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Bidirectional influence: A longitudinal analysis of size of drug network and depression among inner-city residents in Baltimore, Maryland

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Abstract

BACKGROUND—The prevalence of depression among drug users is high. It has been recognized that drug use behaviors can be influenced and spread through social networks.

OBJECTIVES—We investigated the directional relationship between social network factors and depressive symptoms among a sample of inner-city residents in Baltimore, MD.

METHODS—We performed a longitudinal study of four-wave data collected from a network-based HIV/STI prevention intervention for women and network members, consisting of both men and women. Our primary outcome and exposure were depression using CESD scale and social network characteristics, respectively. Linear mixed model with clustering adjustment was used to account for both repeated measurement and network design.

RESULTS—Of the 746 participants, those who had high levels of depression tended to be female, less educated, homeless, smokers, and did not have a main partner. In the univariate longitudinal model, larger size of drug network was significantly associated with depression (OR=1.38, $p<0.001$). This relationship held after controlling for age, gender, homeless in the past six months, college education, having a main partner, cigarette smoking, perceived health, and social support network (aOR=1.19, $p=0.001$). In the univariate mixed model using depression to predict size of drug network, the data suggested that depression was associated with larger size of drug network (coef.=1.23, $p<0.001$) and the same relation held in multivariate model (adjusted coef.=1.08, $p=0.001$).

CONCLUSIONS—The results suggest that larger size of drug network is a risk factor for depression, and vice versa. Further intervention strategies to reduce depression should address social networks factors.

Contributors

Authors Jingyan Yang and Carl Latkin designed the study. Jingyan Yang undertook the statistical analysis and wrote the first draft of the manuscript. Melissa Davey-Rothwell was the Project Director of the CHAT project. Also, authors Carl Latkin and Melissa Davey-Rothwell, Mansi Agarwal edited and contributed to subsequent drafts of the paper. All authors contributed to and have approved the final manuscript.

Conflict of interest

No conflict declared.

INTRODUCTION

The comorbid presentation of drug abuse and depression is relatively common in clinical and community populations. Evidence indicates that psychopathology is a risk factor for drug use [1-5]. In the United States, the prevalence of current depression and lifetime depression among the general population is around 7% and 16%, respectively [6, 7]. The estimates of recent depression and lifetime depression range from 15%-63% and 18-61%, respectively among drug users [8-11]. Individuals with comorbid drug use and depression have poorer health outcomes and are at higher risk for sexual risk behaviors, impairment and needle sharing compared to their non-depressed counterparts[11-14].

Several cross-sectional studies have demonstrated that drug abuse is correlated with depressive symptoms in adults [5, 15, 16]. A few studies among youth suggested that depressive symptoms early in life may increase the risk of drug abuse[17] and may also influence the patterns of drug use[18]. Westermeyer et al. reported adolescents with a substance disorder had increased depressive symptoms with increasing age[19]. Longitudinal studies on disadvantaged populations have suggested an increase in depression after drug use [20, 21]. Individuals who have high levels of psychological distress have been found to be less likely to achieve long-term stable recovery from heroin addiction [8]. Several studies [22, 23] have also looked at characteristics of social support and gender differences with depression among drug users, concluding that lack of social support from a significant other was associated with depression in both female and male injection drug users.

To gain a further understanding of the relationship between drug use and depression, it is important to examine social interaction, as drug use is often a social behavior and low social support is a consistent predictor of depression [24]. Depressed individuals may use drugs to self-medicate and concomitantly seek out other drug users. The stress of interactions with other drug users may increase the risk of depression [25]. Social network theory states that similar individuals tend to affiliate together and individuals who are in the same network influence each other to engage in similar behaviors. However, very few studies have examined the association of drug network characteristics and depression. A cross sectional study of a clinical sample suggested that network density and size of drug sub-networks were positively associated with frequency of drug injection [26]. Wallace et al. pointed out that depression and drug network size were precipitating factors for needle-sharing behaviors among street injection drug users[27]. These prior studies were limited to a cross-sectional study design. The current study utilized longitudinal data to explore whether depression is associated with size of drug network, or vice versa. The focus of our analysis was bidirectional: 1) to examine whether interaction with more drug users is related to or help maintain depressive symptoms and; 2) whether depressed individuals interact with more drug users than non-depressed individuals. Therefore, size of drug network is a proxy for network level mental health. We hypothesized that drug users with a larger size of drug network is associated with higher risk of depression.

METHODS

The present analyses used four-wave data from the CHAT study, a social-network based intervention for women who were trained to be peer mentors for encouraging HIV and STI risk reduction within their social networks [28]. The name CHAT stood for 4 communication skills that peer mentors were taught in the intervention (See Davey-Rothwell et al [28], for more information). Several theoretical approaches guided the CHAT intervention including social affiliation, cognitive dissonance, social identity, social influence and social learning [29-32]. The sample was comprised of two types of participants: index participant (76%) and their network participants (24%). All index participants were while yet network participants included men and women. Index participants were recruited through street outreach, health clinics as well as other local communities in Baltimore, MD, USA.

Eligibility criteria for index participants included: (1) female, (2) age 18-55 years old, (3) did not report injecting drugs in the past 6 months, (4) self-reported sex with at least one male partner in the past 6 months, (5) had at least one of the following sexual risk behaviors in the past 6 months: (a) more than two sex partners, (b) diagnosis of sexually transmitted infection (STI), and (c) had a high risk sex partner (i.e., injected heroin or cocaine, smoked crack, HIV seropositive, or men who have sex with men)[28]. Index participants were asked to refer their peer and risk network members to the study.

Eligibility for network participants included at least one of the following : (1) injecting heroin or cocaine in the past 6 months, or (2) sex partners of the index participant, or (3) those the index participants felt comfortable talking to about HIV or STIs[33]. Network participants were both male and female.

Both index and network participants completed the same study visits at baseline, 6, 12, and 18-month follow-up. Baseline data were collected from September 2005 through July 2007. The final follow-up assessment finished in February 2010. During each visit, part of the survey was administrated by a trained interviewer while sections on HIV risk behaviors were administrated through Audio-Computer Assisted Self Interview (ACASI). The survey lasted approximately two hours. Participants were compensated \$35 for completion of the baseline, 6, and 12 month visits, and \$45 for finishing the 18-month assessment. All protocols were reviewed and approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

Measures

Size of drug network—Social network data were collected using a network inventory. A set of 21 name generating questions such as “during the last 6 months, who could you talk to about things that were personal and private or who could you get advice from?” and “Who are the people you have used heroin, crack, or cocaine with in the past 6 months” were asked and participants responded with the first name and initial of last name of each network member. After the network lists were created, information regarding HIV related risk behaviors, drug use history and relationship were collected for each network member. The size of the drug network is the total number of people listed in the network inventory who

used heroin, cocaine, or crack in the past 6 months. The size of the social support network is total number of people listed in the network who provided emotional, material, or informational support. In order to minimize the overlap between drug network and social support network, we further identified those who were only in the social support network and not in the drug network.

Depressive Symptoms—Depressive symptoms were assessed using the Center for Epidemiological Studies Depression (CES-D) scale [34]. The CES-D is a 20-item measure designed for the general population and scores range from 0 to 60, with higher scores indicating greater depressive symptoms. It has been used successfully in previous studies with drug users [20, 35, 36]. In the present analysis, we used standard cutoff point of 16 or greater to identify individuals at risk for clinical depression[37].

Individual-level demographics—Individual level demographic characteristics were collected at each visit, including age, employment status, education, homelessness in the past 6 months, any main sexual partner, perceived health status, current smoking status and use of heroin, crack or cocaine in the past 6 months.

Statistical Analysis—Demographic characteristics between participants who had depression and who did not have depression were presented in person-visits (which was defined as the number of visits an individual contributed during the study period and therefore we can have a better understanding of the longitudinal data) over follow-up. We used student *t*-tests for normally distributed continuous variables and Chi-square tests for categorical variables. The longitudinal association between depressive symptoms and size of drug network was estimated using multilevel modeling. We calculated a two-level model: at level one, which allows for the repeated measurements over time nested within each individual; at level two, which adjusts for the network design as a clustering variable. To account for the unbalanced nature of the design (i.e. missing data in the dataset), all analyses were carried out using maximum likelihood estimation. All multilevel models with random intercepts were estimated on all available data. Therefore, participants contributed to the analysis even if they had missingness on predictors, but not when they had missing data on the outcome. A logistic multilevel model was applied to the size of drug network as the independent variable and the dichotomized CES-D score as the outcome (Model A). We also fit a linear mixed model for depression as a predictor and size of drug network as a dependent variable (Model B). In order to satisfy model normality and variance assumptions, a natural-logarithm transformation was applied to drug partner count ($\ln[\text{drug partners}+1]$). Poisson regression was also considered, but the model's goodness-of-fit was not upheld. All the results were then back-transformed for presentation. Both multivariate models have adjusted for potential confounders, which were significant at the bivariate level and shown to be associated with depression in previous literature, including age, gender, homeless in the past six months, college education, having a main partner, cigarette smoking, perceived health, and social support network. Since our study sample was largely female (76%), in addition to controlling for gender in the model, we also performed sensitivity analysis by removing all the male participants in the model to see the effect of

gender on our results. All the analyses were done using STATA 13.0 (StataCorp, College Station, TX).

RESULTS

Baseline Demographics

There were 746 participants who completed the baseline survey, out of which 417 were index participants and 329 were network members. Of these, 600 (80%) participants completed the 6-month and 12-month follow-up and 672 (90%) participants completed the 18-month assessment. 70.6% of the participants had drug use in the prior 12 months assessed at baseline. Among non-current drug users, average reported drug users in their network was 0.4 (± 0.9), while among current drug users, the average reported drug users in their network was 2.0 (± 1.9). Difference of sample characteristics by depressive symptoms was presented by person-visits (Table 1). Participant with depressive symptoms compared to those who did not have depression during the study period were more likely to be younger (43 years old vs. 44 years old), female (81.6% vs. 66.3%), homeless in the past 6 months (26.8% vs. 12.9%), smoke cigarette (84.4% vs. 76.9%), and currently use drugs (56.5 % vs. 39.1%). However, they had lower perceived health status, and fewer of them had main partners (70.2% vs. 76.3%) and were less college educated (11.5% vs. 16.8%). They had larger overall size of network (mean= 7.3 vs. 6.6 individuals in network) and drug network (mean= 1.4 vs. 1 individual in drug network). In terms of size of social support network and HIV infection, the two groups had no significant difference.

Longitudinal analysis

The longitudinal analysis (Table 2) explored whether size of drug network was a risk factor of depression. The results indicated that larger size of drug network was significantly associated with depression (OR=1.45, 95% CI: 1.21, 1.75, $p < 0.001$) in the bivariate analysis and remained significant in the multivariate analysis after controlling for potential confounders. When the size of drug network increased by one person, the odds of having depression was 1.19 times higher ($p = 0.001$). Also, female gender, homelessness in the past 6 months, current smoking and use of heroin, cocaine, or crack in the past 6 months were significantly positively associated with depressive symptoms. Older age, having a college education, having a main sexual partner and better perceived health status significantly reduced the risk of having depressive symptoms. Figure 1 indicates that during the study follow-up, participants who had depressive symptoms had larger drug networks compared to those without. The decline in size of drug network as seen from baseline to the 6-month visit was due to attrition.

In order to assess whether the pathway held in either direction, we used size of drug network as outcome, and depression as predictor in Table 3. The results from bivariate analysis demonstrated that those who had depression were more likely to have larger size of drug network (Coef.= 1.23, 95% CI: 1.17, 1.28, $p < 0.001$). After controlling for potential confounders, on average, people who had depression had significantly larger size of drug network (Adj Coef.= 1.09, 95% CI: 1.04, 1.13, $p < 0.001$). Female gender, college education,

homelessness, current drug use, and larger size of social support network were found to be significantly associated with larger size of drug network.

A sensitivity analysis excluding male participants from the study population did not affect the study findings (data not shown).

DISCUSSION

Our study revealed that size of drug network is a risk factor for depressive symptoms, and vice versa, even after controlling for potential confounders. Although prior studies have been conducted looking at the relationship among depression, social network characteristics and drug use behaviors [27], this is the first study to our knowledge that has provided quantitative analysis of the bidirectional association of size of drug network and depression among population who have high risk profile of drug use. Members in one's social network play a crucial role in affecting each other's behaviors. This social dynamic should be taken into account when developing intervention strategies to address depression among drug users.

A major finding of this study was that depression is linked to larger drug network size. Those who are depressed may interact more with others who appear to be mentally challenged as well. Because people who use drugs are more likely suffering from depression, an individual may observe that his or her network members use drugs and then may accept drug use in himself or herself, which could be one way to enlarge the drug network size. In this sense, the spread of depressive symptoms in social network appears to be a factor in the drug use epidemic.

The present study also observed that larger size of drug network is associated with increasing risk of depression. One possible interpretation of this finding is that drug use ties are more stressful and may foster depression. This may be also partially explained by the social contagion theory that positive and negative emotional states behave similar to infectious diseases spreading across groups of intimates in social networks over long periods of time[38]. Longitudinal studies have claimed that depression, loneliness, and happiness are major social contagion components of mood [39-41]. Social influence process which is characterized by the presence of both selection and socialization also supports our findings. Specifically, depressed people not only look for individuals with depressive symptoms and exposure to similar environments (i.e., selection effects), but also affect each other's mood and behavior to become more similar over extended periods of contact (i.e., socialization effects) [42]. However, the dynamic association between changes in interactions among network members and depression is unknown. Individuals both leave and join networks. These two dynamics may not have the same impact on depression nor do we know how drug network interactions foster depression.

Study Limitations

Some limitations of the current study are worth noting. Firstly, causality cannot be determined between size of drug network and depression due to lack of data on prior incident depressive episodes and prior drug use history. Secondly, reporting bias may be

present as those who report more depressive symptoms on self-report questionnaires may also report higher levels of drug use and impairment. Thirdly, the difference in eligibility criteria between index participants and network participants, particularly gender and their drug use history/behavior may not be fully addressed in our analysis, resulting in residual bias. Potential areas for further research include designing assessments to obtain deeper understanding of the micro-processes related to the dynamics of drug network size towards depression. Use of ecologic momentary assessment devices may help to obtain a more detailed understanding of these micro-social dynamics.

There are several implications for behavioral and mental health from our findings. Social influence is potentially a double-edged sword. It may be helpful for drug users to seek out non-drug users, yet we do not know the impact of interactions with drug users on the non-drug users. Prior research suggests that “key” members in larger social networks may exert disproportionate social influence and can change the pattern of contagion, therefore delivering positive messages about health behaviors. A study conducted by Katherine et al. demonstrated that peer-driven interventions has improved the utilization of mental health services among depressed drug users [43]. A randomized controlled HIV-prevention intervention done among homosexual men in US demonstrated that well-linked members of a community who systematically recommend risk-reduction behavior can influence the sexual-risk practices of others in their social network [44]. Positive emotional contagion in a group can result in improved cooperation, decreased conflict and increased performance [45]. Further intervention on drug dependence should take characteristics of drug network as well as treatment of depression into account. Treatment for individual depression may also in turn benefit the other respondents in the same network through social contagion. Moreover, breaking ties among drug users may not only shrink the size of drug network but also aid in reducing depressive symptoms and high risk behaviors.

To sum up, understanding the relationship between social network characteristics and depression is crucial for clinicians and community based organizations working with drug users, as well as developing intervention strategies to reduce depression.

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Figure 1.
Mean Trend of Size of Drug Network by Depression Status

Table 1

Characteristics of Participants by depressive symptoms, person-visit

Characteristics	No Depression N=191	Depression N=555	P-value
Person-visit	1096	1518	
Age, yr, <i>SD</i>	44 (8.4)	43 (8.6)	0.002
Female gender, %	727 (66.3)	1238 (81.6)	<0.001
College education, %	184 (16.8)	174 (11.5)	<0.001
Homeless, %	141 (12.9)	407 (26.8)	<0.001
Main partner, %	826 (76.3)	1060 (70.2)	0.001
Smoking, %	843 (76.9)	1281 (84.4)	<0.001
Perceived health status, %			
<i>Poor/Fair</i>	304 (27.7)	753 (49.6)	
<i>Good</i>	308 (28.1)	379 (25.0)	
<i>Very good/Excellent</i>	484 (44.2)	385 (25.4)	<0.001
HIV infection, %	22 (4.7)	25 (3.3)	0.210
Current drug use, %	429 (39.1)	858 (56.5)	<0.001
Overall network size, <i>SD</i>	6.6 (3.4)	7.3 (3.8)	<0.001
Size of drug network, <i>SD</i>	1.0 (1.5)	1.4 (1.7)	<0.001
Size of social support network, <i>SD</i>	3.5 (1.9)	3.5 (2.1)	0.593

Table 2

Association between Size of Drug Network and Depression (Exposure: Size of Drug Network; Outcome: Depression)

Characteristics	OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Age, yr	0.97 (0.95, 0.99)	0.002	0.96 (0.93, 0.98)	<0.001
Female gender	3.67 (2.48, 5.41)	<0.001	2.34 (1.58, 3.48)	<0.001
College education	0.54 (0.34, 0.86)	0.009	0.58 (0.35, 0.95)	0.031
Homeless	3.42 (2.47, 4.73)	<0.001	2.52 (1.80, 3.53)	<0.001
Main partner	0.72 (0.53, 0.98)	0.036	0.72 (0.52, 0.98)	0.037
Smoking	2.20 (1.45, 3.33)	<0.001	1.48 (0.98, 2.24)	0.060
Perceived health status				
<i>Poor/Fair</i>	ref.	-	ref.	-
<i>Good</i>	0.46 (0.32, 0.65)	<0.001	0.47 (0.33, 0.67)	<0.001
<i>Very good/Excellent</i>	0.25 (0.18, 0.34)	<0.001	0.28 (0.20, 0.39)	<0.001
Current drug use	3.27 (2.50, 4.27)	<0.001	2.01 (1.49, 2.72)	<0.001
Size of drug network	1.45 (1.21, 1.75)	<0.001	1.19 (1.08, 1.32)	0.001
Size of social support network	0.97 (0.91, 1.04)	0.445	1.00 (0.93, 1.07)	0.899

Table 3

Association between Depression and Size of Drug Network (Exposure: Depression; Outcome: Size of Drug Network)

Characteristics	Coef. (95% CI)	P-value	Adjusted Coef. (95% CI)	P-value
Age, yr	1.01 (1.00, 1.01)	<0.001	1.01 (1.00, 1.01)	0.001
Female gender	1.15 (1.07, 1.25)	<0.001	1.07 (1.01, 1.13)	0.015
College education	1.11 (0.99, 1.23)	0.060	1.12 (1.04, 1.21)	0.004
Homeless	1.27 (1.20, 1.36)	<0.001	1.12 (1.06, 1.18)	<0.001
Main partner	0.97 (0.90, 1.03)	0.357	1.00 (0.95, 1.05)	0.925
Smoking	1.17 (1.08, 1.26)	<0.001	1.01 (0.95, 1.07)	0.744
Perceived health status				
<i>Poor/Fair</i>	ref.	-	ref.	-
<i>Good</i>	0.98 (0.92, 1.04)	0.499	1.04 (0.99, 1.09)	0.171
<i>Very good/Excellent</i>	0.93 (0.88, 0.99)	0.028	1.02 (0.97, 1.07)	0.510
Current drug use	1.95 (1.86, 2.03)	<0.001	1.93 (1.84, 2.02)	<0.001
Depression	1.23 (1.17, 1.28)	<0.001	1.09 (1.04, 1.13)	<0.001
Size of social support network	1.00 (0.99, 1.02)	0.861	1.03 (1.02, 1.04)	<0.001