The Association between Social Network Characteristics and HIV Testing Behavior among Users of Illicit Drugs

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Abstract

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Introduction

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.

Objective

To assess the HIV testing behavior of people who use non-injected drugs (PWND) and compare it to that of people who use injected drugs (PWID), in order to determine which factors, in terms of social context as well as individual risks, predict HIV testing among the PWND.

Method

A cross-sectional study of HIV testing behavior of PWND compared to PWID was conducted and the data was analyzed by applying negative binomial regression models. Then, a negative binomial regression using generalized estimating equation (GEE) was employed in order to identify the predictive factors for HIV testing among PWND over a 2-year period.

Results

Individuals who reported using injected drugs tended to undergo HIV tests more often compared to those who used non-injected drugs, PR (95% CI) = 1.24 (1.02, 1.51), $p = 0.03$. The interaction term between injection status and emotional support in relation to HIV testing was significant, 0.75 (0.59, 0.97), $p = 0.03$. PWID that had access to greater emotional support on average tended to test for HIV less frequently than did PWID with less emotional support. In stratified analyses, emotional support was negatively associated with testing among PWID and positively associated

among PWND, though both relationships were borderline significant. HIV testing among users of illicit drugs was dependent on emotional support.

According to the GEE models examining the factors predicting HIV testing among PWND, sexually transmitted infections, non-injected heroin use, being in drug treatment, engagement in sexual transactions, and instability in drug networks were the main factors contributing to being HIV tested, as well as frequency of testing. The positive influence of emotional support on these variables was borderline significant.

Conclusion

People who use non-injected drugs are less likely to test for HIV compared to those who use injected drugs, though they may share similar risk factors for HIV transmission and acquisition. To exert a greater impact on the HIV epidemic, interventions and policies encouraging HIV testing in this subpopulation, which remains under-recognized by both researchers and health practitioners in terms of the potential risks for contracting the HIV, are warranted.

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Chapter 1. Introduction

The *Human immunodeficiency virus* (HIV) incidence rate, while remaining steady over the past decade, is nonetheless high, especially in marginalized communities.[1] HIV, which is transmitted through the exchange of bodily fluids, destroys the immune system if left untreated and may develop into **a**cquired **i**mmune **d**eficiency **s**yndrome (AIDS). There is currently no vaccine or cure for HIV/AIDS. Thus, it is imperative that an HIV-infected person be treated to avoid morbidities, mortality, and adverse impact on the community viral load, as well as minimize transmission. To be treated, the affected individual must be identified first, which necessitates an HIV test. Therefore, understanding HIV testing behaviors of at-risk individuals and identifying ways to promote testing is important. Evidence shows that testing is the most economical and successful defense against HIV transmission.[2;3]

The continued success that combination anti-retroviral therapy has had in suppressing HIV viral load and reducing the AIDS incidence, as well as related morbidity and mortality, has resulted in shifting the policy focus from palliative care to disease management.[4] However, HIV infection remains a significant health outcome that continues to evade efforts of control and substantial reduction. Despite the advancements in HIV detection and treatment, it is estimated that over one million individuals currently live with HIV in the US. In 2009, about 20% of those persons were unaware of their HIV-infection. In 2015, this percentage decreased to 12%.

The risk of HIV infection as a result of unprotected sexual encounters is well established and becomes even greater in the population that also uses illicit drugs, as drugs usually impair judgment. Risky sexual behavior is of concern in both people who inject drugs (PWID) and people who use non-injected drugs (PWND). However, PWID have been disproportionately targeted by intervention, research, and HIV prevention/treatment initiatives. This narrow focus is

likely due to the fact that intravenous administration of drugs is a more efficient mode of HIV transmission. Nonetheless, empirical evidence indicates that, in some cases, the prevalence of HIV among PWND was equal to, or even higher than, that recorded among PWID.[2;5;6] These findings are concerning, as PWND that are not treated or identified as an important 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 of these social groups and identifying the most effective means of promoting testing is important. Individuals who are unaware of their HIV infection are more likely to be diagnosed when the disease is more advanced and are thus more likely to be infectious to drug and/or sexual partners.[7;8]

The social setting, characteristics, and culture of illicit drug users differ by injection status. An inherent difference stems from the type of equipment used, which leads to differing risks, both in terms of disease transmission likelihood and social acceptance. As injecting illegal drugs tends to engender stronger disapproval, it is reasonable to believe that the influence on health behavior may differ as well. Thus, the goal of this dissertation research is to examine the relationship between individual, as well as social network characteristics, and HIV testing behavior among a sample of users of illicit drugs who are uninfected. Furthermore, to compare and contrast these associations between PWID and PWND, and to longitudinally examine PWND—a persistently high-risk group of users of illicit drugs that has remained understudied.

Chapter 2. Literature review on HIV testing in users of illicit drug population

Introduction

The benefits of identifying and treating asymptomatic individuals that are carriers of human immunodeficiency virus (HIV) are firmly established,[1] yet many HIV-infected individuals remain undiagnosed.[2-5] Those that are unaware of their HIV status are more likely to continue to engage in risky behaviors, thereby increasing the risk of transmitting HIV to others. Empirical evidence indicates that the impact of HIV-infected individuals that are unaware of their status on HIV transmission is grave.[6;7] For example, Marks and colleagues found that persons unaware of their HIV status were almost four times as likely to transmit HIV compared to those that are aware of their status.[7] The extent to which persons who use illicit drugs know their HIV status is not well known. This is especially true of people who use non-injected drugs.

The Centers for Disease Control and Prevention (CDC) estimates that 30% of new HIV infections are transmitted by HIV-infected individuals for whom the disease has not been diagnosed.[8] Thus, CDC recommends that everyone aged 13−64 be tested for HIV at least once in their lifetime as a part of routine healthcare, while those deemed at high risk should undergo HIV testing annually. For sexually active gay and bisexual men (the group at the highest risk for contracting HIV), the CDC recommends testing at 3- to 6-month intervals.[3;8] HIV carriers that are aware of their status benefit from this knowledge because (1) they can change their behavior, and (2) they can obtain the necessary treatment—usually combination antiretroviral therapy (cART)—ensuring that they remain healthy and maintain low viral load (the amount of virus in the blood).[8;9] Low viral load can reduce the likelihood of developing an HIV-related illness, while also limiting the potential for spreading the virus. In fact, cART can reduce the chance of transmitting HIV by as much as 96%.[8]

Testing for HIV is the only definitive way of establishing one's HIV status. However, persuading the drug using population to undergo HIV testing is a challenge due to the stigma and discrimination associated with illegal drug use. People who use illicit drugs, and particularly those who inject their drugs, are known to be at high risk for contracting HIV. It is therefore important to know if and how often users of illicit drugs undergo HIV tests. According to Fuqua and colleagues, lack of awareness of HIV status is particularly prevalent among individuals using injectable drugs.[10] This finding is troubling because it means that drug abusers are not only at a high risk of contracting HIV, but are also unaware of their HIV status, making virus transmission more likely. Findings yielded by several studies have demonstrated a strong association between substance abuse and HIV acquisition and transmission.[11;12] Illicit drug use is generally classified into injecting and non-injecting, based on the administration mode. Regardless of mode of administration, HIV testing among people who use illicit drugs is a public and individual health issue. From the public health perspective, identifying and treating HIV-infected persons who use illicit drugs is essential, as it mitigates virus transmission in the community. For the individual, awareness of HIV-positive status enables access to treatment, thus prolonging one's life and improving its quality. Empirical evidence indicates that both the public and individual health benefits are increased by providing an HIV-infected individual with medical care in a timely manner.[3;6]

HIV testing is the first step toward ending the HIV epidemic. It promotes protection by preventing HIV transmission though behavioral changes of those who test positive or negative. Low uptake of HIV testing delays entry into treatment and limits the utility of available care. As a result, the risk of mortality among those unaware of their HIV status increases, while also heightening the potential of HIV transmission within their circle of friends and the wider

community. HIV testing has the benefit of identifying infected individuals. It also prompts those whose results are negative to protect themselves from contracting HIV by modifying risk behaviors and/or accessing medical treatment, such as proactively taking HIV medications daily, known as pre-exposure prophylaxis (PrEP).[13] PrEP may be especially beneficial to HIV-negative individuals that are deemed at high risk of infection, such as illicit drug users. As a part of the HIV test, they can also learn of other options and care modalities if they have been exposed. For example, they can learn about post-exposure prophylaxis (PEP).[13]

Unfortunately, a large portion of the US population, some of whom are at high risk for contracting HIV and other communicable diseases, has never been tested.[14-16] Moreover, 32% of HIV cases that were newly diagnosed between 2001 and 2009 were late diagnoses.[17] It is highly likely that these individuals finally decided to undergo HIV testing due to experiencing some symptoms, suggesting that their viral load was high and CD4 (a biomarker for immune health) was low, increasing the likelihood of transmission. This is particularly worrisome, as antiretroviral therapy is less effective for those in the late stages of the disease. The intravenous use of drugs is recognized, publicized, and actively campaigned upon as a route of HIV transmission for people who inject drugs (PWID). However, sexual transmission remains the most common mode of HIV transmission, as it affects users of injected as well as non-injected drugs. Moreover, authors of several studies have reported a high HIV prevalence among people who use non-injected drugs (PWND).[18-20] However, while both injectors and non-injectors share significant risks, PWND are not presently recognized as a high-risk group and are likely to be overlooked in pertinent studies when examined alongside other subpopulations within the same, often broad, transmission or high-risk categories. In CDC's annual estimates of new HIV infections in the United States, PWND are not listed among the most affected subpopulations.

Furthermore, PWND have neither been a primary focus nor have received funding for prevention at a level comparable to that provided to PWID or men who have sex with men (MSM). It is important to identify and treat HIV-infected individuals in both groups as soon as possible and before any clinical symptoms emerge. Given that testing for HIV is a critical component of the prevention and treatment efforts, and is a known cost-effective measure aimed at improving health, the CDC recommends that providers routinely offer HIV tests to individuals under the age 65, as well as suggest repeat testing.[3] Persons at higher risk of contracting HIV should be tested frequently, as this would allow them to learn their HIV status as early as possible or as close to seroconversion (i.e., exposure) as possible, thus ensuring that they are appropriately counseled and that any treatment offered is at its most effective. Unfortunately, access and uptake of HIV testing remain inadequate[21] and the extent to which the CDC recommendation is implemented in practice is not well known. In order to encourage at-risk individuals to test and retest, it is essential to identify the factors associated with testing. For example, does one's awareness of his/her risky behaviors influence attitudes toward HIV testing? In particular, does mode of drug use (injecting drugs vs. non-injected drugs) influence HIV testing?

In addition to recognizing the mode of drug use as a factor contributing to one's attitude toward HIV testing, researchers have explored the influence of an individual's personal network, or egocentric network, on his/her HIV testing behavior.[10;22;23] Social networks are defined as the web of identified social relationships that surround an individual and the characteristics of those relationships.[24] The dynamics of social networks pertain to both the way an individual influences his/her environment and the influence that the environment exerts on that individual. Based on this premise, it is important to understand if and how social network characteristics affect attitude toward HIV testing among those at high risk for contracting HIV, namely users of illicit

drugs. Available evidence suggests that the likelihood of being tested for HIV is influenced by the prevalent attitude among the members of a person's social network toward testing. In particular, positive associations have been found between the characteristics of people in an individual's network and their HIV risk behaviors.[25-27] Kimbrough and colleagues evaluated social networks and high rates of undiagnosed HIV infection and found that a peer-driven approach was highly effective in identifying undiagnosed individuals.[28] However, while social network effects on the likelihood that PWID will recognize their HIV risk and undergo testing have been explored in the past,[29;30] empirical information on the interaction of PWND with their family and friends (i.e., personal or egocentric network) is limited. HIV, like many sexually transmitted infections, is an inherently social ailment. Thus, the social context is an important factor in one's attitude toward HIV testing. Understanding the role of social context can assist in elucidating the environment within which HIV prevalence or prevention thrives. It has been shown that having social support improves one's health and engagement in care, in particular HIV treatment.[31;32] Hence, it can be postulated that social network characteristics may influence one's attitude toward HIV testing.

As indicated before, substance abuse has a long and well-established link with increased risk of contracting HIV. However, extant research has mainly focused on people who inject drugs.[33;34] While non-injectable drug users are also at risk for HIV transmission and acquisition, they remain insufficiently studied.[18-20;35;36] A possible unforeseen consequence of focusing on some groups deemed at a higher risk relative to others is that those that are not specifically addressed in research and prevention initiatives tend to perceive themselves as being at low risk of HIV infection, resulting in limited uptake of tests and rerests.[37] Begovac and colleagues reported that HIV-infected heterosexuals sought medical treatment at a later stage of infection than did MSM

because heterosexuals typically tested less often.[37] Similarly, PWND most likely believe that they are at a lower risk compared to PWID. As previously noted, the extent to which those who use non-injectable drugs are tested for HIV is not well known. Thus, the aim of the present study was to understand HIV testing behaviors and identify gaps in HIV testing practices among people who use illicit drugs. More specifically, the goal was to ascertain the extent to which attitudes toward and prevalence of HIV testing among users of illicit drugs have been explored in pertinent research. In addition to obtaining this information, the research goal was to establish if, in extant studies in this field, the likelihood of HIV testing among people who used non-injected drugs was compared to that among people who injected drugs, and if social network factors were examined as potential contributors to the attitudes toward HIV testing.

Methods

This literature review focused on studies exploring HIV testing, injection status, and social network characteristics among users of illicit drugs. Thus, its scope was restricted to research examining HIV testing among populations known for injection and non-injection use of illegal drugs. As the aim was to provide an overview of most recent work and because the utilization of social network characteristics became a popular research topic in the past two decades, only studies relating to HIV testing or HIV/AIDS prevention among people who use illicit drugs published between 1995 and 2015 were included in the literature review. The pertinent literature sources were identified by searching PubMed, Google Scholars, and PyscINFO databases. To generate an exhaustive list of relevant articles, the following mesh terms were used in combination: crack, speedball, substance abuse, intravenous, opioid-related disorders, cocaine-related disorders, illegal drug use, street drugs, and HIV infections/diagnosis. Only articles written in English language were included and sources cited within were examined for additional

references. This strategy resulted in 895,054 articles (Figure 1). As 871,576 of those articles did not pertain to drug use or users of illicit drugs, they were excluded from further evaluation. A further 23,170 literature sources were excluded because they were either duplicates or did not pertain to studies in which HIV prevention was treated as the main factor, and one article was retracted. From the 308 remaining articles, 277 were excluded because they did not report on HIV testing among persons using illicit drugs or drug using population. This strategy yielded 31 articles that were subjected to a detailed review.

Results

Summary of Studies Included in this Review (Table 1)

The proportion of participants that had undergone an HIV test varied considerably across the 31 studies included in the review, as it ranged from 14% to 97%. The factors that the authors found to be associated with HIV testing were primarily of sociodemographic nature, namely age, gender, education, and income. Sexually transmitted diseases (STDs) were also commonly identified as a factor contributing to one's attitude toward HIV testing. In addition, perceived risk, ease of access, and confidentiality influenced the likelihood of being tested for HIV. In 13 of the 31 reviewed studies, PWID and PWND were examined. However, only Saw and colleagues specifically explored the link between drug administration mode and likelihood of HIV testing.[38] These authors explicitly differentiated between PWID and PWND and conducted stratified analyses of HIV testing attitudes by injection status. However, they failed to conduct a formal test of interaction between injection status and other variables in relation to HIV testing. Moreover, PWND were not directly compared to the PWID group in any of the reviewed studies. Authors of 23 studies adopted a cross-sectional design. The remaining studies in the selected

literature sources were three qualitative studies, two intervention studies, and one each of a Meta-analysis, a randomized clinical trial, and a case study.

Articles pertaining to studies that included both PWID and PWND

In their 1998 study, Grella and colleagues assessed the relationship between HIV testing and risk behavior among individuals in methadone treatment, and found that knowing someone who was HIV positive, engaging in illegal activity, and individuals who reported they perceived their risk of HIV infection as high were factors that increased the likelihood of HIV testing.[39] Moreover, the authors indicated that individuals whose sexual behavior was the main source of HIV infection risk did not monitor their HIV status as regularly (i.e., did not have comparatively high number of tests) as those whose main source of risk was use of injection drugs. In their 1999 study, Samet and colleagues assessed HIV testing among substance abusers in addiction treatment and found that 53% of alcohol, heroin, and cocaine abusers reported having been HIV tested in the past.[40] While this sample included both PWID and PWND, as the focus was on drug abusers in general, injection status was not specifically explored. Nonetheless, Samet and colleagues noted that participants for whom risk factors for HIV infection (e.g., multiple sex partners) were well established were more likely to have been tested. However, the authors also reported that a significant proportion of participants known to be at high risk for contracting HIV had not been previously tested, and over a third of those for whom the test result was positive were not injection drug users. In a study conducted on drug users in Switzerland, Somaini and colleagues raised similar concerns, noting that those known to be at high risk for HIV did not typically seek to find out their HIV status through testig.[41] These authors reported a 34% refusal rate for voluntary HIV testing among drug clinic participants.

In their respective qualitative studies published in 2001, Vernon and colleagues examined repeated testing,[42] while Reiss and colleagues explored gender differences in attitudes of drug users toward HIV testing.[43] Vernon and colleagues found the that the mean number of tests their study participants underwent was six, and that HIV testing was not motivated by a perceived personal risk, but was rather driven by community factors, such as HIV prevalence in the population, and knowledge of and interaction with an HIV-positive person. Reiss and colleagues found that, compared to men, women were more motivated to test, as they seemed to be more concerned with protecting the wellbeing of their family and others. While this finding might be indicative of the effect of social context, it was not explicitly examined in this study. On the other hand, the authors did examine the prevalence of repeated HIV testing in their sample and found that women tested more frequently than did men (86% of the study sample tested more than once).

In four studies included in the literature review the authors examined policies and/or programs pertaining to HIV. They found that types of policies and programs adopted affected HIV testing behaviors, as well as the size of HIV clinics, staff ratios and training offered, and whether health facilities were run for profit or were non-profit organizations.[44-47] For example, state regulation and on-site testing had a strong effect on HIV testing.

In 2013, Saw and colleagues explored HIV testing behaviors among drug users that were separated for analysis by injection status. According to their findings, 76% of PWID and 46% of PWND had an HIV test.[38] PWND were on average younger than PWID, and younger individuals were also found more likely to take risks. The authors also conducted stratified analysis, revealing that, among PWID participants, perceived risk of HIV, employment status, and being registered as a drug user were associated with testing. Among PWND participants, HIV testing

behavior was influenced by perceived risk, drug treatment, and being registered as a drug user. Moreover, PWID that reported frequent drug use were less likely to test for HIV, while ethnic minority status and multiple drug use decreased the likelihood of PWND being tested. These findings may indicate that PWND who are further marginalized due to their ethnicity do not seek testing or may have limited access to prevention and care, due to the compound discrimination or stigma associated with illicit drug use and minority status. Discrimination and stigma are known factors associated with HIV risk behaviors.[48-50] According to Crawford and colleagues, discrimination is associated with greater propensity for risky behaviors among black drug users.[51] In particular, the association between multiple drug use and low likelihood of HIV testing is concerning because it puts PWND at an increased risk, as they may falsely perceive themselves as not at risk or at a low risk of contracting HIV. Given that PWID are often targeted for blood borne disease and/or HIV prevention, they may be more aware of their risk, unlike PWND who are usually not targeted by such prevention and treatment initiatives. Thus, it must be emphasized that illicit drug use, irrespective of its mode, is a risk factor for contracting and transmitting infectious diseases such as HIV.

Merchant and colleagues conducted a randomized controlled trail in which emergency room attendees who misused drugs took part.[52] Individuals in the intervention arm were given a brief intervention to motivate them to address their drug use, as well as encourage them to undergo an HIV and/or Hepatitis C test. The participants assigned to the control arm were not given this intervention. The authors did not distinguish between injecting and non-injecting drug use. They reported that HIV testing uptake was surprisingly higher in the control arm of the study (44% vs. 37%). However, the likelihood of HIV testing was dependent on the test provider and elapse study time, defined as the time between consenting (i.e., study entering) and testing.

Metsch and colleagues examined HIV testing among women who used drugs in five countries (Argentina, Vietnam, Australia, Ukraine, and United States).[53] Their findings indicate that HIV treatment as a prevention has been largely successful in places with equitable access to cART for all. They further noted scarcity of available HIV care continuum outcome data, such as testing, linkage, and viral suppression.

Frimpong and colleague examined a large sample of individuals in addiction treatment, noting that 64% reported being tested for HIV at some point in the past, 85% of whom received their test results (indicating that 15% of those tested remained unaware of their status).[54] Being female, a minority, employed, having prior drug treatment, having an STD or Hepatitis C, injection drug use, recovery support (some form of social support), and history of mental illness were identified as factors positively associated with testing. Use of alcohol or marijuana had an inverse association with the likelihood of seeking an HIV test.

Articles reporting on studies examining PWID or PWND only

Fifteen of the remaining articles reported on studies focusing on PWID and three focused on PWND, further confirming that PWND population remains understudied. With the exception of three studies, all others focusing on PWID[55-69] were based on cross-sectional design and their findings indicated that 17% to 88% of the examined individuals had tested for HIV at some point in their life. When the authors focused on more recent testing behaviors (i.e., in the preceding 12 months), the percentage of those tested was 50% or lower. These findings indicate that, while PWID are testing for HIV, their testing rates are suboptimal. The factors commonly cited to be contributing to HIV testing included gender, race, STDs, education, and contact with health services. The three studies focusing on PWND[22;70;71] were based on cross-sectional design, and

the findings yielded indicated that 15% to 97% of participants underwent HIV testing. The most frequently cited contributing factors were female gender, higher educational attainment, and prior STD diagnosis.

Authors of one study examining PWID only and one focusing solely on PWND examined social factors as possible contributors to HIV testing.[22;55] More specifically, Tobin and colleagues explored the role of social and contextual factors in PWID attitudes toward HIV testing and the likelihood of being tested in the past 12 months. The authors found that having a main sex partner who underwent an HIV test increased the likelihood of being HIV tested. This finding suggests that a dyad relationship (a social inter-relationship between two people) was influential in an at-risk person's decision to seek an HIV test. The impact of having a main partner who underwent an HIV test on a person's HIV testing behavior versus that exerted by a main partner who did not was twofold. Other influential factors included incarceration, interaction with outreach workers, and being female. In their study on PWND, White and colleagues examined the link between social factors and recent HIV testing (i.e., in the past 12 months). They reported that informational support (defined as having at least one network member that provides information about medication, treatment options, nutrition, food banks, legal aid, healthcare, where to go for service/advice, etc.) was positively and significantly associated with HIV testing. Higher education and prior STD diagnoses were also contributing factors to positive attitudes toward HIV testing.

Authors of three studies included in the literature review aimed to establish the link between the number of HIV tests and various influential factors. Grella and colleagues, for example, found that repeat testers (those that underwent at least three HIV tests) were more likely to know an HIV-positive person, perceive they risk as high (e.g., sharing injection equipment with a high

number of people), and score higher on HIV knowledge and depression scale, compared to those who tested less often. Reiss and colleagues' findings revealed that women were more likely than men to undergo routine HIV testing (i.e., testing repeatedly at regular intervals). Moreover, those tested routinely were largely motivated by prior risk behavior (such as injection drug use). Similarly, women were also more likely, relative to men, to report occasional testing (repeated testing at irregular intervals). Individuals of both genders that underwent occasional HIV testing cited occurrence of possible HIV exposure as the main reason. In their 2014 study, Wright and colleagues conducted an empirical examination of HIV testing frequency, and found that age, being female, prior STD diagnosis, incarceration, and recent change of sex partner (in the past 30 days) were the main factors associated with frequency of HIV testing. These findings indicate that HIV testing is more frequent when part of routine care compared to testing specifically due to HIV exposure.

Discussion

Findings yielded by this literature review confirm that individuals who perceive themselves at high risk (e.g., PWID and MSM) of contracting HIV or other communicable diseases such as STDs are aware of the pertinent risk factors, such as injection drug use, multiple sex partners, MSM, and/or STDs, and are more likely to undergo HIV testing. Clearly, perception of one's risk is an important factor in the decision to take an HIV test and modify one's behavior. Thus, greater efforts must be made to encourage those that have not been traditionally perceived as at high risk of contracting HIV (such as PWND) to be tested. This assertion is supported by the findings reported by Samet and colleagues, who recommended nearly two decades ago that PWND be strongly encouraged to undergo HIV testing and be provided appropriate pre- and post-test counseling. It is also noteworthy that, according to the findings yielded by this review,

even though individuals deemed at risk were more likely to test for HIV, the testing uptake in this population is still suboptimal. While these findings are certainly beneficial, it is necessary to conduct more extensive studies in order to better understand factors that predict HIV testing, especially regular testing, among illicit drug users and PWND in particular.

Finally, authors of some studies noted that fear of the test result may act as a deterrent to testing. Reassurance and promotion of effective treatment is thus urgently needed. Over the years, HIV treatment has transitioned from palliative care to disease management. Thus, it should be treated like any other chronic disease and be destigmatized.

Limitations

The aim of the review presented in this chapter was to establish the extent of the current knowledge on the HIV testing behaviors and attitudes among illicit drug users and identify factors that contribute to testing frequency in this population. In particular, the goal was to ascertain if non-injected drug use was examined in studies that have been conducted in the past two decades and if such analyses included social network characteristics. While 15 of the 31 studies reviewed included both PWID and PWND, injection status was specifically examined in only one. Similarly, authors of only two studies explored social network factors, and three studies focused on repeated testing.

In addition to the varying *quality* of the literature included in this review, this review is further limited by the *quantity*, as only 31 articles published in English language in the last two decades pertained to studies examining drug use and HIV testing among illicit drug users. In particular, only a small portion of these studies focused on both PWID and PWND. As the authors of these works rarely examined social network characteristics as a factor contributing to HIV testing behavior, further research is required. The utility of the available information is further

compromised by the fact that almost all studies reviewed were cross-sectional, and some were based on a small sample comprised of members of specific population (e.g., men only or individuals in treatment only). Thus, the heterogeneity, different designs, and diversity of methods applied made comparisons of study findings difficult and likely contributed to the significant discrepancies among the reported results.

Conclusion

HIV testing in people who use non-injected drugs is presently understudied, and the research that explores social context, such as network characteristics, as it relates to testing, is even scarcer. Sociodemographic factors, perception of risk, and confidentiality of test results are highly important factors in one's decision to undergo HIV testing and thus require further examination. While some individuals may be at a higher risk than others, all persons heavily involved in drug use are at risk of acquiring HIV and must be targeted by HIV testing initiatives. However, while HIV testing is certainly recommended, it is important to recognize that repeatedly obtaining negative results may create a misconception that past and current behaviors are safe. Hence, better understanding of the individual and social contexts within which HIV testing decisions are made and acted upon may help in dispelling these misconceptions. Moreover, the findings yielded by examining these factors will inform more effective intervention strategies that encourage regular HIV testing among communities who are unable to discontinue high risk behaviors and/or avoid high risk events.

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Figure 1. Flow chart of research articles selection

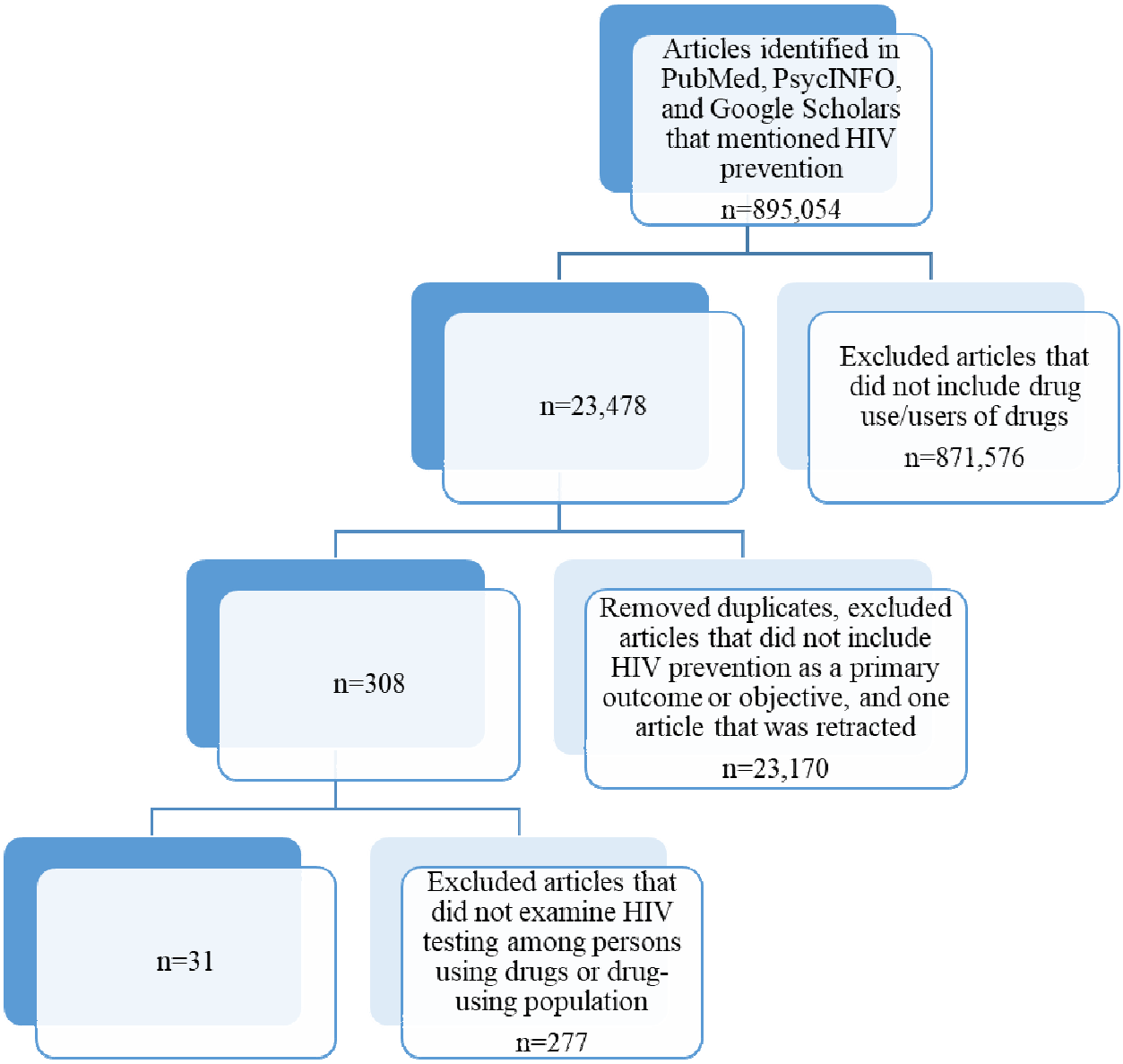

Table 1. Studies focusing on HIV testing among users of illicit drugs

Author(s)	Year	Study sample	Title (outcome)	Study design	Results/Key findings	PWID/PWND
Grella CE, Campos M, and Anglin MG	1998	339 individuals in methadone maintenance in Los Angeles, CA	Relationship of HIV testing and high-risk behaviors among clients in methadone maintenance treatment Outcome: frequency of HIV tests	Cross-sectional	Analyses revealed that **45% of the clients in treatment reported having three or more HIV tests,** and they were more likely to know an HIV positive person, perceive their risk of infection as high (e.g., sharing injection equipment with a high number of people), and score higher on HIV knowledge and depression scale, compared to those who tested less.	PWID & PWND
Samet JH, Mulvey KP, Zaremba N, and Plough A	1999	2,315 patients in addiction treatment, Boston, MA	HIV Testing in Substance Abusers. Outcome: ever HIV tested	Cross-sectional	Analyses revealed that **1,231 (53%)** of alcohol, heroin, and cocaine abusers, **reported having undergone HIV testing in the past**. Those recognized as at high risk for HIV were more likely to have been tested. However, 27% of PWID, 38% of those who reported having multiple sexual partners, and 39% of individuals with STD had not been HIV tested. Finally, 37% of those tested were PWND.	PWID & PWND
Somaini B, Wang J, Perozo M, el al.	2000	603 drug users from four clinics offering opioid treatment, Zurich, Switzerland	A continuing concern: HIV and hepatitis testing and prevalence among drug users in substitution programmes in Zurich, Switzerland. Outcome: ever HIV tested	Cross-sectional	More than **95% of study participants were tested for HIV**, and the median number of tests was four.	PWID & PWND

Vernon KA, Mulia N, Downing M, Knight Km, and Riess T	2001	67 uninfected drug users in San Francisco, CA	"I don't know when it might pop up": Understanding repeat HIV testing and perceptions of HIV among drug users. Outcome: repeated HIV tested	Qualitative study	All but one study participant reported being previously tested for HIV, which was expected, as the study focused on repeated testing. **The mean number of tests was six.** HIV testing was not motivated by perceived personal risk, but was rather driven by community factors, such as HIV prevalence in the population, and knowledge of and interaction with HIV+ person. The participants were motivated to undergo repeated tests by the misunderstanding that HIV lays dormant and their negative status will eventually turn positive.	PWID & PWND
Riess TH, Kim C, and Downing M	2001	66 HIV-tested PWID/PWND from three CA counties—Alameda, Contra Costa, and San Mateo	Motives for HIV Testing Among Drug Users: An Analysis of Gender Differences. Outcome: ever HIV tested	Qualitative study	Qualitative analysis of HIV-tested PWID/PWND. Findings indicated that women were more motivated than men to test for HIV due to family concerns, in order to protect their significant other, and especially when pregnant. Other influencing factors were related to the social setting, such as jail, hospital, or drug rehab.	PWID & PWND
Tobin KE, Tang AM, Gilbert SH, and Latkin CA	2004	558 active PWID in Baltimore, MD	Correlates of HIV antibody testing among a sample of IDUs: the role of social and contextual factors. Outcomes: (1) ever HIV tested and (2) recent HIV test among ever testers	Cross-sectional	According to the study findings, **84% of the sample had an HIV test at least once in their lifetime, while 54% tested in the past 12 months**. Incarceration, interaction with outreach workers, using case manager, and having a main partner that underwent an HIV test were contributing factors in the decision to take an HIV test.	PWID

Ford K, Wirawan DN, Sumantera GM, Sawittri AAS, and Stahre M	2004	40 PWID in Bali, Indonesia	Voluntary HIV testing disclosure, and stigma among injection drug users in Bali, Indonesia. Outcome: ever HIV tested	Qualitative study	About **47% of the sample was tested for HIV** and almost half of those were positive. The average number of sex partners was four. The need to know one's status, protect oneself and others, risky behavior, and education about AIDS were the main reasons for seeking an HIV test. Reported barriers were fear of being positive, death, and stigma.	PWID
Kawichai S, Celentano DD, Vongchak T, et al.	2006	825 PWID in detox or treatment, Thailand	HIV voluntary counseling and testing and HIV incidence in male injecting drug users in northern Thailand: Evidence of an urgent need for HIV prevention. Outcome: ever HIV tested	Cross-sectional	According to the authors, **36% of the sample had an HIV test.** Higher education and having multiple sex partners over one's lifetime were the main factors associated with prior HIV testing. *Only descriptive statistics on frequency of HIV testing were reported.*	PWID
Heimer R, Grau LE, Curtin E, et al.	2007	1,543 PWID from five cities in CT, MA, IL, and CA	Assessment of HIV testing of urban IDUs: Implications for expansion of HIV testing and prevention efforts. Outcome: ever HIV tested	Cross-sectional	About **93% of the sample had a prior HIV test.** The likelihood of HIV testing was higher for SEP customers, women, whites, residents of north eastern cities and younger PWID. In addition, male gender, non-white race, older age, and lower educational attainment were factors associated with HIV seropositivity. Descriptive statistics reported by the authors pertain to repeated testing: reported mean number of tests ~5, median 4.	PWID

Stopka TJ, Marshall C, Bluthenthal RN, Webb DS, and Truax SR	2007	2,950 PWID at five sites across California—Berkeley, Fresno, Humboldt, Riverside, and Solano	HCV and HIV counseling and testing integration in California: an innovative approach to increase HIV counseling and testing rates. Outcome: HIV testing	Intervention study	Rates of HIV testing were higher when offered with HCV testing, than alone (**27% vs 8%**). Those willing to get HCV were also more likely to undergo an HIV test at the same time.	PWID
Moyer LB, Brouwer KC, Brodine SK, et al.	2008	427 PWID in Tijuana and Ciudad Juarez, Mexico	Barriers and missed opportunities to HIV testing among injection drug users in two Mexico-US border cities. Outcome: ever HIV tested	Cross-sectional	Only **38% and 30% of participants in Tijuana and Ciudad Juarez were tested, respectively**. Factors associated with not being tested were being male, single, not having a prior STI diagnosis, not being in drug treatment, and lack of knowledge on how HIV is transmitted.	PWID
Salmon AM, van Beek I, Amin J, et al.	2009	9,778 IDUs attending Sydney Medically Supervised Injecting Center	High HIV testing and low HIV prevalence among injecting drug users attending the Sydney Medically Supervised Injecting Center. Outcome: ever HIV tested	Cross-sectional	Most IDUs were tested for HIV, **94% reported previous HIV testing. In particular, 7,091 (90%) of these tests were undertaken in the past year. However, 545 participants were never tested**. Factors associated with testing were identifying as homosexual, history of drug treatment, imprisonment, being female, increasing age,	PWID

					overdose, and unemployment.	
Pollack HA and D'Aunno T	2010	1,755 outpatient substance abuse treatment facilities, nationwide	HIV testing and counseling in the nation's outpatient substance abuse treatment system, 1995−2005. Outcome: ever HIV tested	Cross-sectional	No differences by clinics were observed, and there were no statistical difference in testing across survey waves. Units with higher proportions of IDU, blacks, and those that had clients who engaged in sex transactions, tested more frequently. Non-profit clinics and methadone-specific units were more likely to offer C&T. Unit size and staff-client ratio were also contributing factors.	PWID & PWND
Niccolai LM, Toussova OV, Verevochkin SV, Barbour R, Heimer R, and Kozlov AP	2010	387 PWID in St. Petersburg, Russia	High HIV prevalence, suboptimal HIV testing, and low knowledge of HIV-positive serostatus among injection drug users in St. Petersburg, Russia. Outcomes: HIV prevalence, ever HIV tested and recently tested	Cross-sectional	The authors reported that **76% of the study participants were tested for HIV (30% recently)**. The median number tests undertaken was two. Overall, having doctors visit was positively associated with having an HIV test. Among men, being in jail was additionally positively associated with the likelihood of being tested, and among women, being pregnant increased the chance of having an HIV test. Structural characteristics may be more important determinants of testing than individual factors.	PWID

Medhi GK, Mahanta J, Paranjape RS, et al.	2012	1,699 PWID, India	Factors associated with ever HIV testing among injecting drug users (IDUs) in two HIV high prevalent States of India. Outcome: ever HIV tested	Cross-sectional	Only **286 (16.8%) of the respondents were ever tested for HIV.** Factors associated with having had HIV tests in the past were higher educational attainment, type of employment, having contact with HIV program workers, having received counseling, knowledge that HIV can be prevented, self-perceived risk, and location.	PWID
Du J, Lombardi C, Evans E, Jiang H, Zhao M, and Meng Y	2012	540 patients in compulsory drug treatment, Shanghai, China	A mixed methods approach to identifying factors related to voluntary testing among injection drug users in Shanghai, China. Outcome: willingness to be HIV tested	Cross-sectional	Only **24% of patients were willing to get an HIV test**. Younger age and positive attitude towards condom use were positively associated with willingness to undergo an HIV test. Fear, stigma, and discrimination, as well as low perceived risk, were the main barriers.	PWID
Saw YM, Yasuoka J, Saw TN, et al.	2013	368 recruited male participants, Lashio, Myanmar	What are the factors associated with HIV testing among male IDU and NIDUs in Lashio, Myanmar? Outcome: ever HIV tested	Cross-sectional	About **77% of PWID and 46% of PWND had ever tested for HIV**. Among PWID, increase age, employment, being in drug treatment, and being registered as a drug user increased the likelihood of testing, while those that were multiple and frequent drug users were less likely to undergo HIV testing. Among PWND, Shan ethnicity and multiple drug use were associated with <u>not</u> being tested.	PWID & PWND

White K, Rudolph AE, Kandice KC, et al.	2013	418 PWND in New York City, NY	Social and individual risk determinants of HIV testing practices among non-injection drug users at high risk for HIV/AIDS. Outcome: recent HIV tested (past 12 months)	Cross-sectional	The authors reported that **97% of PWND had an HIV test in the past while 86% had a recent HIV test.** Education, informational support, and prior positive STI test were associated with HIV testing.	PWND
Seewald R, Bruce RD, Elam R, et al.	2013	7,875 patients in methadone treatment program in New York City, NY	Effectiveness and feasibility study of routine HIV rapid testing in an urban methadone maintenance treatment program Outcome: recent HIV test	Cross-sectional	Among the HIV-tested individuals, **1,121 (14%) were recruited by the traditional targeted testing approach, while 2,700 (34%) underwent routine rapid tests.** Significantly, more patients were tested using the routine rapid testing approach recommended by the CDC, OR (95% CI) = 3.20 (2.90, 3.40).	PWID & PWND
Sarna A, Tun W, Sharma V, et al.	2013	3,793 male PWID in Delhi, India	High uptake of HIV testing in a cohort of male injection drug users in Delhi: Prevalence and correlates of HIV infection. Outcome: HIV-infection	Cross-sectional	A high percentage of participants were **tested (95%).** Those who did not test reported prior HIV testing.	PWID

Ti L, Hayashi K, Kaplan K, et al.	2013	350 PWID in Thailand	HIV test avoidance among people who inject drugs in Thailand. Outcome: ever HIV tested	Cross-sectional	According to the authors, **13% of the study sample avoided HIV testing**. Presumably, the remaining 87% sought testing/were tested, but this was not explicitly stated. Hepatitis C test was associated with having an HIV test. Male gender, frequent drug use, syringe sharing, increased police presence in the community, and being refused healthcare services were associated with not getting an HIV test.	PWID
Wright PB, Booth BM, Curran GM, et al.	2014	251 rural black cocaine users, who were sexually active and using in past 30 days, Arkansas	Correlates of HIV testing among rural black cocaine users. Outcome: number of previous HIV tests, categorized as never, 1, 2−4, 5+	Cross-sectional	About **76% of the study sample had tested for HIV in the past.** HIV testing was strongly associated with being female, of younger age, having been tested for STIs or hepatitis, being in jail or prison, and having had one sex partner in the past 30 days. Injection drug use was excluded from analyses.	PWND
Broz D, Wejnert C, Pham HT, et al.	2014	10,200 PWID from 20 US cities	HIV infection and risk, prevention, and testing behaviors among injecting drug users − national HIV behavioral surveillance system, 20 US cities, 2009. Outcomes: (1) ever HIV tested and (2) recent HIV test	Cross-sectional	According to the authors, **88% of the PWID had an HIV test in the past, but only 49% had been tested in the past 12 months.** In addition, 90% of the sample injected heroin, and 70% of men and 73% of women had unprotected vaginal sex. Finally, 18% and 31% of male and female participants, respectively, had sex transactions.	PWID

Saw YM, Poudel KC, Kham NP, et al.	2014	776 meth users aged 18−24, Myanmar	Assessment of HIV testing among young methamphetamine users in Muse, Northern Shan State, Myanmar. Outcome: ever HIV tested	Cross-sectional	The authors reported that **14.7% of the meth users examined in their study had ever been tested for HIV.** Being female, having higher educational attainment, currently living with spouse/sexual partner, being employed, prior use of non-governmental organization clinics, having had STIs, and wanting/getting help to stop drug use were determined as positive predictors of HIV testing.	PWND
D'Aunno T, Pollack HA, Jiang L, Metsch LR, and Friedmann PD	2014	371 opioid treatment programs (OTPs) nation wide	HIV testing in the Nation's Opioid Treatment Program, 2005-2011: The Role of State Regulations. Outcome: ever HIV tested	Intervention study	The percent of **HIV tests offered decreased between 2005 and 2011**. The **percent of clients tested also decreased significantly from 41% in 2005 to 17% in 2011**. State regulation was a strong contributing factor to positive attitudes toward testing, as was Latino ethnicity and injection drug use. Public and non-profit OTPs were more likely to offer HIV testing and had more clients tested.	PWID & PWND
Uuskula A, Raag M, Folch C, et al.	2014	5,328 current PWIDs in seven European countries (Estonia, Russia, Latvia, Netherlands, Poland, Portugal, and Spain)	Self-reported testing, HIV status and associated risk behaviors among people who inject drugs in Europe: important differences between East and West. Outcome: ever HIV tested	Meta-analysis (pooled cross-sectional dataset)	About **78% of the sample had a previous HIV test**, which means that the remaining 22% remained unaware of the HIV status. HIV-infected individuals were more likely than uninfected persons to share syringe and inject more often. On the other hand, they were also more likely to report being tested at the start of the study.	PWID

Markwick N, Ti L, Callon C, Feng C, Wood E, and Kerr T	2014	600 PWID in Vancouver, Canada	Willingness to engage in peer-delivered HIV voluntary counselling and testing among people who inject drugs in a Canadian setting. Outcome: willingness to be HIV tested	Cross-sectional	A reported **41% of the study sample were willing to undergo an HIV test**. Factors positively associated with testing were daily crack use and engagement in supervised injection facility.	PWID
Merchant RC, DeLong AK, Liu T, and Baird JR	2015	957 emergency department patients who misused drugs, in New England, US	Factors influencing uptake of rapid HIV and HCV screening among drug misusing adult ED patients: Implications for future HIV/HCV screening interventions. Outcome: recent HIV test	RCT − randomized controlled trial	The study findings indicated that **37% of participants in the treatment arm and 44% of those in the control arm had been tested for HIV.** The likelihood of being HIV tested depended on the time between contacts and testing, and was further influenced by the test provider.	PWID & PWND
Metsch L, Philbin MM, Parish G, et al.	2015	Women who use drugs in Argentina, Vietnam, Australia, Ukraine, and the United States	HIV testing, care and treatment among women who use drugs from a global perspective: progress and challenges. Outcome: previously tested for HIV	Case study	The percentage of tested individuals was not reported for all five countries. However, in Argentina, 47% of PWID were reported to have had an HIV test in the past. Overall, testing is suboptimal among the known high-risk populations in all countries studied. Moreover, data on women drug users and/or PWND, and for non-injecting drug users in particular, is limited. HIV treatment as prevention has been largely successful in places with equitable access to ART for all populations, including women drug users.	PWID & PWND

Frimpong JA, Guerrero EG, Kong Y, and Tsai G	2015	139,516 individuals in addiction treatment between 2006 and 2011 in Los Angeles County	Correlates of HIV testing and receipt of test results in addiction health services in Los Angeles County. Outcome: ever HIV tested	Cross-sectional	Only **64% of the study participants reported being tested for HIV**, 85% of whom received the test results. Factors positively associated with testing included being female, a minority, employed, having prior treatment, being diagnosed with an STD or HCV, injection drug use, recovery support, and history of mental illness. Use of alcohol or marijuana was inversely associated with HIV testing.	PWID & PWND
Kyle TL, Horigian VE, Tross S, et al.	2015	1,224 patients in five treatment units in Florida, New York and California, US	Uptake of HIV Testing in Substance Use Disorder Treatment Programs That Offer On-Site Treating. Outcome: recent HIV test	Cross-sectional	A reported **70% of uninfected study patients were tested in the past 12 months,** while 8% have never been tested. Women, blacks, and injection drug users were more likely to be tested in the past 12 months.	PWID & PWND

SEP – syringe exchange program
STI – sexually transmitted infection
STD – sexually transmitted disease
C&T – counseling and testing
HCV – Hepatitis C infection
Meth – methamphetamine

Chapter 3. HIV testing and injection status

Introduction

The *Human Immunodeficiency Virus (HIV)* incidence rate, while remaining relatively stable over the past decade, is still very high. Its prevalence is particularly problematic in marginalized communities,[1] such as users of illicit drugs. HIV is transmitted through the exchange of bodily fluids. If left untreated, it destroys the immune system and may develop into **a**cquired **i**mmune **d**eficiency **s**yndrome (AIDS). There is currently no vaccine or cure for HIV/AIDS. Thus, it is imperative to identify HIV-infected individuals and treat them in a timely manner, as this helps reduce morbidities and mortality, while also minimizing the likelihood of transmission. To establish whether a person has HIV, undergoing an HIV test is necessary. Presently, three types of HIV diagnostic tests are in use, namely antibody, antigen/antibody, and ribonucleic acid (RNA) tests. Antibody tests detect antibodies—i.e., proteins that the body makes against HIV[2]—rather than HIV itself. On the other hand, antigen and RNA tests detect HIV directly. 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.[2] While clinical symptoms associated with HIV infection may prompt patients and providers to suspect positive HIV status, 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.[3;4] 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 that have been diagnosed as HIV carriers can start using antiretroviral therapy and are encouraged to use condoms during

intercourse. In fact, it is well established that early treatment reduces the risk of transmitting HIV to others by as much as 96%.[5] A positive HIV test result does not mean that a person is physically sick. Rather, it simply confirms that the virus is present in the system, prompting the individual to take proactive measures (such as taking antiretroviral drugs) to keep the viral load low and immune system strong. This strategy reduces the risk of opportunistic infections, lowers community viral load, and decreases the likelihood of transmitting the virus to others. In addition, being cognizant of one's infection status can help the person make better decisions about sex and/or drug use. Testing is an opportunity to engage the healthcare system and obtain information on how to protect oneself and to be proactive in mitigating the risks associated with HIV/AIDS. For example, antiretroviral therapy, which is used to treat HIV infection, can also be used as a preventive measure by HIV-negative individuals, if they believe that they have been exposed or are at risk of exposure to the virus. This practice is referred to as pre-exposure prophylaxis or PrEP. Uninfected individuals at risk of contracting HIV can take PrEP and/or can adopt preventive measures (such as condom use) to remain free of the HIV virus. HIV-infected persons who are not aware of their HIV infection status are of particular concern, as they are more likely to engage in behaviors that place their partners at risk of contracting HIV.[6] Moreover, 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 not well understood. 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 becomes more pressing 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 resulted in compounding 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 was equal, or even higher, than among PWID.[15-17] This evidence 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 with more advanced 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 that reported non-injection use of heroin, crack, or cocaine for at least a year, and having used 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 who led the study, and the New York Academy of

Medicine, where the aforementioned data collection procedures were carried out and the gathered data was housed. Informed consent was obtained from all participants.

Dependent variable. The main dependent variable was the frequency of HIV testing. The outcome questions were "*Have you ever been tested for HIV or AIDS?*" and "*How many times have you been tested for HIV?*"

Independent variables. Injection status was 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 (categorized as high school graduate/general equivalency degree (GED)/greater); 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 condomless 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. Owing to one or more of these factors, such individuals were deemed less likely to test for HIV. Network variables of interest 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; emotional support, which was defined as having someone with whom the participant can discuss personal and private matters; structural support, which was based on availability of concrete help, such as having a place to stay and/or ability to borrow $25; 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 graduate/GED or greater; proportion of members that had sex for money or drugs (i.e., engaged in sexual transactions); and the proportion of members that injected drugs. Potential overlaps between the different social support and/or risk network (i.e., drug/sex network) factors was 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 versus 2/5 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.

Analyses. Using baseline data, we conducted descriptive analyses on participant's 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 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 been arrested (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 that 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

Hispanics/Latino, as well as report sniffing/snorting heroin in the past three months, and attending detox and methadone treatment (Table 1). They also had fewer sexual partners and sexual transactions. A greater number of PWID also reported experiencing discrimination, but the difference relative to PWND was not statistically significant (data not shown). Those that 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. Majority of the network members smoked crack, while only 6% injected drugs, and among PWND's network there were only 2% of injectors. Compared to PWID network members, those reported by PWND were older and had higher educational attainment, and were also more likely to be black, crack smokers, and have sexual transactions. Overlap in network members providing both emotional support and having sex and/or doing 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 PR (95% CI) 1.24 (1.02, 1.51) times more than those who used non-injected drugs, $p = 0.03$. Other positive and significant contributing factors to HIV testing were high school graduate/ GED or higher, 1.19 (1.03, 1.38); engaging in condomless 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 interaction between injection status and emotional support was significant, at $p = 0.03$. This finding indicates that the effect of injection status on the frequency of HIV testing depends on the level of emotional support the participant receives from the network members. The average change in the number of HIV tests undertaken by PWID compared to PWND was 0.75 (0.59, 0.97), for each incremental increase in emotional support. In addition, according to the stratified analyses findings, each five year increase in age, MSM, condomless 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 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, nor p values of the variables did not substantially change, suggesting that the results were not influenced by the inclusion of high testers (outliers).

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

Discussion

Injection status is an important factor in determining frequency of HIV testing. However, this relationship is 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 contribute to one's injection status are 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 condomless 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 as were PWID (4% vs. 2%).

Among study participants that used injected drugs, age, MSM, condomless 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 get tested. It was however reassuring to see that identifying as MSM, reporting engagement in condomless 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.

For PWND, it was encouraging to see that heroin use is positively associated with frequency of HIV testing. As this finding indicates that PWND may be aware that this activity increases their risk of contracting HIV, it confirms the importance of continued utilization of prevention strategies that target those that snort/sniff heroin, as well as those that are injecting it. It is also essential to educate these individuals on the importance of testing and preventive measures. Snorting or smoking illicit drugs does not eliminate the risk of contracting infectious diseases, such as hepatitis and HIV/AIDS, as such drugs compromise reasoning ability, while also increasing the likelihood of engaging in risky sexual and other behaviors that can expose the individual to these diseases. The strong association of concrete and emotional support with frequency of HIV testing is also noteworthy. PWND who have greater emotional support in concert with structural support tend to be more likely to undergo HIV testing. Though the difference is not statistically significant, unlike PWID, PWND who had greater emotional support were more likely to undergo a greater number of HIV tests. 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, $p = 0.04$. 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) lessened the 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 was also affected by some limitations. First, as the study participants were selected through non-random convenience sampling, the sample characteristics may not be representative of all marginal populations. In addition, two recruiting methods (RDS and TSO) were adopted, reaching slightly different subpopulations.[20] However, authors of a previous study showed that relying on different recruitment methods in terms of network composition and health behavior did not affect the research findings.[21] Moreover, owing to the nature of data obtained through self-reported questionnaires, there 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. 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, HIV status was self-reported and was not verified. Hence, while it is very unlikely that 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.

There are also several strengths that render this study highly important to both research and practice. In particular, to the author's 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 underwent fewer HIV tests compared to those that injected 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. Moreover, the use of mobile vans in neighborhoods where illicit drug users (regardless of mode of administration) are known to reside, and partner notification may increase the number of individuals willing to undergo HIV testing. This strategy may also help identify those that are HIV positive before any outward symptoms emerge. In addition, using peer engagement, similar to partner notification, could boost testing, as contacted individuals (irrespective of whether their

HIV test was positive or not) are motivated to contact their network members and encourage them to get tested. 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 that you are HIV-positive as early as possible ensures that the anti-retroviral medicines are as efficient as possible in suppressing HIV viral load below detectable levels, which renders HIV untransmittable. Finally, it is essential that the benefits of knowing one's HIV status be emphasized and promoted. Knowing that you are HIV negative provides the opportunity to remain so via a change in behavior and/or use of medications (i.e., PrEP). Similarly, even for HIV-positive individuals, receiving treatment helps protects one's health and safeguards the community from the HIV virus spread.

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Table 1. 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	1.00
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	0.20
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
Condomless 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 3 months	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)	0.90
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)	0.90	1 (1, 2)	1 (1, 2)	0.08

Multiple sex partners was 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?				
Every day	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 was 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/5	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)	0.90 (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	0.90 (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)	0.50
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
Condomless 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**	1.10 (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)	0.40	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)	0.20	1.02 (0.92, 1.12)	0.76
Emotional support	1.08 (0.98, 1.19)	0.11	1.10 (0.99, 1.22)	0.06	0.78 (0.60, 1.01)	0.06	1.10 (0.99, 1.22)	0.07
Proportion of high school graduates	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	0.60 (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)	0.20	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

Chapter 4. Predictors of HIV testing among people who use non-injected drugs

Introduction

The success that combination anti-retroviral therapy has had in suppressing human immunodeficiency virus (HIV) viral load and reducing the effects of acquired immune deficiency syndrome (AIDS), as well as related morbidity and mortality, has resulted in shifting the treatment focus from palliative care to disease management.[1] However, HIV remains a significant health outcome that continues to evade efforts aimed at disease control and substantial reduction in infection rates. These problems are particularly prevalent among hard to reach populations, such as black and Latino communities.[2-4]

Despite the advancements in HIV detection and treatment, it is estimated that over one million people currently live with HIV in the United States. In 2009, about 20% of those persons were unaware of their HIV infection.[2] However, a recent report from the Centers for Disease Control (CDC) shows that this percentage has decreased. About 13% of HIV-infected individuals are presently unaware of their condition.[5;6] While these findings are promising, HIV remains a serious issue, as unawareness of one's HIV status results in late diagnosis, and thus missed opportunities to initiate treatment and suppress viral load. Most importantly, individuals unaware of their HIV infection tend to continue engaging in risky behaviors, thus increasing the potential of HIV transmission to others. New cases of HIV occur mostly among men who have sex with men (MSM) and among minorities.[2-4] In fact, CDC studies have shown that, while the overall number of new diagnoses has decreased between 2005 and 2014, this trend was not evident in minority groups, in particular black MSM, where an increase has been observed.[3;4]

Historically, risk of infection from injection drug use (IDU) has been substantial and was responsible for the rapid increase in HIV transmission at the height of the US epidemic.

However, this risk has waned due to expanded sterile syringe access through syringe exchange programs (SEP) and pharmacies.[7-9] Nonetheless, risk of HIV infection related to drug use remains a cause for concern. Several recent studies have revealed high HIV prevalence among those who use *non-injected* drugs (PWND).[10-12] Furthermore, PWND are not given sufficient attention as a specific high-risk group and could thus be overlooked when their data is combined with that pertaining to individuals in other transmission categories, such as the "heterosexual" group. In CDC's annual estimates of new HIV infections in the US, PWND are not listed separately among the Most Affected Subpopulations.[2;3] Moreover, PWND have neither been a primary focus nor have received funding for prevention at a significant level comparable to that afforded to people who inject drugs (PWID) or men who have sex with men.

HIV testing is one of the most cost-effective ways to reduce HIV risk and transmission.[13;14] It is therefore important to understand the factors influencing HIV testing behaviors, especially among at risk subpopulations. Extant studies suggest that individuals' risk of contracting HIV or other communicable diseases is, in part, a function of the composition and behavior of their social network members, including those with whom they have sex and/or take drugs.[15-17] In this context, social networks are defined as the web of identified social relationships that an individual partakes in and the characteristics of those relationships.[18] The dynamics of social networks are important determinants of the manner in which individuals influence their environment and vice versa. Based on this premise, it is important to understand if and how network characteristics affect HIV testing practices among those who remain at high risk for contracting HIV, namely users of illicit drugs.

In the US, although significant public health resources are dedicated to HIV testing, social and behavioral aspects pertaining to the HIV testing behavior itself have not been fully explored. Furthermore, these resources, as well as pertinent research, tend to overwhelmingly focus on PWID.[2;19] Thus, in order for these interventions to have a greater impact on HIV acquisition and HIV testing, it is important to understand not only individual factors, but also elucidate social influences on HIV testing behavior. In addition, studies conducted in this field should explore predictors of testing among PWND, especially in light of high HIV prevalence rates among PWND compared with some PWID samples.[10-12] Gaining a better understanding of factors that reliably predict HIV testing among PWND will assist in the development of strategies that are more comprehensively aimed at the reduction of HIV among all drug users who face high transmission risk.

In preceding analyses, a comparison of HIV testing practices of PWND with those of PWID, revealed that, generally, PWND have fewer HIV tests than PWID do, PR (95%CI) = 0.81(0.66, 0.98), $p = 0.03$ (unpublished work). This is an important finding, as low testing rates in the population characterized by high HIV prevalence increases potential for HIV transmission. Earlier investigations also illustrated that some social factors were important in one's decision to undergo HIV testing (unpublished work). In particular, emotional support was an important effect modifier. This is of interest, as findings yielded by prior studies suggest that individual risk factors might not be the only determining factors in HIV infection risk and prevention.[20-22] Conversely, the findings of these studies indicated that social network characteristics may offer insight into the main drivers behind the high sustained prevalence of HIV infection in marginalized groups. Given that HIV testing is the first tier in HIV care, treatment, and

prevention interventions, understanding predictors of HIV testing in this under-recognized high-risk group of PWND is warranted.

In this study, it was hypothesized that, among a group of uninfected illicit drug users, individual as well as social network factors, in particular change in network characteristics, will predict HIV testing among PWND.

Methods

Data required for testing this hypothesis was obtained from the Social Ties Associated with Risk of Transition into Injection Drug Use or "START" study, described in detail elsewhere.[23;24] In brief, START was designed to determine the incidence of transition into injection drug use for persons who were already using non-injection drugs in the 2006–2009 period. The authors sought to identify risk factors, such as social network characteristics, that may influence transition into injecting drugs among young adult drug users in New York City (NYC). Enrollment was open and participants could enter at any time over the study period. The study participants completed questionnaires at baseline, and those who used non-injected drugs were followed and interviewed at 6-month intervals for two years. This data collection strategy resulted in four waves of data—baseline, 6, 12, and 18 months. This is a heterogeneous population that used hard drugs, such as heroin, crack, or cocaine, 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. PWND who reported having a negative HIV test or no HIV test and had completed at least three questionnaires were included in this analysis. Those who transitioned into injection drug use and/or reported a positive HIV test after baseline were censored.

Dependent variables. The main dependent variables in the data analyses were recent HIV testing and frequency of HIV testing. The pertinent information was gathered by asking the participants to answer the following questions, "*In the last 6 months, have you been tested for HIV or AIDS?*", "*In the last 12 months, have you been tested for HIV or AIDS?*" and "*In the last year, how many times have you been tested for HIV?*" Endorsement of being tested in the past 6 or 12 months was defined as having a recent HIV test.

Independent variables. The variables of interest for this investigation were: participant's age at baseline (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/GED or greater), income (none, ≤ $5,000 US, and > $5,000 US), married/not single, treatment program (a composite of methadone, narcotics, cocaine, outpatient, and other treatment), men who have sex with men (MSM), multiple sexual partners (having two or more partners), sexually transmitted infection (STI), smoked crack in the past 3 months, sniffed/snorted heroin in the past 3 months, and condomless sex. These variables were dichotomized (yes/no) unless otherwise specified.

The network variables of interest included: informational support (defined as having someone to ask advice about healthcare or medical services, talk to about issues related to drug use, or obtain information about social services), emotional support (defined as having someone with whom to discuss personal and private matters), and structural support (defined as having someone able and willing to offer concrete help, such as having a place to stay and/or ability to borrow $25). Further network variables included: network size (number of members), drug network (network members the participant used drugs with), sex network (network members the participant had sex with), overlap between networks (e.g., a member who provided structural/ emotional/

informational support and with whom the participant had sex and/or took drugs with), proportion of female members, proportion minority members, proportion high school graduate/GED or greater, proportion of members that had sex for money or drugs (sexual transactions), and proportion of members that injected drugs. The network proportions were used, as an incremental increase may not be as impactful, or have a meaningful difference, as the number of members in terms of size of the network on HIV testing.

Further, to assess associations of within-person change over time and between-persons central tendency (as opposed to cross-sectional association),[25] the mean of X (e.g., emotional support) across all measures for each person was calculated, and the difference between X at each time point and the mean across all measures was calculated—i.e., the difference between the emotional support at a given time and the mean overall emotional support for all measures (i.e., all follow-up data points) on that person. Both variables were fitted in the model and the coefficient provided estimates of the effect of between-persons central tendencies and within-person changes for the given variable. Given that this is personal network (also known as egocentric network) data, individual outcome controlling for aggregated network characteristics was assessed.

Analyses. Descriptive analyses on participants' demographic characteristics at baseline and at each follow-up wave were conducted. Network member characteristics were also described at each wave. Generalized estimating equations (GEE) regression models were employed to identify HIV testing predictors. This was achieved using a binary distribution with a logit link function for recent HIV test (yes/no), and using a negative binominal distribution with a log link function for frequency of HIV tests (count variable). The correlation matrix was a diagonal working covariance matrix to ensure unbiased cross-sectional estimates given the presence of

time-updated covariates.[26] GEE accounts for the correlated nature of the dataset due to repeated measures. To achieve a parsimonious model, variables with a conservative $p \leq 0.20$ were retained in the final model. All analyses were performed using SAS v. 9.4 (SAS Institute, Cary North Carolina, USA).

Results

The study sample included 303 participants who used non-injected drugs, reported having no HIV tests in the past or having negative HIV test results over the two year study period, and who had a least three waves of survey data. The analytic sample was racially/ethnically diverse and the participants were predominantly male (Table 1a). A large proportion of the sample had an HIV test at each wave. The proportion of participants who reported having multiple sexual partners, sexual transactions, smoking crack, and sniffing/snorting heroin decreased over time. Most variables were statistically significantly ($p < 0.05$) different across waves, with the exception of sex, race, education, married/not single, MSM, network size, sex network, structural support network, and emotional support network.

Participants' network members were predominantly female, ethnic minorities, and high school graduates or higher, and the most commonly reported network relationship was friend (Table 1b). Non-injected drugs, such as smoking crack or marijuana, were the substances participants reported having used with their drug network members. A significant proportion of network members overlapped, in that they provided both support and were a source of risk.

In adjusted GEE models examining whether participants had an HIV test (yes/no), sexually transmitted infection [adjusted odds ratio (aOR) (95% CI) = 7.93 (4.30, 14.62)], sniffed/snorted heroin [aOR = 2.02 (1.03, 3.99)], reported having been in drug treatment [aOR = 2.09 (1.17,

3.74)], and having an increased number of network members who engaged in sexual transactions [aOR = 1.30 (1.02, 1.65)] had a positive association with having a recent HIV test (Table 2). Participants who had an STI had seven times greater odds of having had a recent HIV test, compared to those who did not have an STI. The subgroup that reported having no income had lower odds of having a recent HIV test compared to those with > $5,000 US, aOR = 0.51 (0.26, 1.00) (Table 2). Associations of within-person change over time and between-persons central tendency were not statistically significant. However, the relationship between an increase in emotional support over time and having a recent HIV test was borderline statistically significant, aOR = 1.80 (0.98, 3.31), $p = 0.06$. Similar results were obtained for frequency of HIV testing (Table 3). However, a higher proportion of ethnic minority network members was positively associated with frequency of HIV testing, IRR = 1.38 (1.01, 1.90). In addition, having no income was positively associated with frequency of HIV testing, while a negative association between HIV testing and having a greater number of network members who engaged in sexual transactions was noted (Table 3). In particular, a change or increased instability within a participant's drug network was a positive predictor of frequent HIV testing, IRR = 1.11 (1.06, 1.16), $p < 0.001$.

Because START participants were recruited by open enrollment, 285 individuals entered the study at baseline, while a further 18 joined at the first follow-up six months later. However, sub-analysis based on the data pertaining only to the 285 participants who entered at baseline revealed no substantive difference in the results (data not shown). Results also did not change when all individuals, regardless of the number of waves of data completed, were retained in the analysis.

Discussion

Among uninfected PWND, both individual and network characteristics were important predictors of HIV testing. Not surprisingly, sexually transmitted infection was very strongly associated with recent HIV testing in the studied sample, aOR = 7.93. Ward and colleagues have shown a strong association between STI and HIV.[27] Thus, healthcare providers and interventionists may recognize that testing positive for an STI is a strong indicator of increased risk of contracting HIV, and may use this opportunity to prompt the patient to undergo an HIV test. Likewise, being in drug treatment is an opportunity to be HIV tested, which was confirmed by the findings reported here, whereby participants in treatment were at twice the adjusted odds of having a test compared to participants not in treatment.

Evidence that both snorting/sniffing heroin and engaging in sexual transactions is positively associated with HIV testing is encouraging, given that these behaviors increase the likelihood of HIV infection. Having changes in a participant's drug network was also identified as an important factor in the decision to undertake a greater number of HIV tests. Over the two-year follow-up period, the number of HIV tests increased on average by 11% for each increase in the instability of a participant's drug network. This is noteworthy, as it may imply that the participants were aware that adverse changes to their social network composition and characteristics increased their risk of HIV infection. The descriptive analyses conducted as a part of this investigation revealed that participants most frequently reported smoking crack and/or marijuana with their drug network members. This finding warrants further exploration, as crack cocaine and marijuana are not usually injected, and it is unlikely that individuals taking these drugs in this manner believe that this practice increases their risk of HIV infection. However, extant studies have shown that crack cocaine use has a direct influence on sexual network

interactions and behaviors, through increased sexual exploitation, engagement in higher-risk behaviors, and more frequent sexual transactions.[28;29]

All these factors are recognized risks for HIV transmission. Moreover, while the current study participants predominantly reported using crack and marijuana with their network members, this does not imply that these are the only drugs the members use. The results yielded by descriptive analyses indicated that at least 2% of participants' network members use injected drugs, according to their reports. The actual number of network members who inject drugs is likely to be higher, because participants may not know the injection status of all their network members. If these members are infected intravenously and the participant had sex or smoked crack with them, their HIV exposure risk would be significantly increased. Additionally, 11−19% of participants' social network members reportedly engaged in sexual transactions over the study period. More importantly, 12−15% of their network members overlap in terms of providing participants practical support (i.e., offering a place to stay and/or lending money) while also exposing them to risks (i.e., drugs and/or sex). Although the HIV status of network members was not ascertained, it is plausible to assume that their HIV status would influence the participants' testing frequency. However, this link is only speculative. To directly examine if network members' HIV status influences a person's HIV testing behavior and/or frequency, it may be necessary to conduct a more detailed network analysis or a complete network analysis. This would necessitate asking not only the individuals enrolled in the study about their risky behaviors, but also seeking direct input from each network member listed about his/her risk behaviors. Including a complete network or sociometric network, as opposed to a personal/egocentric network, in future research endeavors may shed light on membership influence on the frequency of HIV testing of others.

A complete network analysis may also explain the positive association between an increased number of network members engaging in sexual transactions and having a recent HIV test, and the inverse association of this network factor with HIV testing frequency. In other words, the nature of a member's sexual transactions may prompt the participant to get tested, but not motivate him/her to test repeatedly. One could speculate that after a single test (if the results are negative), the participants may falsely assume that network members' risky behaviors do not affect their HIV risk. If their test was positive, naturally participant would need not test again.

Finally, changes in drug networks should be seen as an indicator of network instability and transience of relationships formed within. Thus, with frequent changes in the network structure, it is unlikely that participants would trust its members implicitly, which may increase the HIV testing frequency, potentially even after each encounter involving sex or drug use. Conversely, a stable drug network may reinforce social norms that discourage or hinder HIV testing. For example, a false sense of low risk due to trust and familiarity, or an unchanging group, may discourage the participant from adopting new behaviors, such as HIV testing or other preventive measures.

A large proportion of the study sample was black or Hispanic/Latino, which is significant given that, while HIV prevalence has decreased among white population over the past decade, it has increased among non-whites.[2;3] According to a 2016 CDC report, in the past decade, the number of annual new HIV diagnoses increased by 22% and 24% among black and Hispanics/Latinos, respectively.[4] This finding is especially concerning, given that among minority men who have sex with men, these percentages increase to 50% and 25%, respectively. This racial disparity in HIV prevalence has been attributed to stigma, discrimination, and inadequate access to services. For example, asymptomatic minorities may avoid testing and use healthcare services less often

due to stigma and discrimination.[4;30] Thus, they may seek an HIV test only when they develop symptoms and invariably much later in the disease stage, providing time and opportunity for transmission to others. This may be true for users of illicit drugs who also feel stigmatized and discriminated against.

Moreover, discrepancies in the public health outreach among different high-risk populations may result in lack of access to care. As minorities and PWND are less aware of their risk status, healthcare access, and treatments (such as PrEP),[31;32] there is a clear need for new and improved strategies aimed at reducing the number of new HIV diagnoses among these populations. In particular, the adverse implications of high HIV prevalence among PWND warrant measures specifically targeting this subpopulation, as their risk levels are deemed lower than those associated with injectable drug use, even though they are just as vulnerable to HIV transmission and acquisition as PWID are. According to the available data, PWID experienced a 63% decrease in annual HIV infections over the past decade, and a decline in HIV was noted even for PWID that identify as MSM.[3;4] On the other hand, members of these groups were more likely to be tested for HIV in this period, confirming that HIV testing can be an effective first tier of disease prevention and reduction. The same targeted outreach and intervention aimed at PWID and MSM groups could be offered to PWND, and would likely produce positive results. Most importantly, motivating individuals at risk of HIV infection to be tested increases the likelihood that those that receive positive results are given timely treatment. This will help ensure that their viral load is managed and kept at low levels, while also motivating all testers to adopt a safer lifestyle, thus reducing the likelihood of transmission.

Finally, in addition to recognizing that PWND should be a specific target group for strategies and interventions aimed at preventing HIV transmission, these initiatives should also incorporate

social network factors. In their 2005 paper, Adimora and Schoenbach suggested that social context (such as poverty and discrimination) is a driving force in the persistent disparities in both the help offered and the prevalence of HIV infection.[22] These authors found that, while individual-level interventions, such as increased condom use, had reduced HIV prevalence in minority groups, these measures alone were insufficient for reversing the infection trends. Among its 10 indicators of success for the next five years, reduction in disparities in the rate of new diagnoses by at least 15% is the top priority for the National HIV/AIDS Strategy. Bringing PWND into the fore and incorporating social network factors in intervention and outreach initiatives will help achieve that aim.

Conclusion

The findings reported here suggest that exclusive focus on individual risk factors that do not include one's personal/egocentric social network characteristics is insufficient for fully understanding HIV testing behaviors, and continuing to under-recognize PWND as a target risk group results in missed opportunities to reduce HIV prevalence. The reasons behind the persistent racial/ethnic disparities in HIV infection rates remain poorly understood. However, incorporating network factors, such as social network characteristics, will paint a more comprehensive picture of how HIV is spread and how it can be prevented among marginalized populations. Population patterns not only determine public health outcomes, but also influence prevalence of inherently social diseases, such as STIs and HIV in particular.[15]

Strategies that incorporate peer-to-peer education and encouragement on HIV testing are clearly needed. Prior work showed that having main partners who tested for HIV was positively and significantly associated with the propensity for individual testing.[33] Clinical practices that

encourage those who come in to test to invite network members to also undergo testing would increase the prevalence of HIV testing and would lead to more timely disease detection.

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Table 1a. Descriptive statistics of HIV uninfected individuals who reported using non-injected illicit drugs in NYC 2006-2009, *n* = 303

Variables %	BL n = 285	6 months n = 268	12 months n = 276	18 months n = 288
Sex				
Male	66	66	64	67
Female	34	34	36	33
Race				
Hispanic/Latino	26	23	24	25
Black	66	63	63	62
White/other	8	14	14	14
High school graduate/GED or greater	45	47	45	45
Income				
none	24	24	15	15
≤ $5,000	59	59	59	56
> $5,000	17	17	26	29
Married/Not single	28	36	36	31
Arrested	88	31	28	25
Jailed	67	19	19	16
State or federal prison	35	32	3	1
Multiple sex partners	38	32	28	26
MSM	3	5	5	5
Sex transactions	29	19	16	15
Condomless sex	47	46	47	50
Sexually transmitted infection test	75	44	47	42
Smokes crack	82	34	27	22
Sniffed/snorted heroin	38	21	21	17
Detox	55	15	16	13
HIV test	96	76	88	85
Any treatment program	59	33	29	30
Number of times tested for HIV, IQR	4 (2, 6)	5 (3, 7)	2 (1, 2)	2 (1, 2)
Network size, IQR	3 (2, 5)	3 (2, 5)	3 (2, 5)	3 (2, 4)
Drug network, IQR	1 (0, 1)	1 (0, 2)	1 (0, 1)	0 (0, 1)
Sex network, IQR	1 (1, 1)	1 (1, 2)	1 (1, 2)	1 (1, 1.5)
Structural support, IQR	1 (1, 2)	1 (1, 2)	1 (1, 2)	1 (1, 2)
Informational support, IQR	1 (0, 1)	1 (0, 2)	1 (0, 2)	1 (0, 2)
Emotional support, IQR	1 (0, 1)	1 (1, 1)	1 (1, 1)	1 (1, 1)

Multiple sex partners was defined as having two or more partners in the past two months; MSM was defined as men who reported having sex with men in the past two months; Sexually transmitted infection test was defined as having been tested for herpes, gonorrhea, syphilis, and/or chlamydia at any time in the past; Any treatment program is a composite variable of methadone, narcotics, cocaine, outpatient, and other treatments; 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 for advice about healthcare or medical services, talk to about issues related to drug use, or obtain information about social services; Emotional support was defined as having someone to talk to about personal or private matters.

Table 1b. Descriptive statistics of network members at each survey wave: baseline, 6, 12 and 18 months

	BL %	6 months %	12 months %	18 months %
Sex				
Male	43	42	43	42
Female	56	57	57	58
Race				
White	6	6	7	5
Black	56	63	60	62
Hispanic/Latino	33	27	30	28
Other	4	4	3	4
High school graduate/GED or greater	72	73	65	67
How often did you see or talk to the member?				
Every day	44	45	43	45
What was your relationship to the member?				
Friend	29	27	27	28
Injected drugs	2	2	2	2
Smoked crack	30	28	20	18
Snorted heroin	10	7	6	6
Sex transactions	19	18	11	12
Jail	16	13	11	9
Drug participants reported using with network member				
None	58	64	72	71
Heroin	4	2	3	2
Cocaine	6	3	3	4
Smoked crack	20	21	13	13
Marijuana	8	6	6	8
Other[1]	4	3	2	2
Overlap				
Informational support and risk behavior[2]	7	9	11	10
Emotional support and risky behavior[2]	10	12	12	13
Structural support and risky behavior[2]	12	14	12	15
MSM	3	6	5	5
Age, mean (SD)	39 (13)	41 (12)	41 (13)	42 (13)
Age, IQR	37 (30, 46)	40 (33, 49)	40 (31, 49)	41 (33, 50)
Number of times member was named, IQR	1 (1, 2)	1 (1, 3)	1 (1, 3)	2 (1, 3)

1. Other drugs was a composite of methamphetamine, PCP, LSD, ecstasy, other, refused to respond and "don't know"

2. Risky behavior was defined as participants reporting taking drugs with or having sex with a network member

Table 2. Adjusted odds ratio and 95% CIs from GEE regression model, predicting recent HIV tests, START study (*n* = 303), 2006–2009.

	Adjusted Model[1]	
Parameter	**aOR (95% CI)**	***p* value**
Age per 5-year increment	0.91 (0.72, 1.15)	0.42
Female	1.43 (0.81, 2.51)	0.22
Hispanic/Latino (ref. white/other)	0.35 (0.09, 1.38)	0.13
Black (ref. white/other)	0.42 (0.11, 1.60)	0.20
No income (ref. > $5,000)	0.51 (0.26, 1.00)	**0.05**
≤ $5,000 US (ref. > $5,000)	0.69 (0.37, 1.27)	0.23
MSM	2.41 (0.37, 15.52)	0.36
Sexually transmitted infection	7.93 (4.30, 14.62)	**< 0.001**
Sniffed/snorted heroin	2.02 (1.03, 3.99)	**0.04**
Any treatment program	2.09 (1.17, 3.74)	**0.01**
Proportion of network female	2.00 (0.95, 4.23)	0.07
Proportion of network minority	1.81 (0.43, 7.63)	0.42
Proportion of network who have sex for drugs/money	1.30 (1.02, 1.65)	**0.04**
Network overlap of structural support and risky behavior	0.77 (0.36, 1.63)	0.49
Mean information network	0.91 (0.56, 1.48)	0.71
Mean emotional support network	1.80 (0.98, 3.31)	0.06
Mean drug network	0.82 (0.59, 1.12)	0.21
Change in the information network	1.06 (0.85, 1.32)	0.61
Change in the emotional network	0.76 (0.56, 1.02)	0.07
Change in the drug network	1.14 (0.92, 1.43)	0.24

Table 3. Adjusted incidence rate ratio and 95% CIs from GEE with a negative binomial distribution, predicting frequency of HIV tests, START study (*n* = 303), 2006–2009

	Adjusted Model[2]	
Parameter	**IRR (95% CI)**	***p* value**
Age per 5 years increment	1.00 (0.91, 1.10)	0.98
Female	1.09 (0.89, 1.32)	0.42
Hispanic/Latino (ref. white/other)	0.77 (0.48, 1.24)	0.28
Black (ref. white/other)	1.00 (0.64, 1.56)	0.99
No income (ref. > $5,000)	1.37 (1.04, 1.80)	**0.03**
≤ $5,000 US (ref. > $5,000)	1.29 (0.98, 1.71)	0.07
MSM	0.90 (0.75, 1.07)	0.24
Sexually transmitted infection	1.21 (1.06, 1.39)	**0.01**
Sniffed/snorted heroin	1.14 (0.98, 1.34)	0.09
Any treatment program	1.00 (0.89, 1.12)	0.98
Proportion of network female	1.15 (0.90, 1.47)	0.26
Proportion of network minority	1.38 (1.01, 1.9)	**0.04**
Proportion of network having sex for drugs/money	0.89 (0.84, 0.93)	**<0.001**
Network overlap of structural support and risky behavior	1.00 (0.77, 1.29)	0.98
Mean information network	0.96 (0.84, 1.11)	0.58
Mean emotional support network	1.09 (0.94, 1.27)	0.24
Mean drug network	1.01 (0.91, 1.13)	0.85
Change in the information network	1.01 (0.96, 1.06)	0.68
Change in the emotional network	0.99 (0.9, 1.07)	0.74
Change in the drug network	1.11 (1.06, 1.16)	**< 0.001**

Chapter 5. Discussion

Users of non-injected illicit drugs that took part in the present study underwent fewer HIV tests compared to those that injected drugs. This finding is very concerning, as HIV prevalence among people who use non-injected drugs (PWND) has been shown to be actually equal to, and even higher than, that among the injectors. Understandably, people who inject illicit drugs (PWID) have been historically targeted for HIV prevention. Thus, it was reassuring to find that known high-risk populations such as MSM and PWID tended to undergo HIV testing with relatively high frequency.

However, suboptimal testing among PWND is a cause for concern. In this study, PWND were more than twice as likely as PWID to report having sex transactions, and were equally likely to engage in condomless sex. This is a troubling combination of high-risk behaviors in this subpopulation that remains under-recognized in most prevention and treatment initiatives. Moreover, among PWND, men who had sex with men tested less frequently.

Still, amidst these concerns, it was encouraging to note that PWND who had greater emotional support, especially when coupled with structural support from their personal/egocentric network members, tended to have more frequent HIV tests. In fact, it appears 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, as the manner in which the illicit drugs are administered was shown in this study to determine the effects of drug use on HIV testing practices. This assertion is supported by the significant interaction term between emotional support and injection status.

Among uninfected PWND, both individual and network characteristics were important predictors of HIV testing. Not surprisingly, having sexually transmitted infections (STIs) had a very strong association with recent HIV testing in our study. PWND who reported having had or presently being affected by an STI were eight times more likely than those who did not to have an HIV test in the past 12 months. Likewise, those who reported being in a drug treatment were twice as likely to test for HIV. Conversely, these results also indicated that a stable drug network may reinforce social norms that discourage or hinder HIV testing. For example, a false sense of low risk due to trust and familiarity in an unchanging group may discourage an individual from adopting new behaviors, such as HIV testing or other preventive measures. Therefore, change in drug network may be positive in terms of its influence on individual attitudes toward HIV testing and prevention.

It is also speculated that the HIV status of one's network members may influence the individual's frequency of testing. Unfortunately, the HIV status of participants' network members was not ascertained as a part of this investigation. To directly examine if network members' HIV status influences a person's HIV testing behavior and/or frequency, it may be necessary to conduct a more detailed network analysis or a sociometric network analysis. That would necessitate asking not only the study participants about their risk behaviors, but also directly contacting each network member they listed in order to obtain information on their own risk behaviors. A sociometric or complete network, as opposed to a personal/egocentric network study, would likely elucidate membership influence on the frequency of HIV testing of others. Moreover, a study focusing on sociometric network may also help explain the positive association between an increased number of network members who engaged in sexual transactions and recent HIV testing, and the inverse association with HIV test frequency. In other

words, the nature of a member's sexual transactions may prompt participants to get tested, but not necessarily lead to repeated testing. It could be speculated that, after a single test (if results are negative), participants may falsely assume that network members' risky behaviors do not affect their risk levels and would thus not be motivated to test again. They would also not test again if their initial test was positive. In the present study, 4% of PWND reported a positive test at the 6-month follow-up, and 7% and 6% reported this outcome in the 12- and 18-month follow-up waves, respectively.

The impact of some network support factors on HIV testing practices was either not statistically significant or the significance was at the borderline level. More importantly, emotional support went in opposite directions, 0.78 (0.60, 1.01) among PWID versus 1.10 (0.99, 1.22) among PWND. Further investigation is warranted to better understand social support factors and HIV testing. A sociometric network analysis as a part of which reciprocity can be measured and examined may better inform us on the impact of these factors.

Perceived HIV risk is another factor that may influence the attitudes toward HIV testing. In the present study, having an STI and engaging in condomless sex were variables positively associated with the frequency of HIV testing and may thus be considered indicators of participants' perceived risk. Nonetheless, in order to determine if self-perceived risk is an important factor driving the HIV testing behavior of these subpopulations, questions such as, "Do you think that you have been infected or will be infected with HIV/AIDS?" should be included in future versions of questionnaires.

The adverse implications of high HIV prevalence among PWND warrant introduction of initiatives specifically aimed at this group, as they are presently not recognized as being at as

high risk of contracting HIV as are people who use injected drugs. Thus, to prevent HIV transmission and acquisition in this subpopulation, strategies that combine social, behavioral, and structural interventions aimed at HIV prevention, treatment, counseling, and support should be offered to PWND, as similar initiatives have been shown to reduce HIV incidence among PWID. Some barriers to HIV test uptake can be overcome by routinely offering the tests while allowing the individuals to opt out. Similarly, access to testing should be increased through the expansion of mobile van programs that already facilitate HIV testing in neighborhoods of illicit drug users (regardless of the mode of administration). We can further increase HIV testing by promoting partner notification, and ensuring that we identify as many HIV positive individuals as possible before the onset of symptoms. Similarly, using peer engagement, much like partner notification, would be beneficial, as this would encourage the individuals already involved in the programs to contact their social network members (regardless of the outcome of their own HIV test) and invite them to get tested. Such peer-to-peer information dissemination may change community attitudes and lessen the stigma and fear associated with HIV testing and the disease itself. Prior studies have shown that having main partners who tested for HIV was positively and significantly linked to the likelihood that an individual would undergo an HIV test. In fact, peer-based testing may help reduce stigma, discrimination, and fear related to both HIV testing and drug use.

Testing is just the first tier of prevention, which must always include treatment. Knowing that you are infected as early as possible will ensure that anti-retroviral medicines are received in a timely manner, when they are as efficient as possible in suppressing HIV viral load to the level at which it is undetectable, and thus the virus untransmittable. Finally, and more importantly, the benefits of knowing one's HIV status must be emphasized and promoted. Knowing one's HIV-

negative status provides the opportunity to remain virus free by making positive changes to everyday behaviors, undergoing routine testing, and/or starting preventive medical treatments (i.e., PrEP). Moreover, even if a person is HIV positive, being treated will improve his/her life quality while also protecting the community.

The findings of the present study are highly important as they pertain to PWND, a hidden and hard to reach subpopulation. Authors of most extant studies examining HIV testing among drug users focused on individuals undergoing some type of treatment or engaged in drug programs. While their work is highly important, targeting users of drug treatments and programs could have produced biased findings, as these initiatives provide an opportunity for education, testing, and prevention activities that can limit the risk of HIV transmission. It is important to recognize that not all drug users are willing to seek treatment and some may be placed in intervention programs involuntarily (i.e., by court order). While it is good that, as a part of such treatment, these individuals will undergo HIV testing, this is insufficient to target all at-risk individuals that would benefit from knowing their HIV status. Illicit drug use engenders a hidden population with limited access to treatment and other types of healthcare services.

The findings reported in this dissertation suggest that mode of administration of illicit drugs affects attitudes toward HIV testing. Moreover, exclusive focus on individual risk factors that do not include one's personal/egocentric social network characteristics is insufficient for gaining a comprehensive understanding of HIV testing behavior of at-risk subpopulations. Finally, unless PWND are recognized as a target risk group in prevention initiatives and research studies, we will continue to miss opportunities to reduce HIV prevalence.

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Appendices

Appendices for Design and Method

Study Population

To answer the questions posed in this dissertation, the required data was sourced from the **S**ocial **T**ies **A**ssociated with **R**isk of **T**ransition into Injection Drug Use (START) study. This longitudinal cohort study aimed to identify social risk factors associated with transitioning from non-injection to injection drug use among young adults residing in New York City.[1-3] The START data was collect from July 2006 to June 2009, and since the study's primary aim was to identify social predictors of transitioning from non-injection to injection drug use, people who use non-injected drugs (PWND) were followed prospectively to establish if they transitioned to injecting drugs during the investigation period. Thus, they were invited for a follow-up appointment at three time points, i.e., at 6, 12 and 18 months after baseline. START employed an open cohort approach to data collection, whereby new participants could be continually added.

Recruitment. Adults aged 18 to 40 years were recruited using respondent-driven sampling (RDS) and targeted street outreach (TSO) concurrently.[1-3] RDS is a validated probability sampling method based on conventional sampling used to recruit hidden populations, such as sex workers and people who use illicit drugs.[4;5] On the other hand, as the name implies, TSO uses a targeted sample plan, and was developed for HIV prevention studies.[6] START researchers employed both recruitment methods to maximize the number of potential participants. Each method targeted different subpopulation in hard to reach, economically disadvantaged and racially diverse New York City communities with high rates of HIV infection and overdose mortality.[3] The TSO approach yielded 217 participants, in addition to

recruiting 46 RDS seeds (individuals that were likely to identify other potential participants) in Brooklyn, Bronx, Manhattan and Queens. Each individual willing to act as a seed was asked to recruit up to three peers (using coupons), each of whom were asked to recruit three additional peers, and so on until recruitment ended in June 2009, resulting in 357 peer recruits. RDS coupons had a unique 9-digit number linking each participant to (1) the seed initiating the recruitment chain, (2) the individual recruiting him/her, and (3) his/her peer recruit. Peer-recruits presenting without a coupon were asked to provide the study ID or full name of the participant who referred them to the study before they were screened for eligibility. Rudolph and colleagues have shown that no statistically significant differences in either network composition or health seeking behavior existed between participants identified by these recruitment methods.[2;7]

Participant eligibility. People who use injected drugs (PWID) were drug users that have been injecting heroin, crack, or cocaine for four years or less at the time of the study, who have injected at least once in the past six months. As a part of START, injection drug use was verified by visible track marks. PWND was the term used to refer to individuals reporting non-injection use of heroin, crack, or cocaine for at least a year, and having used heroin, crack, or cocaine 2-3 times per week in the last three months. Self-reported drug use was verified via rapid drug tests, which screened for opiate and cocaine metabolites in urine. Participants received $30 and a round-trip travel card for completing the questionnaire at each appointment they attended (baseline and three follow-ups). START was approved by the Institutional Review Board of Columbia University Medical Center who led the study, and the New York Academy of Medicine, where data collection efforts were carried out and data was housed. Informed consent was obtained from all participants.

Data Collection

A 90-minute face-to-face interview during which a questionnaire was administered was conducted with each participant. Demographic, behavioral, and social contextual characteristics, drug use, and HIV testing were ascertained by asking the participants a series of interview questions. The behavior and characteristics of people with whom study participants interact with (i.e., their personal or egocentric network members) were also discussed during these interviews. At baseline, both PWID and PWND were interviewed. At six-monthly follow-ups—6, 12, and 18 months after the initial visit—PWND were interviewed to ascertain any changes in their injection status. The recruited PWND participants provided answers to questions regarding themselves as well as members of their personal or egocentric network. In the study sample of 652 participants at baseline, there were 511(78%) PWND and 141 (22%) PWID.

Dependent variable(s). The main dependent variable was HIV testing, which was self-reported. The outcome questions were "*Have you ever been tested for HIV or AIDS?*" and "*How many times have you been tested for HIV?*" and the responses they yielded were used to establish if the participant has ever been tested for HIV (yes/no) and the frequency of HIV testing.

Independent variables. For examining the link between the frequency of HIV testing and injection status, the primary predictor of interest was PWND injection status, which was examined in relation to that recorded for PWID. Further, individual and network characteristics that predicted HIV testing among PWND, was examined. Variables of interest for both analyses mentioned above were: participant's age at baseline per five year increments, race (categorized as black, Hispanic/Latino, and white/other), gender (male or female), education (dichotomized as high school graduate/GED or greater), income (none, ≤ $5,000 US, and > $5,000 US),

married/not single, treatment program (a composite of methadone, narcotics, cocaine, outpatient, and other treatment), men who have sex with men (MSM), multiple sexual partners (having two or more partners), sexually transmitted infections (STI), smoked crack in the past three months, sniffed/snorted heroin in the past three months, and condomless sex. In the analyses, participants that reported their race as white and "other" were combined into a single group due to their small percentages in the sample, which limited examining them separately. All the aforementioned variables were dichotomized (yes/no) unless otherwise specified and were deemed of interest as they may be associated with drug use and/or HIV testing. For example, when compared to men, women have been shown to be more likely to test for HIV and less likely to use illicit drugs, particularly injected drugs.[8-10] They also tend to have more social support relative to men.[11]

The network variables of interest included (1) informational support, (2) emotional support, and (3) structural support. Informational support was defined as having someone to ask for advice on healthcare or medical services, talk to about issues related to drug use, or obtain information about social services. Its extent was ascertained based on the participants' responses to the questions, "Who could you ask for advice about healthcare or medical services?", "Who could you talk to about issues related to drug use, for example, drug treatment or how to use drugs safely?", and "Who could you get information about social services like housing, welfare, or social security from?" Emotional support pertained to the ability to discuss personal and private matters with members of one's social network. Its degree was established by asking the participants "Who could you talk to about personal or private matters?" Finally, structural support pertained to having individuals in one's social network that could provide concrete help, such as offering a place to stay and/or lend $25 to the participant. To establish the degree of this type of support, the participants were asked to "name a person you could borrow $25 from."

Further network variables included: size (number of members in the network), drug network (network members the participant used drugs with), sex network (network members with whom the participant had sex), overlap (e.g., a member who provided structural support and with whom the participant had sex and/or took drugs, i.e., the risk network), proportion of female members, proportion of minority members, proportion of high school graduate/GED or greater, proportion of members that had sex for money or drugs (sexual transactions), and proportion of members that injected drugs.

The network proportions were used in the analyses, as an incremental increase may not be as impactful, or have a meaningful difference, as the number of members in terms of size of the network on HIV testing. For example, two participants may be deemed equal in terms of attributes, and both may report having two female network members, but have networks of different size. If they, for example, report having three and five members in their respective networks, this would result in a proportion of 2/3 or 0.67 versus 2/5 or 0.40 of female members, which is a meaningful difference. Thus, the proportion of females in the network, instead of the number of females, was used in analyses.

Analytical Plan

Given that the outcome of interest was HIV testing, and because people who have tested positive in the past or know that they are HIV positive would have no need to be tested again to learn their HIV status, analyses focused on individuals who self-declared as uninfected. Thus, the pertinent analyses focused on the baseline difference in HIV testing between PWND and PWID, controlling for potential confounders. Interaction terms between structural, emotional, and informational support and injection status in relation to HIV testing were examined, and stratified models by injection status were ran. For more longitudinal analyses, along with

baseline data, follow-up waves of data were used to determine which network and individual characteristics predict HIV testing among PWND. People who transitioned into injection drug use and/or became HIV positive between consecutive follow-ups were censored.

In addition, descriptive analyses of participants' demographic characteristics overall, and by injection status, as well as median number of HIV tests, were conducted. Network member characteristics were also described. Examination of the relationship between HIV testing and injection status, adjusting for important covariates, was conducted 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 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 HIV testing frequency because the outcome of interest (number of HIV tests) was not normally distributed and the conditional variance exceeded the conditional mean. This difference implied that over-dispersion was present, rendering a Poisson distribution inappropriate. To ensure that there were no influential outliers in the data related to HIV testing, sensitivity analysis was conducted by setting the frequency of HIV testing at the 95th percentile or above to "missing" (Table 1). This process is referred to as winsorization, named after the biostatistician Charles P. Winsor, and is adopted when the aim is to exclude the extreme values from the data set to eliminate their effects.[12] In addition, a posteriori interaction term with MSM (a group traditionally targeted in HIV prevention strategies because of their known high risk of contracting HIV), injection status, and HIV testing was examined and was significant ($p = 0.04$). Furthermore, an evaluation of frequency of HIV testing by MSM status revealed that they were not driving high frequency of HIV testing (Table 2).

Moreover, generalized estimating equations (GEE) models using an independent correlation structure were employed to assess the temporal changes in the relationship between individual and network characteristics and HIV testing among PWND. GEE accounts for the correlated nature of the data and allows use of several distributions. In other words, it permits the frequency of HIV testing (a count variable) and network characteristics to be assessed via a negative binomial distribution with a log link function, while the association between network characteristics and recent HIV testing (yes/no) can be assessed using a binary distribution with a logit link function. GEE uses marginal distribution and has robust standard errors.[13] To examine associations of within-person change over time and between-persons central tendency (as opposed to cross-sectional association), the mean of X (e.g., emotional support) across all measures for each person was calculated, and the difference between X at each time point and the mean across all measures was also calculated (e.g., emotional support at follow-up minus mean emotional support overall). Both variables were fitted in the model and the coefficient provided the effect of between and within person change. To ensure unbiased estimates, due to the presence of time-updated covariates, the identity matrix was used as the default correlation matrix.[14]

Uninfected participants for whom at least three waves of data were available (baseline and two or more follow-up sets obtained at 6, 12 or 18 months) were included in these analyses. These criteria resulted in 337 individuals (Figure 1, Table 3). A sub-analysis not restricted to three waves of data produced similar results to those pertaining to the aforementioned sample (Table 4 a, b). There were no substantive changes in magnitude or direction of the associations. A couple of variables that were borderline became significant or, if significant, became borderline (e.g., income). This indicates that regardless of the selection criteria used in sub-sample

selection, the findings remained unchanged. It should be noted that 43% of PWND that were initially recruited completed all four surveys, and 4% to 6% tested HIV positive at subsequent follow-ups. Moreover, 2% of this group transitioned into injection drug use over the study period. Descriptive analyses of participants' demographic characteristics at baseline and at each follow-up wave were performed. Network member characteristics were also described at each wave. The reported relationship showed that friends (29%), client/casual sex partner (11%) and girlfriend (10%) were the most common ties participants formed within their networks (Table 5). Only 38 (2%) participants endorsed casual acquaintances.

The proportion of PWID by network types ranged from 13% to 18% (Figure 2a and 2b) and did not have an impact on the attitude toward HIV testing or frequency of testing. These were PWID that would be considered new injectors, as they had been injecting for five years or less at the time of the study. While PWID are heavily targeted for HIV prevention and treatment, and are therefore more aware of HIV services than are PWND, it is possible that, as new injectors, they are not as connected or as informed on HIV prevention as would be expected from this subpopulation. Hence, an association between proportion of PWID in one's network and HIV testing was not observed. All analyses were performed on SAS v. 9.4 (SAS Institute, Cary North Carolina, USA).

Statistical power and sample size

In studies of this nature, it is typically required to ascertain if there was sufficient power to detect a difference between treated and untreated or exposed and unexposed study participants. However, this is purely a pretrial concept, as Goodman and Berlin aptly stated that "the probability of a group of possible results. Once data has been collected the study produces only one result."[15] For secondary data analyses, point estimate and confidence intervals (CI) are

more suitable.[16] According to the negative binomial regression model results, participants that injected drugs tested for HIV on average [PR (95% CI) 1.24 (1.02, 1.51)] times more than those who used non-injected drugs, $p = 0.03$. In other words, the expected number of HIV tests for a PWID compared to a PWND was 1.24 higher. The confidence interval did not include zero, indicating presence of a difference between the groups, and the lower and upper bound provide an indication of the magnitude of this difference. Moreover, the length of the 95% confidence intervals, $1.51 - 1.02 = 0.49$, is reasonably small and is suggestive of good model precision. That said, using PASS software would yield 80% power with a sample size of 544, as well as an estimated variance of 0.09 in HIV testing, an alpha set at 0.05, adjusting for the first 5 confounders, in the analysis examining the association between injection status and HIV testing. For the predictors of HIV testing analysis, using Diggle's power equation,[17] we'd be 80% powered with a sample size of 366, assuming an effect size of 0.20, with 3 waves of data, and correlation rho of 0.20.

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Table 1. Winsorization results based on treating the frequency of HIV tests (no. of tests exceeding 18, i.e., the 95th percentile) as outliers and setting them to "missing" values

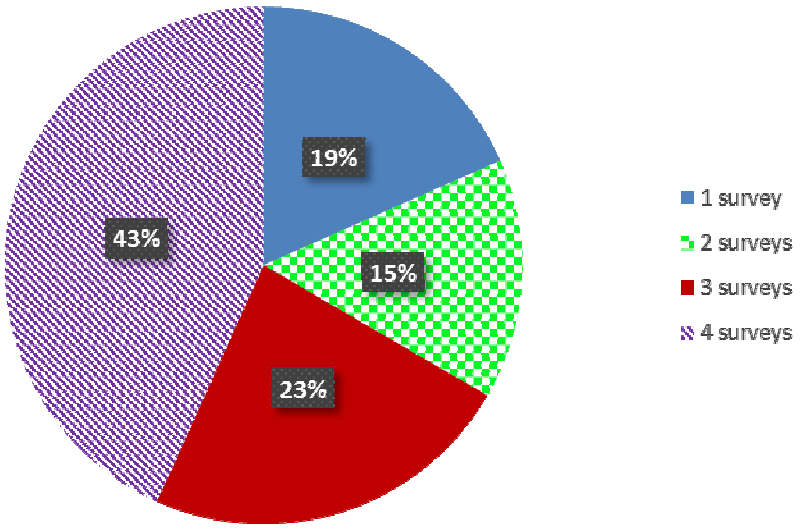
Parameter	PR (95% CI)	p value
People who used injected drugs	1.17 (1.00, 1.37)	**0.05**
Age/5	1.05 (0.99, 1.11)	0.08
Hispanic (ref. white/other)	1.20 (0.99, 1.45)	0.06
Black (ref. white/other)	1.23 (1.00, 1.51)	**0.05**
High school graduate/GED or greater	1.15 (1.02, 1.29)	**0.02**
Multiple sex partners	0.91 (0.79, 1.04)	0.17
MSM	0.98 (0.70, 1.39)	0.93
Condomless sex	1.05 (0.93, 1.19)	0.42
Sexually transmitted infections	1.48 (1.29, 1.70)	**<0.001**
Crack	0.99 (0.86, 1.15)	0.90
Sniffed/snorted heroin	1.17 (1.04, 1.32)	**0.01**
Sex network	1.04 (1.00, 1.08)	**0.05**
Structural support	0.95 (0.90, 1.00)	**0.04**
Informational support	1.07 (1.00, 1.14)	0.06
Emotional support	1.09 (1.00, 1.18)	**0.05**
Proportion high school graduates	0.82 (0.70, 0.96)	**0.01**
Proportion overlap with structural and informational support	0.71 (0.51, 1.00)	**0.05**
Proportion overlap with structural and emotional support	0.99 (0.70, 1.38)	0.93
Proportion overlap with emotional support and risk network	0.95 (0.74, 1.23)	0.69

Risk network comprises of people with whom participant took drugs and/or had sex

Table 2. Number of HIV tests by MSM status (0 = no, 1 = yes)

MSM	Number of HIV tests	Frequency	Percent
0	0	20	3.55
0	1	43	7.62
0	2	95	16.84
0	3	88	15.60
0	4	80	14.18
0	5	61	10.82
0	6	35	6.21
0	7	12	2.13
0	8	18	3.19
0	9	3	0.53
0	10	34	6.03
0	12	11	1.95
0	13	2	0.35
0	15	14	2.48
0	16	1	0.18
0	18	2	0.35
0	20	17	3.01
0	21	1	0.18
0	24	1	0.18
0	30	6	1.06
0	36	1	0.18
0	50	1	0.18
1	1	2	0.35
1	2	4	0.71
1	3	4	0.71
1	4	3	0.53
1	5	1	0.18
1	8	2	0.35
1	15	1	0.18
1	20	1	0.18

Figure 1. Number of surveys a PWND completed



While the data set comprised of 506 surveys, 93 participants completed only one survey, 76 completed two, 118 completed three, and 219 complete all four. Thus, 337 completed at least three surveys.

Table 3. START follow-up basic descriptive statistics of eligible participants

Among uninfected PWND	**baseline**	**6 months**	**12 months**	**18 months**
N	439	337	335	364
HIV tested	424 (96)	251 (74%)	288 (86%)	305 (84%)
positive test	0	15 (4%)	22(7%)	22(6%)
Transition into injecting drugs		2 (0.6%)	6 (2%)	6 (2%)
Censored		17	27	27

Participants who transitioned to injecting and/or tested HIV positive between consecutive follow-ups were censored (in the 12- & 18-month survey, there was one participant who did both)

Figure 2. Proportion of PWID and PWND by network type, among (a) those who tested for HIV and (b) did not test

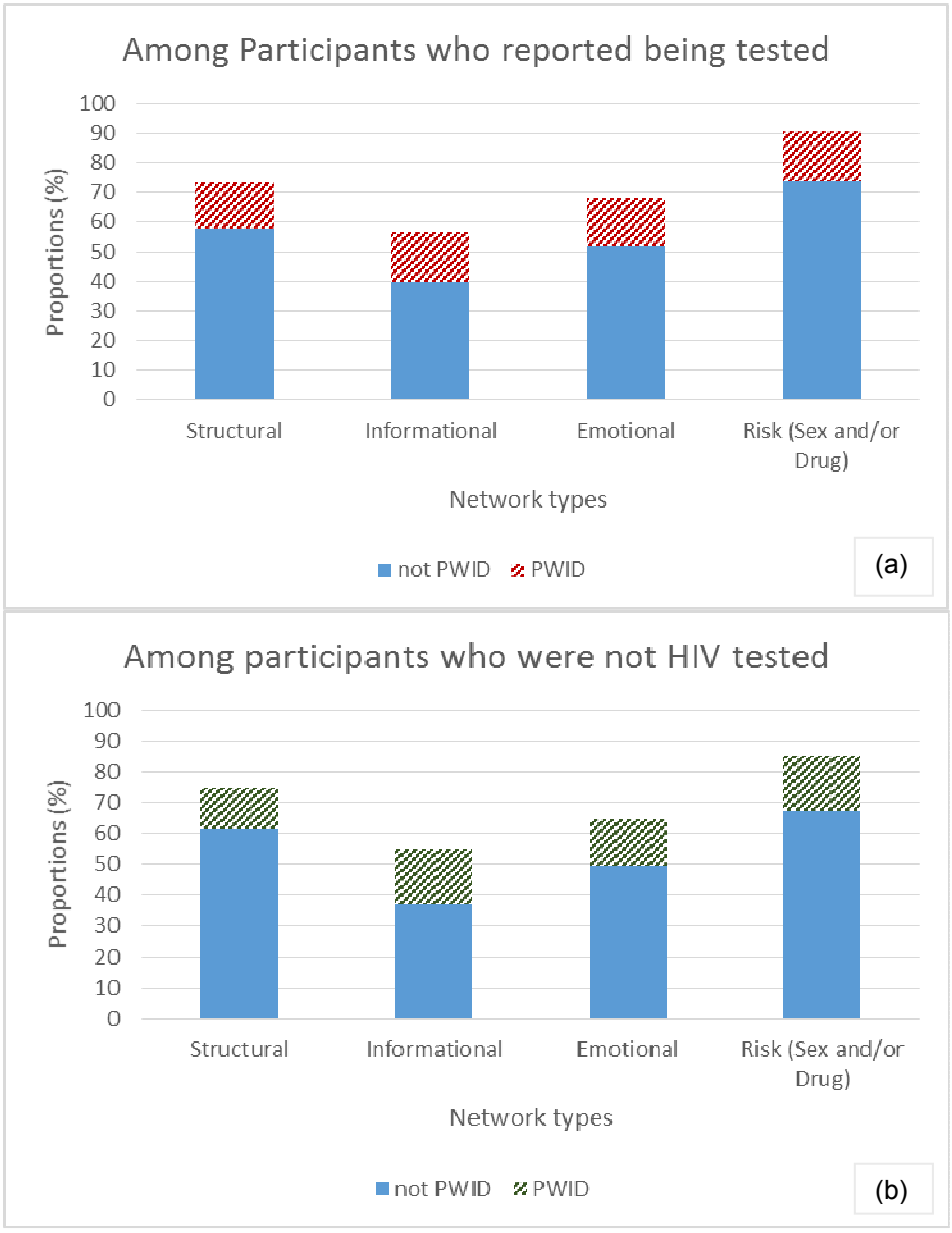


Table 4. Models <u>not</u> restricted to participants with at least three waves of data.

a) Adjusted GEE model of recent HIV testing and individual and network factors

	Adjusted Model	
Parameter	**OR (95% CI)**	**p value**
Age/5	0.85 (0.68, 1.07)	0.170
Female	1.20 (0.71, 2.04)	0.489
Hispanic (ref. white/other)	0.64 (0.23, 1.78)	0.393
Black (ref. white/other)	0.79 (0.30, 2.06)	0.624
No income (ref >$5,000)	0.55 (0.29, 1.04)	0.068
≤ $5,000 US (ref. >$5,000)	0.68 (0.38, 1.21)	0.190
MSM	2.89 (0.50, 16.64)	0.234
Sexually transmitted infection	7.34 (4.23, 12.72)	**<0.001**
Sniffed/snorted heroin	1.85 (1.03, 3.32)	**0.039**
Any treatment program	2.24 (1.31, 3.83)	**0.003**
Network % female	1.65 (0.84, 3.23)	0.146
Network % minority	1.12 (0.34, 3.69)	0.858
Network % having sex for drugs/money	1.19 (0.97, 1.45)	0.096
Network % overlap structural support and risk	0.84 (0.43, 1.67)	0.624
Mean information network	0.94 (0.61, 1.45)	0.778
Mean emotional support network	1.51 (0.90, 2.54)	0.117
Mean drug network	0.87 (0.64, 1.19)	0.388
Change in information network	1.05 (0.85, 1.30)	0.668
Change in emotional network	0.76 (0.57, 1.01)	0.060
Change in drug network	1.16 (0.93, 1.45)	0.197

b) Adjusted GEE model of frequency of HIV testing and individual and network factors

	Adjusted Model	
Parameter	**IRR (95% CI)**	**p value**
Age/5	0.99 (0.91, 1.07)	0.739
Female	1.04 (0.87, 1.23)	0.682
Hispanic (ref. white/other)	0.69 (0.46, 1.03)	0.073
Black (ref. white/other)	0.90 (0.62, 1.31)	0.573
No income (ref >$5,000)	1.29 (1.01, 1.65)	**0.044**
≤ $5,000 US (ref. >$5,000)	1.28 (1.00, 1.65)	**0.049**
MSM	0.97 (0.79, 1.19)	0.758
Sexually transmitted infection	1.22 (1.08, 1.38)	**0.001**
Sniffed/snorted heroin	1.13 (0.99, 1.29)	0.063
Any treatment program	1.00 (0.91, 1.11)	0.955
Network % female	1.10 (0.89, 1.34)	0.380
Network % minority	1.28 (0.98, 1.66)	0.072
Network % having sex for drugs/money	0.88 (0.84, 0.93)	**<0.001**
Network % overlap structural support and risk	0.94 (0.74, 1.20)	0.635
Mean information network	0.95 (0.85, 1.07)	0.404
Mean emotional support network	1.10 (0.97, 1.24)	0.123
Mean drug network	1.00 (0.92, 1.09)	0.939
Change in information network	1.01 (0.96, 1.06)	0.637
Change in emotional network	0.99 (0.92, 1.07)	0.835
Change in drug network	1.10 (1.06, 1.15)	**<0.001**

Table 5. Distribution of the reported relationship between study participants (aka ego) and the members in the their network (aka alters)

What was your relationship with alter?	n	%
Friend	572	29.1
Client/casual sex partner	216	11.0
Girlfriend/female lover	206	10.5
Sister/brother/stepsister/stepbrother	169	8.6
Other	166	8.4
Mother	164	8.3
Boyfriend/male lover	117	5.9
Wife	77	3.9
Uncle/Aunt	71	3.6
Casual Acquaintance	38	1.9
Cousin	37	1.9
Father	35	1.8
Grandparent	32	1.6
Husband	29	1.5
Running Buddy	12	0.6
Stepfather	9	0.5
Daughter/son	5	0.3
Drug Dealer	4	0.2
Don't know	3	0.2
Refused to answer	3	0.2
Neighbor	2	0.1
Stepmother	1	0.1
Distant Relative	1	0.1