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Difference in HIV Testing Behavior by Injection Status, among users of Illicit Drugs

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Abstract

Human Immunodeficiency Virus (HIV) infection remains prevalent among the minority and drug using population in the United States. Testing for HIV is an important and cost-effective way to reduce HIV prevalence. Using a cross-sectional design, we assessed the HIV testing behavior of People who use Non-Injected Drugs (PWND) and compared it to People who use Injected Drugs (PWID) using negative binomial regression models. People who use non-injected drugs were less likely to test for HIV compared to those who use injected drugs. To exert a greater impact on the HIV epidemic, interventions and policies encouraging HIV testing in PWND, an under-recognized and equally at risk sub-population, are warranted.

Introduction

The *Human Immunodeficiency Virus* (*HIV*) infection rate in the United States, while remaining relatively stable over the past decade, is still very high, and its prevalence is particularly problematic in marginalized communities [1], such as users of illicit drugs. It is imperative to identify HIV-infected individuals and treat them in a timely manner, as this helps reduce morbidity and mortality, while also minimizing the likelihood of transmission. To establish whether a person has HIV, undergoing an HIV test is necessary. While clinical symptoms associated with HIV infection may prompt a person or his/her provider to suspect HIV infection, testing is the only definitive way to establish whether this is the case. More importantly, HIV testing is the foundation for both prevention and care. In fact, HIV testing has been shown to be an economical and effective defense against HIV transmission [2,3]. Early identification, i.e., prior to the emergence of clinical symptoms and a decline in health, empowers affected individuals to take action, thus increasing the likelihood that they will continue living healthy and productive lives, while also protecting the public. For example, those who have been diagnosed with HIV can start using Antiretroviral Therapy (ART) and, if adherent would prevent transmission to others even with condomless sex [4]. ART reduces the risk of opportunistic infections, lowers community viral load, and decreases the likelihood of transmitting the virus to others. In fact, it is well established that early treatment reduces the risk of transmitting HIV to others by as much as 96% [5]. In addition, being cognizant of one's infection status can help the person make better decisions about sex and/or drug use. Moreover, the act of testing is a means of connecting with the healthcare system and is especially important given the important role currently played by ART in preventing seroconversion of uninfected individuals, both when taken after a high-risk exposure as post-exposure prophylaxis, or PEP, and when taken daily as pre-exposure prophylaxis, or PrEP, to supplement condom use, partner reduction, use of clean needles for injection, and other extant risk reduction strategies. HIV-infected persons who are not aware of their HIV infection status (i.e., those that remain untested) are of great concern, as they are more likely to engage in behaviors that place their partners at risk of contracting HIV [6]. Available estimates indicate that this group accounts for the majority of sexual HIV transmissions in the United States [7].

HIV testing among individuals who use illicit drugs is understudied. People who use Injected Drugs (PWID) remain an important subpopulation in the Centers for Disease Control (CDC) annual surveillance report focusing on social strata deemed at the greatest risk of HIV infection [1]. Over the past few decades, structural interventions geared towards reducing HIV risk from

intravenous drug use, such as needle exchange, have reduced the number of new HIV cases among PWID [1-8]. However, while PWID may have reduced their risk by changing their injection patterns, they may remain vulnerable to HIV exposure due to risky sexual behaviors. The risk of HIV infection as a result of unprotected sexual encounters is well established and is exacerbated in the population that also uses illicit drugs, as drugs usually impair judgment. Risky sexual behavior is of concern in both PWID and people who use non-injected drugs (PWND). Moreover, the growing body of research has provided compelling evidence on the importance of shared social networks between PWID and PWND and the risk of HIV and Sexually Transmitted Infections (STIs), beyond individual behavior [9]. Extant studies in this field show that an individual's risk of HIV and other communicable diseases is in part a function of the composition and behavior of his/her network of drug users and/or sexual partners [10-12]. For example, individuals whose friends engage in high-risk behaviors are more likely to engage in similar practices themselves [9,13,14]. However, thus far, prevention strategies tended to predominantly target PWID because of their very high risk of transmission from intravenous use. An unforeseen consequence of this limited focus is the disproportionate targeting of PWID for intervention, research, and prevention/treatment of HIV, resulting in PWND being overlooked. Empirical evidence indicates that, in some cases, the prevalence of HIV among PWND is equal, or even higher, than among PWID [15-17]. This finding is concerning, as PWND that are not treated or identified as at-risk subpopulation may not encounter opportunities for HIV testing, intervention, or treatment. Moreover, it is not presently known if PWID and PWND take similar approaches to HIV testing. Therefore, understanding HIV testing behavior and identifying the most optimal means of promoting HIV testing in both groups is important. People who are unaware of their HIV infection are more likely to be diagnosed at more advanced stages of HIV disease and are thus more likely to be infectious to sexual partners [18,19].

Therefore, the aim of the present study was to examine the frequency of HIV testing in a group of illicit drug users who reported being uninfected. The study was guided by the hypothesis that individuals using injected drugs will have a greater number of HIV tests than people who use non-injected drugs. In addition, having some social support was posited to be associated with increased likelihood of HIV testing, independent of drug injection status.

Method

Data for these analyses were obtained from the Social Ties Associated with Risk of Transition into Injection Drug Use or "START" study, which is described elsewhere [20,21]. In brief, START was designed to determine the incidence of transition from non-injection into injection drug use. Its authors sought to identify risk factors, such as social network and social support characteristics, which may influence the transition into injection drug use among young adult drug users in New York City (NYC) from 2006 to 2009. Participants were recruited via Respondent-Driven Sampling (RDS) and Targeted Street Outreach (TSO) methods. Both PWID and PWND completed the questionnaires at baseline as a part of a 90-minute face-to-face interview. The PWID group comprised of individuals that reported injecting heroin, crack, or cocaine for four years or less, and having injected at least once in the past six months. Injection drug use was verified by visible track marks. The PWND group included those who reported non-injection use of heroin, crack, or cocaine for at least a year, as well as usage of these drugs 2-3 times per week in the last three months. Self-reported drug use was verified via rapid drug tests that screened for opiate and cocaine metabolites in urine. This was a heterogeneous population that used hard drugs. Participants received $30 and a round-trip travel card for completing the questionnaire. START was approved by the Institutional Review Board of Columbia University Medical Center that led the study, and the New York Academy of Medicine, where the aforementioned data collection procedures were carried out and the gathered data was stored. Informed consent was obtained from all participants.

Dependent variable

The main dependent variable wasthe frequency of lifetime HIV testing. The outcome question was "How many times have you been tested for HIV?"

Independent variables

Injection statuswas the primary predictor of interest. Other variables of interest were participant's age (divided by 5 for a more meaningful increment); race (categorized as black, Hispanic/Latino, white and/or other); gender (male or female); education (dichotomized as high school graduate/General Equivalency Degree (GED) or greater, yes/no); income (categorized as none, <$5,000 US, and ≥$5,000 US); jail/incarceration; drug treatment; detox; Men who have Sex with Men (MSM); multiple sexual partners (having two or more partners, yes/no); STIs; and non-condom use or condom less sex. Any discrimination (due to age, race, sex, orientation, drug use, religion, imprisonment, mental health, poverty, or disability) was also examined, with the premise that those who are discriminated against will be less likely to seek healthcare or visit a treatment facility on their own volition. Network variables of interest were 1) social support variables that included informational support, which was established through questions on drug use and harm reduction, health and medical services, and social services, and was defined as having someone to ask advice about healthcare or medical services, talk to about issues related to drug use, or get information about social services; 2) emotional support, which was defined as having someone with whom the participant can discuss personal and private matters; and 3) structural support, which was based on availability of concrete help, such as having a place to stay and/or ability to borrow $25. Other network variables were network size (number of members); drug network (number of network members that the participant used drugs with); sex network (number of network members the participant had sex with); proportion of female members; proportion of minority members; proportion of high school graduates/those with GED/and greater educational attainment; proportion of members that had sex for money or drugs (i.e., engaged in transactional sex); and the proportion of members that injected drugs. Potential overlaps between different social support and/or risk network (i.e., drug/sex network) factors were also examined. Network overlap occurs when the same network member provides more than one type of support or interaction, such as structural as well as emotional support. These network characteristics were ascertained via a common inventory, similarly to the methods employed in prior research [22,23].

The network proportions were used in data analyses, as an incremental increase may not be as impactful on HIV testing or have as meaningful a difference as the number of members in terms of size of the network. For example, two participants may be deemed equal in terms of attributes, and both may report having two female network members, but their networks are of different size, as they report having three and five members, respectively. This results in a proportion of 2/3 or 0.67 versus2/5 or 0.40, which is a meaningful difference. Thus, the proportion of females in the network, instead of the number of females, was used in analyses. Moreover, due to their small sample size, white and other race was combined for the regression model.

Analyses

Using baseline data, we conducted descriptive analyses on participants' demographic characteristics overall, and by injection status and median number of HIV tests. Network member characteristics were also described. For example, the most commonly endorsed relationship (friend) and how often the participant saw or spoke to a particular network member (e.g., every day) were reported. In addition, the relationship between HIV testing and injection status was examined, adjusting for important covariates using a negative binomial regression model. To achieve a more parsimonious model, variables with a conservative threshold of $p \leq 0.20$ were retained in the reduced model. Model fit was assessed using log Likelihood Ratio Test (LRT), by restricting the reduced model to the observations in the full model to ensure comparability. A negative binomial regression model was employed to examine the association between injection status and frequency of HIV testing because the outcome of interest (number of HIV tests) was not normally distributed and the conditional variance exceeded the conditional mean. This difference implies that over-dispersion was present, rendering a Poisson distribution inappropriate. We also conducted a sensitivity analysis to examine if potential outliers of HIV testing behavior were influential, by setting the frequency of testing at the 95th percentile or above to "missing" and thereby excluding the most frequent testers from the dataset. Statistical analyses were conducted via SAS, version 9.4.

Results

The study sample included 564 participants that reported either never having an HIV test or having a negative HIV test, 125 of whom were PWID and 439 were PWND. The mean age of the full sample was 32 and the median personal or egocentric network size was 3 (Table 1). Participants were predominantly male (70%), black or Hispanic/Latino (85%), and had a history of arrest (91%). Most of the individuals that took part in the study reported an annual US income of ≤$5,000 (59%), used non-injected drugs (78%), admitted to smoking crack in the past three months (77%), and indicated being in a treatment program of some kind (60%). A significantly greater percentage of participants who reported taking part in a treatment program also reported undergoing detox, compared to those who were not involved in any treatment (78% vs. 30%, $p<0.001$). The median number of HIV tests was four, interquartile range (2,6).

Bivariate analysis results revealed that, compared to those who used non-injected drugs, individuals that used injected drugs were younger (30 vs. 33), were more likely to be Hispanic/Latino, as well as report sniffing/snorting heroin in the past three months, and attending detox and methadone treatment (Table 1a). They also had fewer sexual partners and engaged in less transactional sex. A greater number of PWID also reported experiencing discrimination, but the difference relative to PWND was not statistically significant (data not shown).Those who reported having a greater number of HIV tests than the median for the sample were more likely to be jailed, have an STI, report having sniffed/snorted heroin in the past three months, having attended detox, and receiving methadone treatment, compared to those who tested less frequently than the median. In addition, they were less likely to have smoked crack in the past three months.

The participants' network members had a mean age of 38, were more likely to be female, black or Hispanic/Latino, and to have completed high school or higher (Table 1b). Friend was the most common reported relationship characterizing the network members, and the participants reported interacting with these members by seeing them or talking to them every day. Overall, a majority of the network members smoked crack, while only 6% injected drugs. Compared to the PWID network members, those reported by PWND were older, had higher educational attainment, and were more likely to be black, smoke crack, and have transactional sex. In addition, only 2% of PWND network members injected drugs, compared to 23% of PWID network members. Overlap, meaning network members who provided both emotional support and had sex and/or took drugs with participants, was significantly different between PWND and PWID network (10% vs. 14%, p=0.03).

According to the results yielded by negative binomial regression models, participants that injected drugs tested for HIV on average 1.24 times more than those who used non-injected drugs, prevalence ratio (PR) (95% CI) = 1.24 (1.02, 1.51), p = 0.03. Other positive and significant factors associated with HIV testing were educational attainment (high school graduate/ GED or greater), 1.19 (1.03, 1.38); engaging in condom less sex, 1.17 (1.01, 1.36); STI, 1.37 (1.16, 1.62); sniffing/snorting heroin, 1.17 (1.01, 1.35); and having a sex network, 1.05 (1.00, 1.11) (Table 2). The model with interaction terms indicated that the effect of injection status on the frequency of HIV testing depends on the level of emotional support the participant receives from his/her network members, as the interaction between injection status and emotional support was significant, at p = 0.03. The more emotional support PWID received from their network, the lower the number of HIV tests undertaken on average, compared to PWND, 0.75 (0.59, 0.97). In addition, according to the stratified analyses findings, each five-year increase in age, MSM, condom less sex, and sexually transmitted infection were positively associated with HIV testing among PWID. Among PWND, STIs, sniffing/snorting heroin, and having network members who simultaneously provided structural and emotional support were positively associated with HIV testing. On the other hand, Hispanic/Latino ethnicity, having network members who provided both structural and informational support, and offering both emotional support while being a source of risk (i.e., sex/drug network) were inversely associated with the propensity for HIV testing. The stratified models showed a strong modifying effect of MSM status, 3.65 (1.24, 10.74) among PWID vs. 0.93 (0.61, 1.39) among PWND.

In sensitivity analysis, when the data pertaining to frequency of testing at the 95th percentile or higher was excluded (the entry was

Table 1a: Baseline descriptors of users of illicit drugs in NYC 2006−2009 who reported being HIV uninfected: Participants' demographics and behavioral characteristics (*n*=564).

	Overall	Injection Status			Frequency of HIV test		
Variables %		**No n=439**	**Yes n=125**	***p* value**	**<4 n=256**	**≥4 n=308**	***p* value**
Sex				0.86			0.13
Male	70	70	70		73	68	
Female	30	30	30		27	32	
Race				**<0.001**			0.44
Latino/Hispanic	38	31	60		37	38	
Black	47	59	6		45	49	
White	10	5	30		12	9	
Other	5	5	4		6	4	
High school graduate/GED or greater	50	49	53	0.44	46	53	0.08
Income				0.68			0.56
none	24	24	23		25	23	
≤ $5,000	59	58	62		57	61	
>$5,000	17	18	15		19	16	
Married	26	25	27	0.64	27	24	0.49
Arrested	91	90	94	0.51	91	91	1
Juvenile detention center	27	26	31	0.29	27	27	0.97
Jailed	79	78	82	0.33	74	83	**0.01**
State or federal prison	41	42	38	0.39	38	44	0.2
Multiple sex partners	38	41	30	**0.02**	41	36	0.19
MSM	3	4	2	0.39	4	3	0.38
Sex transactions	24	28	11	**<0.001**	22	26	0.27
Condom less sex	47	46	54	0.11	46	48	0.59
Sexually transmitted infection	73	74	70	0.45	64	80	**<0.001**
Injected drugs							0.58
No	78				79	77	
Yes	22				21	23	
Smoked crack ever	86	87	79	**0.02**	88	84	0.25
Smoked crack in the past 3months	77	81	62	**<0.001**	81	73	**0.04**
Sniffed/snorted heroin ever	65	56	96	**<0.001**	62	68	0.15
Sniffed/snorted heroin in the past 3 months	46	41	60	**0.0002**	41	50	**0.03**
Detox	58	56	66	**0.03**	54	62	**0.05**
Methadone maintenance	26	16	61	**<0.001**	20	31	**0.005**
Narcotics anonymous	40	39	43	0.39	33	46	**0.002**
Cocaine treatment	18	19	15	0.32	16	20	0.14
Outpatient treatment	36	35	42	0.17	35	37	0.59
Other treatment	4	5	2	0.26	3	5	0.33
Any treatment program	60	56	73	**0.001**	54	65	**0.01**
Age, mean (SD)	32 (6)	33 (6)	30 (6)	**<0.001**	32 (6)	33 (5)	0.21
Number of HIV tests, IQR	4 (2, 6)	4 (2, 6)	4 (2, 8)	0.13			
Network size, IQR	3 (2, 5)	3 (2, 5)	3 (2, 4)	0.33	3 (2, 4)	3 (2, 5)	0.07
Drug network, IQR	1 (0, 1)	1 (0, 1)	1 (0, 1)	0.21	1 (0, 1)	1 (0, 1)	0.9
Sex network, IQR	1 (1, 1)	1 (1, 1)	1 (1, 1)	0.76	1 (1, 1)	1 (1, 1)	0.77
Structural support, IQR	1 (0, 2)	1 (0, 2)	1 (0, 2)	0.53	1 (1, 2)	1 (0, 2)	0.56
Informational support, IQR	1 (0, 1)	1 (0, 1)	1 (0, 1)	0.69	1 (0, 1)	1 (0, 1)	0.06
Emotional support, IQR	1 (0, 1)	1 (0, 1)	1 (0, 1)	0.73	1 (0, 1)	1 (0, 1)	0.17
Social support, IQR	1 (1, 2)	1 (1, 2)	1 (1, 2)	0.9	1 (1, 2)	1 (1, 2)	0.08

Multiple sex partners were defined as having sex with two or more people in the past two months.

MSM was defined as men who reported having sex with men in the past two months.

Sexually transmitted infection was defined as being tested at some point in the past for herpes, gonorrhea, syphilis, and/or chlamydia.

Any treatment program is a composite variable of methadone, narcotics, cocaine, outpatient, and other treatment.

Structural support was defined as having a place to stay or someone to borrow $25 from.

Informational support was defined as having someone to ask advice about healthcare or medical services, talk to about issues related to drug use, and/or get information about social services.

Emotional support was defined as having someone to talk to about personal or private matters.

Social support was defined as having informational and/or emotional support.

Table 1b: Baseline network members' characteristics overall and stratified by injection status of participants who used illicit drugs in NYC 2006–2009.

		Injection status		
Variables %	**Overall** ***n*** **= 2,033**	**No** ***n*** **= 1,630**	**Yes** ***n*** **= 403**	***p*** **value**
Sex				1.00
Male	43.32	43.28	43.47	
Female	56.33	56.28	56.53	
Race				**<0.001**
White	10.99	6.55	28.79	
Black	47.68	56.36	12.88	
Hispanic	37.15	32.68	55.05	
Other	4.00	4.00	3.00	
High school graduate/GED or greater	69.99	72.28	61.49	**<0.001**
How often did you see or talk to the network member?				
Everyday	45.25	44.54	48.09	0.21
What was your relationship with the network member?				
Friend	29.05	28.78	30.13	0.60
Injected drugs	6.56	2.43	22.63	**<0.001**
Smoked crack	27.62	30.05	17.94	**<0.001**
Snorted heroin	12.35	9.84	22.11	**<0.001**
Male sex partner	49.89	50.90	45.88	0.09
Female sex partner	45.48	45.92	43.77	0.46
Sex transactions	16.65	18.67	8.84	**<0.001**
Jail	15.30	15.94	12.84	0.14
Drug participants reported using with network member				
None	59.01	57.06	66.83	**0.0004**
Heroin	5.98	3.42	16.21	**<0.001**
Cocaine	5.48	5.72	4.49	0.33
Smoke crack	16.33	19.48	3.74	**<0.001**
Marijuana	7.42	8.34	3.74	**0.002**
Other[1]	3.44	3.55	2.99	0.59
Overlap				
Emotional and structural support	18.00	18.47	16.13	0.27
Informational and structural support	10.18	9.88	11.41	0.36
Emotional and informational support	10.87	10.55	12.16	0.35
Emotional support and risk behavior[2]	10.67	9.94	13.65	**0.03**
Informational support and risk behavior[2]	7.13	6.63	9.18	0.07
Structural support and risk behavior[2]	11.76	11.78	11.66	0.95
MSM	3.15	3.31	2.48	0.39
Age, mean (SD)	38 (13)	39 (13)	36 (13)	**0.001**
Number of times member was named, IQR	1 (1, 3)	1 (1, 2)	1 (1, 3)	0.33

1. Other drugs were a composite of methamphetamine, PCP, LSD, ecstasy, other, refused to answer or "don't know."

2. Risk behavior was defined as a member with whom participants took drugs or had sex.

Table 2: Adjusted prevalence ratio and 95% CIs from negative binomial models, estimating frequency of HIV tests, START study (*n*=539), 2006−2009.

	Adjusted Model[1]		Adjusted Model[2]		Among PWID		Among PWND	
Parameter	**PR (95% CI)**	***p* value**	**PR (95% CI)**	***p* value**	**PR (95% CI)**	***p* value**	**PR (95% CI)**	***p* value**
People who used injected drugs	1.24 (1.02, 1.51)	**0.03**	1.57 (1.19, 2.09)	**0.002**				
Age per 5-year increments	1.05 (0.98, 1.13)	0.17	1.05 (0.98, 1.13)	0.14	1.23 (1.07, 1.41)	**0.004**	1.01 (0.93, 1.09)	0.82
Hispanic (ref. white/other)	0.9 (0.72, 1.12)	0.35	0.88 (0.71, 1.10)	0.27	1.03 (0.74, 1.43)	0.88	0.74 (0.55, 1.00)	**0.05**
Black (ref. white/other)	1.16 (0.91, 1.47)	0.23	1.15 (0.91, 1.46)	0.25	0.65 (0.32, 1.31)	0.23	1.08 (0.81, 1.43)	0.61
High school graduate/GED or greater	1.19 (1.03, 1.38)	**0.02**	1.18 (1.02, 1.36)	**0.03**	1.15 (0.86, 1.54)	0.34	1.17 (0.99, 1.39)	0.06
Multiple sex partners	0.9 (0.76, 1.07)	0.23	0.91 (0.77, 1.08)	0.29	0.72 (0.50, 1.06)	0.09	0.94 (0.78, 1.13)	0.5
MSM	0.99 (0.66, 1.50)	0.96	0.93 (0.61, 1.39)	0.71	3.65 (1.24, 10.74)	**0.02**	0.77 (0.49, 1.20)	0.24
Condom less sex	1.17 (1.01, 1.36)	**0.04**	1.19 (1.03, 1.39)	**0.02**	1.46 (1.09, 1.95)	**0.01**	1.14 (0.96, 1.36)	0.13
Sexually transmitted infections	1.37 (1.16, 1.62)	**0.0002**	1.36 (1.15, 1.61)	**0.0003**	1.62 (1.17, 2.24)	**0.003**	1.29 (1.06, 1.57)	**0.01**
Crack	0.85 (0.71, 1.01)	0.07	0.87 (0.73, 1.03)	0.11	0.97 (0.73, 1.29)	0.83	0.91 (0.73, 1.13)	0.39
Sniffed/snorted heroin	1.17 (1.01, 1.35)	**0.04**	1.16 (1.00, 1.34)	**0.05**	1.09 (0.82, 1.45)	0.54	1.22 (1.03, 1.45)	**0.02**
Sex network	1.05 (1.00, 1.11)	**0.05**	1.05 (1.00, 1.11)	**0.05**	1.1 (0.97, 1.25)	0.12	1.04 (0.99, 1.10)	0.14
Structural support	0.93 (0.87, 0.99)	**0.02**	0.94 (0.87, 1.00)	0.06	0.94 (0.81, 1.09)	0.4	0.93 (0.87, 1.00)	0.06
Informational support	1.03 (0.95, 1.12)	0.48	1.02 (0.93, 1.13)	0.61	1.12 (0.94, 1.33)	0.2	1.02 (0.92, 1.12)	0.76
Emotional support	1.08 (0.98, 1.19)	0.11	1.1 (0.99, 1.22)	0.06	0.78 (0.60, 1.01)	0.06	1.1 (0.99, 1.22)	0.07
Proportion of high school graduates/GED or greater	0.77 (0.63, 0.94)	**0.01**	0.77 (0.63, 0.93)	**0.01**	0.76 (0.53, 1.10)	0.14	0.79 (0.63, 1.00)	**0.05**
Proportion overlap with structural and informational support	0.6 (0.39, 0.91)	**0.02**	0.57 (0.38, 0.87)	**0.01**	0.47 (0.21, 1.05)	0.07	0.58 (0.36, 0.95)	**0.03**
Proportion overlap with structural and emotional support	1.41 (0.93, 2.15)	0.11	1.48 (0.98, 2.25)	0.07	1.26 (0.57, 2.81)	0.57	1.69 (1.04, 2.74)	**0.03**
Proportion overlap with emotional support and risk	0.78 (0.57, 1.07)	0.12	0.81 (0.59, 1.12)	0.2	1.32 (0.77, 2.25)	0.31	0.66 (0.45, 0.97)	**0.03**
Injector*informational support			1.11 (0.92, 1.34)	0.29				
Injector*emotional support			0.75 (0.59, 0.97)	**0.03**				
Injector*structural support			0.93 (0.79, 1.10)	0.41				

1. Adjusted model

2. Adjusted model with interaction terms.

set to "missing" in order to exclude the frequent testers from the data set), the results were similar. The magnitude (i.e., effect size), direction, and *p* values of the variables did not substantially change, suggesting that the results were not influenced by the inclusion of frequent testers (outliers).

The log likelihood ratio test ($p = 0.48$) indicated that the reduced model with fewer variables, and consequently more power, fit the data just as well as the full model.

Discussion

In this cohort of hard to reach users of illicit drugs, injection status was an important factor in determining frequency of HIV testing. However, this relationship may be dependent on emotional support. Lauby and colleagues reported similar findings, indicating that individuals with greater social support had fewer unrecognized HIV infections.[24]However, the authors did not include the interaction term with injection status in their analysis. More importantly, various factors that are associated with one's injection status were shown in this investigation to also affect the decision to undergo HIV testing.

Notably, when compared to PWID, PWND were more than twice as likely to report having sex transactions (28% vs. 11%, $p< 0.001$), and were equally likely to report having had condom less sex-a concerning combination in a subpopulation presently under-recognized as being at risk of contracting HIV. In addition, while the difference was not statistically significant, PWND were twice as likely to be MSM compared to PWID (4% vs. 2%).

Among study participants that used injected drugs, age, MSM, condom less sex, and having an STI were factors that exerted the strongest influence on greater frequency of HIV testing. Younger PWID and PWID who reported having multiple sexual partners tended to test less frequently (though the latter difference was borderline statistically significant) and may need more focused strategies to voluntarily undergo testing. It was however reassuring to see that identifying as MSM, reporting engagement in condom

less sex, and having an STI were associated with more frequent HIV testing among PWID, given the compounding effects of these risk factors.

Among individuals using non-injected drugs, several important factors primarily having social network members who simultaneously provide both structural and emotional support and reporting recent heroin use were positively associated with the increase in the average number of HIV tests. Conversely, overlap between emotional support and risk network was associated with fewer tests, and warrants further research.

The positive association of heroin use with frequency of HIV testing may indicate that PWND are aware that this activity increases their risk of contracting HIV, and confirms the importance of continued utilization of prevention strategies that target those who snort/sniff heroin, as well as those who are injecting it. It is important to recognize and reiterate that snorting or smoking illicit drugs instead of injecting them does not eliminate the risk of contracting infectious diseases, such as hepatitis and HIV/AIDS, as drugs compromise reasoning ability and increase the likelihood of engaging in risky sexual and other behaviors that can expose the individual to these diseases.

The importance of having supportive network is also noteworthy. In our cohort, PWND who were able to receive both emotional and structural support from their friends tended to be more likely to undergo HIV testing. Further, though the difference was not statistically significant, PWND who had greater emotional support were more likely to undergo a greater number of HIV tests, compared to PWID. This discrepancy would suggest that the presence of a social network that serves as a source of support is an important factor to consider when designing intervention and prevention strategies at the network level, as the manner in which the illicit drug is administered determines its effects on person's attitudes toward HIV testing. This assertion is supported by the significant interaction term between emotional support and injection status.

Another striking observation arose from the stratified analysis, as it revealed presence of a strong relationship between MSM and HIV testing among PWID, and the seemingly null effect among PWND. This is a classic definition of an effect modifier. A posteriori interaction term analysis was conducted and the results were significant, at $p = 0.04$. The association between MSM and HIV testing among PWID may be an indication that prevention and treatment is primarily geared toward MSM and PWID, who consequently undergo a greater number of HIV tests, which are offered to subpopulations recognized as at risk. It was reassuring that PWID who also identify as MSM were being tested, but was concerning to find that the MSM in the PWND group were not. In addition, among PWND, having a network member who provided both emotional support and with whom the participant engaged in risky behaviors (sex/drugs) was associated with a reduced number of HIV tests. This inverse relationship may suggest that any positive impact that emotional support has on testing may be mitigated by risky behaviors. Further exploration of the overlap of emotional support and risk networks is therefore needed.

As with any study of this type, this research has limitations. First, as the study participants were selected through non-random convenience sampling in NYC, the sample characteristics may not be representative of all marginal populations. Therefore, these results may not be generalizable to all users of hard drugs. However, acquisition of HIV from drug use remains relevant. As we are reminder with the current opioid epidemic in the US that illustrates the troubling link of drug use and abuse, risky behavior, and HIV infection [26,27]. Acquisition of HIV from drug use, either via injecting the drug or from addiction to the drug leading to initiation of heroin use remains a point of great concern [28,29].

In addition, two recruiting methods (RDS and TSO) were adopted, reaching slightly different subpopulations [20]. However, in an earlier study, Rudolph and colleagues showed that relying on different recruitment methods in terms of network composition and health behavior did not affect the research findings [21]. Another possible limitation, owing to the nature of data obtained through self-reported questionnaires, is a potential for under- and over-reporting. Nonetheless, there is no reason to suspect that this effect would be differential or result in biased findings, as this behavior is not dependent on injection status. Also, it is plausible that the HIV testing behavior of participants' network members may influence their personal attitudes, but whether the network members the study participants endorsed had an HIV test was not ascertained as a part of this investigation. Finally, the self-reported HIV status was not verified. Hence, while it is very unlikely those individuals that declared themselves as HIV positive were misclassified, the reverse is not true. In other words, it is possible that some respondents who claimed to be uninfected were unaware of being HIV-positive or chose not to disclose their HIV status. Still, such misclassification is most likely non-differential (i.e., independent of injection status). There are also several strengths that render this study highly important to both research and practice. In particular, to the authors' knowledge, this is the first study in which HIV testing behaviors of PWND to PWID were directly compared using a diverse sample drawn from a hard to reach, high-risk population. Moreover, social network characteristics and their association with HIV testing behavior were examined for the first time.

Conclusion

Users of non-injected illicit drugs that took part in this investigation underwent fewer HIV tests compared to those who inject drugs. This finding is very concerning, as HIV prevalence among PWND is actually equal to or higher than among injectors. However, PWND who had greater emotional support, especially if coupled with structural support, from their personal or egocentric network, tended to have a greater number of HIV tests. Strategies tailored towards this subpopulation, presently under-recognized in research and treatment efforts as being at high risk of HIV infection, are thus warranted.

For example, routinely offering this subpopulation HIV tests at emergency rooms and treatment centers, while allowing them to opt out if desired, may increase their testing propensity. In addition, use of mobile vans in neighborhoods where illicit drug users (regardless of mode of administration) are known to reside, along with partner notification, may increase the number of individuals willing to undergo HIV testing. Similarly, HIV test kits that can be used at home have recently become available, whereby the user takes a swab from the inner gums and obtains results in 20 minutes, and could

be suitable for this subpopulation [25]. Informing individuals on new and varying ways to get tested may increase HIV testing uptake, and may also help identify those who are HIV positive before any outward symptoms emerge. Given that structural and emotional support was found to exert a positive effect on attitudes toward HIV testing among PWND, it is likely that learning that one should test, and test often, would prompt an individual to consider this information seriously and even act upon it, if it came from a member of one's network. Moreover, hearing from a network member about the importance of HIV testing and risk avoidance may lessen the stigma associated with this important preventive and diagnostic measure. These strategies, however, must be coupled with access to counseling and treatment. Testing is just the first tier of prevention, which must also include treatment. Knowing one's HIV-positive status as early as possible ensures that the anti-retroviral medicines are received when they are as efficient as possible in suppressing HIV viral load below detectable levels, which renders HIV untransmittable [4]. Finally, it is essential that the benefits of being cognizant of one's HIV status be emphasized and promoted. Obtaining negative results provides the opportunity to remain infection-free via a change in behavior and/or use of medications (i.e., PrEP). Similarly, even for HIV-positive individuals, receiving treatment not only helps protect their health, but also safeguards the community from the HIV virus spread.

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