported a history of injection drug use at baseline. To further clarify, all individuals and their network members had to have reported a history of injection drug use at baseline, but only individuals contributing to the outcome measure (not network members, who contribute only to the exposure measure) had to report injection drug use in the past 6 months at baseline. Network members must have reported a history of injection drug use at baseline; those network members who reported injecting drugs in the past 6 months at baseline were considered to be currently injecting and those network members who reported a history of injection drug use at baseline but no injection drug use in the past 6 months at baseline were considered to have stopped injecting. This resulted in the inclusion of 244 unique individuals and 746 unique dyads. Using the 'geepack' package in R version 3.5.1, we fit a generalized estimating equations logistic regression model and regressed individual injection drug use cessation on peer injection drug use cessation. To account for the fact that unique individuals could enter the analysis multiple times due to their relationships with two or more study participants, we clustered on individuals and specified a robust variance estimator to account

for misspecification of the working correlation structure. Our analyses aimed to (1) assess the relationship between peer injection cessation and individual injection cessation overall and (2) use stratified analyses to determine whether the strength of this association varies by relationship-level variables (i.e., relationship role, relationship type, duration of relationship, frequency of interaction, residential proximity).

Results

As seen in Table 1, the median sample age was 30 years and most had spent the majority of their life in Eastern Kentucky (median=29 years; IQR:24–34). Overall, 36.5% reported receiving any income from employment in the past 30 days; among those reporting any source of income from employment, the median income reported was \$650 US dollars per month. Most had completed high school or had a GED, 93.9% were non-Hispanic white, and over half were male (57.8%). Of the drugs injected in the 6 months prior to completing the baseline survey, nonmedical use of prescription opioids were most frequently reported (94.3%), followed by cocaine (40.2%), and heroin (9.8%). In this sample, the median relationship duration was approximately 10 years and this did not differ for those who ceased injection vs. continued injecting. Overall, relationships with sex partners were shorter (median=5 years) and relationships with drug partners and those with whom support was exchanged were longer (median=11 years and 12 years, respectively).

Based on data from the 6-month survey, 15.6% had spent time in jail over the past 30 days. Of the 244 individuals sampled, 29.5% stopped injecting drugs between the baseline and 6-month follow-up survey. Those who stopped injecting drugs between the baseline and 6-month study visit were less likely to have reported injecting prescription opioids or heroin at the baseline study visit, and slightly more likely to have reported injecting cocaine. Of note, there were no statistically significant differences with respect to the type of drug used for those who stopped injecting and those who continued injecting.

Figure 1 depicts the overlapping types of relationships present in our sample. Of the 746 relationships included in the dyadic analysis, 35.7% involve social support, 92.0% involve drug co-usage, and 24.8% were sex partners. However, many of these relationships fulfilled more than one role. For example, 9.8% of network members fulfilled all three roles, 83.8% of partnerships that involved exchange of social support also involved co-usage of drugs, and 84.3% of sex partners were also drug use partners. Drug use partners were less likely than social support or sex partners to fulfill multiple roles (i.e., 55.4% fulfilled only this role); however, when they fulfilled more than one role, they were most likely to also involve the exchange of social support. Only 11.7% of partnerships involving exchange of social support and 9.2% of sex partners did not play another role.

Table 2 presents the odds of injection drug use cessation (i.e., reported injecting drugs in the past 6 months at baseline but not at the first follow-up visit) for those with peers who reported injecting in their lifetime but not in the past 6 months at baseline, overall and stratified by relationship-level attributes. For example, we considered 746 relationships in total, of which 266 involved the exchange of social support, 185 were sex partners, and 686 involved co-usage of drugs. As depicted in Figure 1, these are not mutually exclusive

relationships. In Table 2, we present unadjusted associations and adjusted associations which account for the individual's age (years), sex, months of education, recent time spent in jail (no time vs. any time in the past 30 days), and monthly income from employment (US dollars). Age (Evans et al., 2009; Huo, Bailey, & Ouellet, 2006; Shah, Galai, Celentano, Vlahov, & Strathdee, 2006), sex (Shah et al., 2006), education (Mehta et al., 2012), incarceration (DeBeck et al., 2009; Mehta et al., 2012), and employment (Steensma et al., 2005) have all been previously associated with injection drug use cessation. Although these variables were not significantly associated with injection drug use cessation in our sample (see Table 1), they were included as potential confounders based on their demonstrated relationship with injection drug use cessation in the prior literature.

Overall, those with a network member who ceased injection drug use were more likely to stop injecting over the following 6-month period (OR=1.67 95%CI:1.06–2.63; AOR=1.65 95%CI:1.03–2.65). The magnitude of this association was greater when restricted to social support partners (AOR=2.95), family members (AOR=3.56), those with whom he/she interacted at least daily (AOR=2.17), and those who he/she knew for more than five years (AOR=2.09). Further, among family members, the effect size was larger when relationships were further restricted to include only immediate family members (i.e., parent, step-parent, child, sibling, spouse) (AOR=5.35; 95%CI:1.91–14.96). Of note, the precision of this estimate was very low due to the smaller number of relationships in this category (N=117). Because the relationships examined in this table are not mutually exclusive, it is difficult to determine whether the differences in the effect sizes observed across strata are statistically significant; there are qualitative differences in the strength of the associations reported, but the confidence intervals do overlap.

Despite being the largest strata, the association was not statistically significant when only drug use relationships were considered (AOR=1.42 95%CI:0.90–2.23). The association was also not significant when restricted to only sex partners (AOR=1.78; 95%CI:0.80–3.99). Importantly, the association between peer injection drug use cessation and individual injection drug use cessation was positive for each strata considered, even though many of these associations were not statistically significant in the present study.

Discussion

Among those who reported injecting drugs at baseline, 29.5% reported stopping injection between the baseline and 6-month follow-up visit. It is important to note that in this particular rural community, (1) access to methadone maintenance and other legal forms of medication for opioid use disorder (MOUD) were extremely limited, (2) a majority of those who stopped injecting drugs continued to use drugs via non-injection routes, and (3) injection cessation in this sample is more likely to reflect changes in the type(s) of drug(s) used and changes in mode of administration (i.e., injection to smoking or snorting) and is less likely to reflect tighter regulations which limit access to prescription opioids. First, with respect to access to MOUD, only one participant in our sample reported having enrolled in methadone maintenance in the past 6 months at the 6-month study visit. Instead, most individuals reported using other types of programs for assistance between the baseline and 6-month follow-up visit; 5 reported enrolling in non-methadone detoxification programs in

the past 6 months and 14 reported enrolling in 12-step programs in the past 6 months (4 reported enrolling in both non-methadone detoxification and 12-step programs). For this reason, MOUD among peers or individuals is unlikely to explain the relationships observed here. Second, in our sample, 90.28% of those who were classified as ceasing injection drug use between the baseline and the 6-month visit still reported using prescription opioids to get high at the 6-month study visit; although not via injection. Among those who continued to inject, 98.84% reported using prescription opioids to get high. The high proportion of persons sampled who report use of prescription opioids at the 6-month visit suggests that injection cessation is not the result of restricted access to prescription opioids in our sample. Instead, it more likely reflects changes in drug use patterns (i.e., decreasing cocaine and heroin use, increasing methamphetamine use) and harm reduction (i.e., switching from injection of prescription opioids to non-injection modes of administration).

Some studies among adults have reported that changes in drug use were more likely to reflect changes in network composition than changes in friends' behaviors (i.e., social selection) (Bohnert et al., 2009) while others have reported evidence of social influence (C. A. Latkin et al., 1999). The current study is only able to assess the role of social influence, as we used the network structure and network members' injection status at baseline to predict injection cessation among individuals between the baseline and 6-month follow-up visit. Although the current analysis could not assess the role of relationship turnover, the long relationship duration reported for ties is a notable strength of the current analysis, because it permitted us to examine the effect of peer injection drug use cessation on recent injection drug use cessation among individuals. Our findings are consistent with those of Latkin and colleagues (1999) which suggest a role for social influence in an urban center. There are at least two potential explanations for the observed findings. First, observing others in one's network (and particularly those with whom he/she is closest) stop injecting may increase one's motivation to stop injection. Our observation that the peer-influence of injection cessation was stronger for relationships involving exchange of social support than for relationships characterized by risk (i.e., sex or drug use partnerships) is consistent with this theory and findings from Latkin and colleagues, who reported that social support predicted a lower risk of relapse (C. A. Latkin et al., 1999). It is also consistent with prior findings which showed that women in Baltimore who had a smaller proportion of network members who used drugs and a larger proportion of network members who were kin were less likely to report exchanging sex for drugs of money (median proportion of network who were kin: 38% for those exchanging vs. 50% for those not exchanging sex for money) (Rudolph, Linton, Dyer, & Latkin, 2013). The second hypothesis is that injection drug use is a social behavior. As injection drug use within a person's circle of friends and family members decreases (1) norms shift away from injection drug use and (2) there are fewer peers available to inject with; both of which could result in individual-level changes in drug use practices.

Our observation that the influence of peer injection cessation was stronger when peers were family members is supported by findings from others which demonstrated that (1) interventions including family therapy were more effective than individual or mixed approaches (Johansen, Brendryen, Darnell, & Wennesland, 2013) and (2) positive family relationships can reduce the likelihood of relapse (Duffy & Baldwin, 2013). This may be

particularly important in the Appalachian context, where close personal bonds among family members are common (Hicks, Ergood, & Kuhre, 1976) and the family is considered to be a “central unit of rural Appalachian social organization” (Keefe, 1988)(p 24). Our findings are also consistent with previous research suggesting that the importance of these bonds be considered in the delivery of healthcare for Appalachians. (Hansen & Resick, 1990; Keller & Helton, 2010) Our work extends this recommendation to the consideration of familialism and social support when developing programs for substance use treatment and harm reduction for those in rural Appalachia.

Limitations

Because we used self-reported information about injection drug use in one’s lifetime and over the past 6 months for both members of the dyad, it is possible that some relationships between participants were not reported (i.e., participants knew one another but omitted these relationships from the network inventory survey) and thus not captured in our analysis. There is some evidence in the literature to suggest that the most influential network members are nominated first (Burt, 1984; Hickson et al., 2017; Merluzzi & Burt, 2013); thus, those not listed may be less likely to influence individual behaviors. Further, because network members could only be included in the sample if they were also study participants, our analysis is limited because we were not able to assess peer-influence for network members who were not also study participants, however, the implications of this limitation are much less for a dyadic analysis than they would be for a sociometric network analysis.

Our analytic approach also assumed that if at least one person in the dyad reported knowing the other that a relationship was present. This assumption is reasonable given that our name generating questions elicited the names of sex partners, drug partners, and those who provided some form of social support. For example, if person A lists person B as someone with whom he/she uses drugs and person B does not similarly list person A, it is more likely that person B forgot to mention or intentionally omitted person A than it is that the two are not connected. This approach is consistent with the approach used in other published research on risk networks. (Rudolph et al., 2017, 2019; April M Young et al., 2016)

For the dyadic analysis, we also assumed that the relationship characteristics (i.e., drug use partner, sex partner, family/immediate family member, daily interaction, and relationship duration) reported by A about B could be applied to the relationship between B and A if B did not list A as a network member. This assumption is likely to be valid for all of the variables assessed, with the exception of provision of social support, which may not be reciprocal. As we cannot assume that the provision of social support is reciprocal in these relationships, the interpretation of this variable in our analysis is the peer-influence among relationships where some form of social support is exchanged.

There is also a potential for misclassification of our peer measure of injection drug use cessation. Although individual injection drug use cessation was measured as self-reported injection drug use in the 6 months prior to the baseline survey but not in the 6 months between the baseline survey and the 6 month follow-up survey, peer-injection cessation was defined as having ever reported injection drug use in his/her lifetime, but not in the past 6

months at the time of the baseline survey. In this way, peers who stopped injecting 5 years ago are treated the same as those who stopped injecting in the past 6 months. To examine this further, we looked at the year that network members reported for the date of last injection and the date of the baseline interview to determine a cut-point that was most comparable to the cut-point we used to measure individual injection drug use cessation (i.e., injected within the past 12 months but not within the past 6 months). Given that the date of last injection variable was discretized by year, we considered those who reported (1) not injecting in the past 6 months at the baseline survey and (2) that their last injection was in the same year as the baseline survey or within the two years prior to the baseline survey to be *recent* injection drug use cessation events. This corresponds with 54% of the network members currently classified as having ceased injection drug use in our sample. We re-ran the same stratified analyses presented in Table 2, but with only those alters who reported that their last injection was within two years of their baseline interview (n=677 dyads). All adjusted and unadjusted associations were in the same direction as those reported in Table 2, but due to the smaller sample size for the sensitivity analysis, the confidence intervals were generally wider and the point estimates for the following strata were no longer statistically significant in the restricted adjusted models: family members, immediate family members, relationships where drugs were used and support was exchanged, relationships where the two interacted at least daily, and all types of relationships grouped together. Interestingly, while the adjusted odds ratio for the family strata was not statistically significant in the restricted model, it was statistically significant in the unadjusted restricted model (OR_{restricted}:2.73; 95%CI:1.09–6.80). It is also noteworthy that the point estimate and significance for relationships where social support was exchanged remained stable across the models (AOR_{original}:2.95; 95%CI:1.55–5.63 and AOR_{restricted}:2.94; 95%CI:1.19–7.23). The strata representing relationships which were greater than five years long also remained stable and significant in the restricted model (AOR_{original}:2.09; 95%CI:1.24–3.51 and AOR_{restricted}:2.27; 95%CI:1.09–4.70), likely because relationships where social support was exchanged tended to be longer in duration, on average. The fact that the point estimate for relationships involving exchange of social support remained consistent in both models provides some reassurance that the variation in time since injection cessation among alters included in our analysis is not likely to bias our main finding.

Additionally, our baseline cohort was recruited over a two year period. Thus, even though a peer's injection status was reported in an earlier survey than the individual's injection status, it is possible for a peer's 6-month interview to occur before that of his/her network member's baseline survey, depending on which peer was enrolled in the survey first and the time between the two baseline interviews.

As many people report periods of injection drug use cessation, maintained injection, and relapse over the course of their life, it is possible that individuals who were categorized as stopping injection drug use in our analysis may have had other attempts at injection drug use cessation in the past. Because we did not collect this information at baseline, we were unable to account for this variable in our analysis. There is also a potential for social desirability bias to influence self-reported responses on injection drug use status.

Conclusion

These findings can be used to inform both practice and network data collection methods. First, our findings suggest that in the Appalachian context, social support throughout the recovery process (including cessation attempts with peers) may increase likelihood of successful and sustained cessation. This is consistent with other research in a variety of different contexts which has shown that peer support can increase rates of abstinence and satisfaction with substance use treatment and decrease the frequency of relapse (Tracy & Wallace, 2016). It is also consistent with qualitative research highlighting the important role of receiving help from supportive network members for one's personal recovery journey. (Johansen et al., 2013) One potential future direction of this research is the development of substance use treatment programs which are designed for family members or peers who can support one another, rather than for individuals. In the Appalachian context, where the family is a central unit of society, approaches that consider familism and social support may be particularly effective. If individuals are permitted to initiate the recovery process together and can rely on each other for support throughout the process, outcomes may improve (i.e., better retention, fewer relapses).

Our findings also highlight the relevance of collecting information about social support networks in addition to drug use and sex networks when examining drug use risk behaviors, particularly risk reduction and health service use. For example, analyses which aim to better understand injection and drug use behaviors typically focus on drug use ties as the most relevant relationship; however, in this analysis, we found that the relationship between peer cessation of injection drug use and individual cessation of injection drug use was statistically significant for relationships where social support was exchanged, but not for drug use or sex partners. Importantly, the direction of the effect was positive for all relationship strata, and some strata were smaller than others, which limited our power to detect significant differences. Also, because the relationship roles were not mutually exclusive, we cannot say with certainty that the association observed in one strata is statistically different than one observed in another strata, even though the effect sizes may differ. Thus, we believe it is important for future studies to collect information on both social support and risk relationships.

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Figure 1.
Prevalence of overlapping network roles among dyads, as a count and percent of all dyads considered (n=746)

Table 1:

Descriptive statistics for PWUD in rural Eastern Kentucky who reported injecting in the past 6 months at baseline, overall and for those who did and did not cease injection between the baseline and 6-month study visit (N = 244)

	ALL N=244	Injection Cessation N = 72	Continued Injection N = 172
Individual-level variables	Median (IQR)	Median (IQR)	Median (IQR)
Age (years)	30.0 (26.0, 36.0)	31.0 (25.0, 40.0)	30.0 (26.0, 35.0)
Years living in Eastern Kentucky	29.0 (24.0, 34.0)	29.5 (22.0, 37.0)	29.0 (24.0, 33.0)
Education (months), median (IQR)	144.0 (120.0, 144.0)	144.0 (120.0, 144.0)	144.0 (120.0, 144.0)
Income from employment, or net income (past 30 days, US Dollars)	0 (0, 400.0)	0 (0, 354.8)	0 (0, 400.0)
Among those receiving any income from employment in the past 30 days, income from employment (past 30 days, US Dollars)	650 (300, 1200)	750 (364, 1275)	600 (300, 1000)
	N (%)	N (%)	N (%)
Received any income from employment (past 30 days)	89 (36.48)	24 (33.33)	65 (37.79)
Sex (male)	141 (57.79)	38 (52.78)	103 (59.88)
Jail (no time spent in jail over past 30 days) ^I	206 (84.43)	61 (84.72)	145 (84.30)
Types of drugs injected to get high (past 6 months)			
Prescription Opioids	230 (94.26)	66 (91.67)	164 (95.35)
Prescription Stimulants	10 (4.10)	4 (5.56)	6 (3.45)
Prescription Benzodiazepines	10 (4.10)	4 (5.56)	6 (3.45)
Methamphetamine	5 (2.05)	1 (1.39)	4 (2.33)
Cocaine	98 (40.16)	29 (40.28)	69 (40.12)
Heroin	24 (9.84)	7 (9.72)	17 (9.89)
Drug treatment history (previous enrollment in lifetime)			
Methadone detox	18 (7.38)	5 (6.94)	13 (7.56)
Methadone maintenance	35 (14.34)	7 (9.72)	28 (16.28)
Outpatient drug free	43 (17.62)	12 (16.67)	31 (18.02)
Residential treatment	107 (43.85)	27 (37.50)	80 (46.51)
Non-methadone detoxification	28 (11.48)	2 (2.78)	26 (15.12)
12-step program (AA/NA)	92 (37.70)	22 (30.56)	70 (40.70)
Drug treatment between baseline and 6-month visit ^I			
Methadone detox	29 (11.89)	7 (9.72)	22 (12.79)
Methadone maintenance	1(0.41)	1 (1.39)	0 (0.00)
Outpatient drug free	5 (2.05)	2 (2.78)	3 (1.74)
Residential treatment	12 (4.92)	3 (4.17)	9 (5.23)
Non-methadone detoxification	5 (2.05)	0 (0.00)	5 (2.91)
12-step program (AA/NA)	14 (5.74)	3 (4.17)	11 (6.40)
Relationship-level variables	Median (IQR)	Median (IQR)	Median (IQR)
Relationship duration across all types of relationships (months)	120 (44, 288)	120 (24, 276)	120 (48, 288)

Relationship duration stratified by relationship type

Social support partner	144 (48, 276)	126 (36, 273)	156 (48, 276)
Sex partner	60 (13, 120)	42 (12, 120)	60 (24, 120)
Drug use partner	132 (48, 300)	120 (36, 276)	132 (48, 300)

[/] Measured at 6-month follow up survey; all other variables were measured at baseline

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Table 2:

Dyadic Results: Odds of ceasing injection drug use between baseline and 6 months based on network member injection cessation status, overall and stratified by relationship type (N=746 relationship pairs)

	# of network relationships considered ¹	# of relationships where the individual stopped injecting drugs	# of relationships where the individual continued injecting drugs	Odds Ratio ² and 95% Confidence Interval	Adjusted Odds Ratio ³ and 95% Confidence Interval
Overall	746	203	543	1.67 (1.06, 2.63)	1.65 (1.03, 2.65)
<i>Stratified by Relationship-Level attributes⁴</i>					
Exchange of social support	266	74	192	2.59 (1.36, 4.94)	2.95 (1.55, 5.63)
Sex partner	185	56	129	1.71 (0.78, 3.76)	1.78 (0.80, 3.99)
Family member	209	59	150	3.33 (1.61, 6.91)	3.56 (1.63, 7.78)
Immediate family member ⁵	117	35	82	3.89 (1.58, 9.57)	5.35 (1.91, 14.96)
At least daily interaction	442	127	315	1.98 (1.14, 3.43)	2.17 (1.21, 3.88)
Drug use partner	686	177	509	1.44 (0.87, 2.37)	1.42 (0.90, 2.23)
Drug use partner and exchange of social support	223	52	171	2.71 (1.24, 5.93)	2.97 (1.43, 6.15)
Residential distance ⁶ < 4 miles	498	149	349	1.70 (1.01, 2.86)	1.62 (0.98, 2.67)
Relationship duration > 5 years	484	123	361	2.01 (1.12, 3.59)	2.09 (1.24, 3.51)

¹ All network relationships where the individual reported injecting in the past 6 months at baseline and the network member reported injecting during lifetime

² The odds of injection cessation among those with a network member who did not inject within 6 months prior to baseline vs. the odds of injection cessation among those with a network member who injected drugs within 6 months prior to baseline.

³ The odds in ², adjusted for the individual's age, sex, education, recent time spent in jail (binary), and monthly income from employment (net income).

⁴ Counts do not sum to 746 because the strata are not mutually exclusive

⁵ Immediate family includes: father, mother, daughter/son, sister/brother, step-mother/step-father, and husband/wife

⁶ Distance was not recorded for 19 ego/alter pairs; they were removed from this row of the table.