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Is Injection Serosorting Occurring among HIV-Positive Injection Drug Users? Comparison by Injection Partner's HIV Status

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ABSTRACT *Research needs to build evidence for the roles that HIV status of injection partners may or may not play in injection risk behaviors of injection drug users (IDUs). Using baseline data collected from a randomized controlled study (INSPIRE) conducted in four cities (Baltimore, Miami, New York, and San Francisco) from 2001 to 2005, we categorized 759 primarily heterosexual HIV-positive IDUs into four groups based on HIV serostatus of drug injection partners. Thirty-two percent of the sample injected exclusively with HIV-positive partners in the past 3 months and more than 60% had risky injection behavior with these partners. Eight percent injected exclusively with HIV-negative partners and 49% injected with any unknown status partners. The remaining 11% reported having both HIV-positive and -negative injection partners, but no partners of unknown HIV status. Riskier injection behavior was found among the group with mixed status partners. The risk among the group with any unknown status partners appeared to be driven by the greater number of injection partners. No major group differences were observed in socio-demographic and psychosocial factors. Our analysis suggests that serosorting appeared to be occurring among some, but not an overwhelming majority of HIV-positive IDUs, and knowledge of HIV status of all injection partners per se did not appear to be as important as knowledge of sexual partner's HIV status in its association with risk behavior.*

KEYWORDS *HIV-positive IDUs, Injection partner's HIV status, Injection serosorting*

INTRODUCTION

Worldwide, injection drug use is a significant mode of HIV transmission. In the USA, injection drug users (IDUs) account for approximately one fifth of the

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estimated number of adults or adolescents living with a diagnosis of HIV infection or AIDS at the end of 2007.[1] Although rates of HIV infection among IDUs have decreased over time,[1] many IDUs continue to share syringes and other injection paraphernalia such as cookers, cotton, and rinse water with their injection partners.[2] HIV-positive IDUs are of particular concern because their risky injection practices can transmit HIV very efficiently.[3]

Many studies on sexual behaviors of HIV-positive persons suggest that the HIV status of an HIV-positive person's sex partner is one of the factors that might influence their sexual behavior.[4–15] The findings from these studies suggest that in some populations, HIV-positive persons may be adopting serosorting, in which unprotected sexual encounters are limited to partners who have the same HIV status.

Serosorting can be viewed as part of broader partner selection strategies. One of these broader strategies may be to select and limit sex partners to persons of a particular HIV status. Such a partner-sorting strategy may be more readily used by populations that, relative to MSM, report having fewer sex partners (e.g., IDUs). A previous study[16] examined the extent to which HIV-positive IDUs used the partner-sorting strategy with sexual partners. The data provided some evidence for sexual serosorting—about 40% of the sample reported having sex exclusively with HIV-positive partners and about half reported having unprotected sex with these partners. Twenty percent had sex exclusively with HIV-negative partners, and their sexual behaviors tended to be least risky, with about two thirds reporting their sex to be protected. This group appeared to be the most empowered, as they were more likely to show many of the attributes that can be protective for HIV prevention such as greater self-efficacy, knowledge, and social support, and more positive condom beliefs and partner norms supporting condom use. Another 40% had at least one partner of unknown HIV status, and sexual risk was the highest in this group. This third group was also least empowered and were likely to show attributes that could undermine HIV prevention efforts, such as lower self-efficacy for disclosing HIV status to sex partners and higher depression scores.

Studies on injection risk behaviors have examined the characteristics of injection partners that are associated with risky injection.[17–19] These studies suggest that IDUs do not engage in risky injection practices with just anyone. For example, Valente and Vlahov[19] found that among IDUs in a needle exchange program, IDUs were more likely to share with a strong-tie close friend and less likely to share with others if they were weak ties and new to their network. Unger et al.[18] found that IDUs tended to share needles with those whom they had close emotional and sexual relationships. Unlike research on sexual behaviors, however, studies on whether HIV status of injection partners may influence risky injection behaviors are just beginning to emerge. For example, Yang et al.[20] found that 94% of HIV-negative IDUs shared injection paraphernalia exclusively with perceived HIV-negative networks. In the same study, however, they found that 82% of HIV-positive IDUs shared paraphernalia with perceived HIV-negative networks. Burt et al.[21] found that some IDUs tended to share injection equipment with a partner of like HCV (hepatitis C virus) status while Bryant et al.[22] found that HCV status of injection partners did not appear to affect injection practices in heterosexual relationships. The research still needs to build evidence for the roles that HIV/HCV status of injection partners may or may not play in injection risk behaviors of IDUs.

Using the same data from primarily heterosexual HIV-positive IDUs who were enrolled in a multi-site behavioral intervention study,[23] the purpose of this study is to extend the previous study of sexual partner sorting[16] by examining the extent to which HIV-positive IDUs select and limit injection partners to persons of a particular HIV status, and then to examine who, among IDUs, are likely to adopt such a strategy, and whether their injection risk behaviors are different from those who do not adopt such a strategy. Specifically, we categorized the study participants into four groups based on the HIV status of injection partners: (1) those who reported having exclusively HIV-positive injection partners, (2) those who reported having exclusively HIV-negative injection partners, (3) those who reported having injection partners of any unknown HIV status, and (4) those who reported having HIV-positive and -negative injection partners but no partners of unknown HIV status. The groups of participants were then compared with respect to the levels of injection risk behavior and drug use, as well as socio-demographic and psychosocial characteristics that have been found to be associated with injection risk behavior of HIV-positive IDUs.[2,24] To our knowledge, this is one of the first studies to explore the topic of injection serosorting among primarily heterosexual HIV-positive IDUs.

METHODS

Participants

We report baseline data collected from participants of the Intervention for Seropositive Injectors—Research and Evaluation (INSPIRE), a randomized controlled trial of an HIV prevention intervention designed for HIV-positive IDUs.[23] The study was conducted in four cities in the USA (Baltimore, Miami, New York, and San Francisco) from 2001 through 2005. Participants were recruited from a variety of HIV care and community venues. Eligibility criteria included being at least 18 years old, confirmed HIV-positive serostatus, self-reported injection drug use in the past 12 months, and having sex with an opposite sex partner in the past 3 months. Assessments on sexual and injection risk behaviors, utilization of health care, and adherence to HIV medications were administered by audio-computer assisted self-interview. Participants also provided a blood specimen for CD4 count and viral load testing. Participants were reimbursed $30 for their time and effort for the baseline appointment. More detailed description of INSPIRE and its methodology has been reported elsewhere.[23] This study was registered as a clinical trial (Behavioral Intervention Trial for HIV-infected Injection Drug Users, NCT00146445 [available at: http://clinicaltrials.gov/ct/show/NCT00146445?order=1]).

Measures

To measure HIV status of injection partners, participants were asked how many of their injection partners in the past 3 months told them they were HIV-positive and -negative, and how many of their injection partners did not tell them about their HIV status. Participants were categorized into groups based on reported HIV status of injection partners, irrespective of whether they reported engaging in any injection-related risk behaviors (see "Data Analysis" section below). Socio-demographic variables examined include age (in years), biological sex (male or female), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), education (high school or more vs. less than high school), income ($5,000 or more per year vs. less than $5,000 per year), and housing status (currently housed vs. not). Based on a median split, $5,000 was selected as the cut off. "Being housed" was defined as having a place (e.g., own, partner's, or someone else's house or apartment, single room, treatment facility) to stay 5–7 days a week. We also examined CD4 count (less than 200 vs. 200 or greater) and viral load (undetectable vs. detectable). We also examined sexual orientation defined by the biological sex of partners with whom participants reported having sex in the past 3 months. Although eligibility criteria of this study aimed to exclude those who engaged in exclusively same sex sexual behavior, a small number of participants ($n = 101$, <10%) reported engaging in this behavior in the 3 months prior to their interview. In addition, about 15% reported having sex with both men and women. We created a dichotomous variable indicating heterosexual (i.e., participants who had sex only with opposite sex partners) vs. not heterosexual (i.e., participants who had sex with both men and women or those who had sex only with same sex partners).

For the present study, we used two measures to assess participants' injection risk in the past 3 months: number of injection partners and whether or not participants shared injection paraphernalia (cotton, cooker, or rinse water) with any of their injection partners or lent needles to any of their injection partners after use (yes/no). We also examined the frequency of injection in the past 3 months and the use of three most commonly injected drugs in our study sample, namely, cocaine or crack, heroin, and speedball (injecting heroin and cocaine together) in the past 3 months.

Psychosocial factors were as follows. Based on the Theory of Reasoned Action, subjective norms supporting safer drug use was assessed using four questions: (1) two questions on whether the participant perceived that their friends refused to share needles or objected to share injection paraphernalia (normative belief) and (2) two questions on whether the participant felt it was important to comply with that expectation (motivation to comply).[25] The normative belief score (response options ranged from "strongly disagree [–2]" to "strongly agree [+2]") was multiplied by the motivation score (response options ranged from "strongly disagree [1]" to "strongly agree [5]") to create the final score with a higher score indicating stronger subjective norm supporting safer drug use.[24] Participants' sense of responsibility for protecting others from HIV was measured by a seven-item scale developed for this study.[26] Examples of items include "I feel responsible for protecting my partners from HIV" and "It is my responsibility to protect others from getting HIV." Response options ranged from "strongly disagree (1)" to "strongly agree (5)." A higher score indicated greater sense of responsibility (alpha = 0.83). Empowerment was assessed using a 28-item scale that measured participants' perceived ability to take control of their environment.[27] A higher score indicated greater sense of empowerment (alpha = 0.76). Psychological distress was measured by averaging scores across 18 items including depression (seven items), anxiety (six items), and hostility (five items) items of the Brief Symptom Inventory.[28] A higher score indicated more distress (alpha = 0.95).

Data Analysis

From the 1,161 participants who were enrolled into the study, we excluded 182 participants who reported no injection activity in the past 3 months prior to baseline. In addition, 196 participants were excluded because they did not report having any injection partners in the past 3 months (i.e., they injected alone). Additionally, 24 cases were omitted because data on number of injection partners or HIV status of injection partners were missing. We categorized the remaining 759 participants into one of the four groups based on injection partner's HIV status: group P (only *p*ositive)—participants who, in the past 3 months, had only HIV-positive partners (i.e., participants who reported that all of their injection partners had told them that they were HIV-positive); group N (only *n*egative)—participants who had only HIV-negative partners (i.e., participants who reported that all of their injection partners had told them that they were HIV-negative); group U (any *u*nknown)—participants who had any partners of unknown HIV status (i.e., participant who reported that any of their injection partner had not told their HIV status; this group includes participants who had injection partners with various combinations of HIV status so long as any of them was a partner of unknown HIV status); and group M (*m*ixed positive and negative)—participants who reported having both HIV-positive and HIV-negative partners but no partners of unknown HIV status.

Frequency distribution of HIV-positive IDUs categorized into these four groups was examined. We then conducted bivariate analyses to compare characteristics of participants in the four groups, examining the levels of injection risk behaviors, drug use behaviors, socio-demographics, and psychosocial factors typically associated with injection risk. For categorical variables, we used chi-square tests, and for continuous variables we used analysis of variance if normally distributed, and Kruskal–Wallis tests if non-normally distributed. When differences were observed at the $p<0.1$ level, we further conducted post hoc tests to assess pair-wise differences among the four groups. Significance level of the pair-wise tests was set at $p<0.05$. Appropriate parametric or non-parametric tests were conducted for continuous variables.

We further examined what factors might help explain any group differences by estimating a series of logistic regression models, using injection risk behavior as an outcome. We entered groups P, N, and M (or group U) affiliations into the model, treating group U (or group M) as a reference group. Then we tested whether any of the group differences in the risk behavior disappear when variables that have demonstrated significant group differences in the earlier analyses were entered into the model.

RESULTS

Of the 759 participants in the final sample, 32% (n=244) injected exclusively with HIV-positive partners, 8% (n=60) injected exclusively with HIV-negative partners, 49% (n=369) injected with any injection partners of unknown status, and 11% (n=86) reported having HIV-positive and -negative partners but no partners of unknown HIV status. Table 1 describes the characteristics of the total sample (n=759) and also compares the participants categorized into the four groups.

Socio-Demographic Factors and Health Status

No significant socio-demographic or health status differences were observed among the four groups.

Injection Risk

Groups U and M had greater numbers of injection partners in the past 3 months (mean was approximately 7) than groups P or N (mean, approximately 3). For the categorical variable indicating whether a participant engaged in any injection-risk behavior (i.e., either lent a used needle or shared injection paraphernalia) in the past 3 months, group U and M were significantly riskier (71% of group U and 78% of group M reported this risk behavior) than group P (61% of group P reported this risk behavior). Group M was also riskier than group N (58%). A greater proportion

TABLE 1 Comparisons HIV-positive IDUs by their injection partners' HIV sero-status

	All ($n=759$)[a]	Group P ($n=244$)[a]	Group N ($n=60$)[a]	Group U ($n=369$)[a]	Group M ($n=86$)[a]	Test statistics for overall test[b]	Pair-wise comparison[c]
Age	$M=42.0$ (SD=6.7)	$M=42.5$ (SD=6.6)	$M=42.1$ (SD=6.8)	$M=41.9$ (SD=6.6)	$M=41.4$ (SD=7.2)	$F=0.66$, $p>0.1$	NS
Biological sex							
Male	494 (65.1%)	149 (61.1%)	38 (63.3%)	249 (67.5%)	58 (67.4%)	$X^2=2.96$, $df=3$, $p>0.1$	NS
Sexual orientation based on behavior							
Heterosexual	515 (71.8%)	169 (72.2%)	39 (75.0%)	252 (71.6%)	55 (69.6%)	$X^2=0.48$, $df=3$, $p>0.1$	NS
Race							
White	81 (11.0%)	26 (11.1%)	9 (15.3%)	41 (11.4%)	5 (6.0%)	$X^2=9.44$, $df=9$, $p>0.1$	NS
Black	477 (64.5%)	140 (59.6%)	36 (61.0%)	244 (67.6%)	57 (67.9%)		
Hispanic	123 (16.6%)	49 (20.9%)	9 (15.3%)	51 (14.1%)	14 (16.7%)		
Other	58 (7.8%)	20 (8.5%)	5 (8.5%)	25 (6.9%)	8 (9.5%)		
Education							
<High school	317 (41.9%)	102 (42.0%)	23 (38.3%)	156 (42.4%)	36 (41.9%)	$X^2=0.35$, $df=3$, $p>0.1$	NS
Income <$5,000 per year	391 (52.9%)	125 (52.5%)	30 (51.7%)	190 (52.8%)	46 (55.4%)	$X^2=0.26$, $df=3$, $p>0.1$	NS
Currently housed	599 (79.5%)	203 (83.9%)	48 (80.0%)	282 (77.3%)	66 (76.7%)	$X^2=4.39$, $df=3$, $p>0.1$	NS
CD4<200	214 (29.2%)	72 (30.5%)	17 (28.8%)	94 (26.6%)	31 (36.9%)	$X^2=3.74$, $df=3$, $p>0.1$	NS
Detectable viral load	599 (82.4%)	200 (85.5%)	44 (78.6%)	286 (81.0%)	69 (82.1%)	$X^2=2.55$, $df=3$, $p>0.1$	NS
Injection risk							
Number of injection partners	$M=5.25$ Median=3 (SD=9.69)	$M=2.53$ Median=2 (SD=5.97)	$M=2.80$ Median=1 (SD=3.79)	$M=7.03$ Median=3 (SD=11.0)	$M=7.03$ Median=3 (SD=12.6)	$H=158.18$, $p<0.00$	PN vs. UM
Lent used needle or shared paraphernalia	509 (67.7%)	148 (61.4%)	35 (58.3%)	259 (71.0%)	67 (77.9%)	$X^2=12.63$, $df=3$, $p<0.01$	P vs. UM N vs. M

Drug use							
Number times injected	M=86.45 Median=16.0 (SD=131.7)	M=66.54 Median=10.5 (SD=105.6)	M=79.35 Median=13 (SD=135.4)	M=92.79 Median=24 (SD=133.6)	M=120.67 Median=42 (SD=173.7)	$H=8.57$, $p<0.05$	P vs. UM
Number of different drugs used	M=3.88 (SD=2.22)	M=3.75 (SD=1.99)	M=3.20 (SD=1.92)	M=3.96 (SD=2.38)	M=4.41 (SD=2.18)	$H=11.30$, $p<0.05$	PN vs. M N vs. U U vs. M
Injected cocaine or crack	242 (32.4%)	77 (32.1%)	8 (13.8%)	131 (35.9%)	26 (31.3%)	$X^2=11.25$, $df=3$, $p<0.05$	N vs. UM
Injected heroin	453 (60.7%)	146 (60.8%)	34 (58.6%)	219 (60.3%)	54 (63.5%)	$X^2=0.41$, $df=3$, $p>0.1$	
Injected "speedball" (heroin and cocaine together)	386 (51.8%)	104 (43.3%)	27 (46.6%)	200 (55.1%)	55 (65.5%)	$X^2=15.40$, $df=3$, $p<0.01$	P vs. UM N vs. M
Psychosocial factors							
Partner norm supporting safer drug use	M=1.12 (SD=3.33)	M=1.22 (SD=3.16)	M=1.51 (SD=3.05)	M=1.13 (SD=3.45)	M=0.53 (SD=3.44)	$H=3.65$, $p>0.1$	NS
Psychological distress	M=2.00 (SD=0.80)	M=1.98 (SD=0.77)	M=1.98 (SD=0.82)	M=2.00 (SD=0.79)	M=2.07 (SD=0.91)	$H=0.21$, $p>0.1$	NS
Empowerment	M=2.84 (SD=0.28)	M=2.85 (SD=0.26)	M=2.88 (SD=0.34)	M=2.83 (SD=0.27)	M=2.81 (SD=0.31)	$H=2.68$, $p>0.1$	NS
Responsibility	M=4.23 (SD=0.69)	M=4.22 (SD=0.69)	M=4.43 (SD=0.50)	M=4.20 (SD=0.71)	M=4.22 (SD=0.68)	$H=4.91$, $p>0.1$	NS

Data from INSPIRE Study conducted in four US cities (Baltimore, Miami, New York, and San Francisco) from 2001 to 2005

Group P had HIV-positive injection partners only. *Group N* had HIV-negative injection partners only. *Group U* had any injection partners of unknown HIV status. *Group M* had HIV-positive and HIV-negative injection partners. *PN vs. UM* groups P and N are significantly different from groups U and M, but there is no significant difference between groups P and N and between groups U and M. *P vs. UM* group P is significantly different from groups U and M, and there is no significant difference between groups U and M. *N vs. M* groups N and M are significantly different. *PN vs. M* groups P and N are significantly different from group M, and there is significant difference between groups P and N. *N vs. U* groups N and U are significantly different. *U vs. M* groups U and M are significantly different. *N vs. UM* group N is significantly different from groups U and M, and there is no significant difference between groups U and M. *NS* there is no significant difference is observed among the four groups

[a]Total does not always equal 759, 244, 60, 369, or 86 due to missing data

[b]For categorical variables, chi-square test statistics are reported. For normally distributed continuous variables, *F* statistics are reported and for non-normally distributed continuous variables, Kruskal–Wallis *H* statistics (denoted as *H*; chi-square with 3° of freedom is used to approximate the significance level) are reported

[c]Significance level <0.05 for pair-wise tests

of group U also reported this risk behavior than group N, and the difference was nearly significant ($X^2=3.85$, $df=1$, $p=0.05$).

Drug Use

Participants in groups U and M reported significantly greater frequencies of injection in the past 3 months (mean approximately 93 for groups U and approximately 121 for group M) than the participants in group P (mean approximately 67). Significantly higher proportions of participants in groups U (36%) and M (31%) reported injecting cocaine or crack than participants in group N (14%). Significantly higher proportions of participants in groups U (55%) and M (66%) reported injecting "speedball" (heroin and cocaine together) than participants in group P (43%). A significant difference in the use of speedball was also observed between groups M and N (47%).

Psychosocial Factors

No significant group differences in psychosocial factors were observed among the four groups.

What Factors Might Explain Group Differences in Injection Risk Behavior?

We found that significantly greater proportions of groups U and M reported risky injection behavior than groups P and N. In order to examine what factors might help explain these group differences, we further estimated logistic regression models, using injection risk behavior as an outcome. First, we entered groups P, N, and M affiliations into the model, treating group U as a reference group. Then we tested whether any of the group differences disappeared as the number of injection partners, number of injections, injection of cocaine or crack, or injection of speedball (i.e., variables that were found to have significant group differences) was entered into the model. As shown in the first model, participants in group P (OR= 0.65, 95% CI 0.46–0.92) had significantly decreased odds of reporting injection-risk behavior compared with participants in group U, and those in group N also had reduced odds of reporting the risk behavior compared with participants in group U (OR=0.57, 95% CI 0.33–1.00). These patterns did not change appreciatively when the number of injection was controlled for in the model (model 2). When injection of cocaine or crack (model 3) or injection of speedball (model 4) was controlled for, the difference between groups N and U became non-significant ($p>0.1$). Finally, when number of injection partner was controlled for, the difference between groups P and U, as well as the difference between groups N and U, became non-significant (model 5), and number of injection partners was only the variable significantly associated with injection risk behavior (Table 2).

We repeated the same procedures with group M as a reference group. Table 3 presents the results. Unlike what we observed above, inclusion of any of the variables did not change the significant difference between groups P and M or between groups N and M.

DISCUSSION

More than a third of the sample reported injecting exclusively with HIV-positive partners, and about 60% of them reported engaging in injection risk behavior with these partners. These numbers are comparable to the numbers found in the analysis

TABLE 2 Logistic regression predicting risky injection risk behavior in the past 3 months; group U as a reference category, odds ratios and 95% confidence intervals

	Model 1	Model 2	Model 3	Model 4	Model 5
Group P	0.65 (0.46–0.92)	0.68 (0.48–0.95)	0.66 (0.47–0.94)	0.68 (0.48–0.96)	0.75 (0.53–1.08)
Group N	0.57 (0.33–1.00)	0.58 (0.33–1.02)	0.62 (0.35–1.10)	0.64 (0.36–1.13)	0.65 (0.37–1.15)
Group M	1.44 (0.83–2.52)	1.40 (0.80–2.45)	1.61 (0.90–2.87)	1.56 (0.87–2.79)	1.46 (0.84–2.56)
Group U	Ref	Ref	Ref	Ref	Ref
Number of injection	–	1.002 (1.00–1.004)	–	–	–
Injected cocaine/crack	–	–	1.11 (0.80–1.54)	–	–
Injected speedball	–	–	–	0.74 (0.54–1.01)	–
Number of injection partner	–	–	–	–	1.04 (1.01–1.07)

Data from INSPIRE study conducted in four US cities (Baltimore, Miami, New York, and San Francisco) from 2001 to 2005
Ref reference category

TABLE 3 Logistic regression predicting risky injection risk behavior in the past 3 months; group M as a reference category, odds ratios and 95% confidence intervals

	Model 1	Model 2	Model 3	Model 4	Model 5
Group P	0.45 (0.25–0.80)	0.48 (0.27–0.86)	0.41 (0.23–0.75)	0.43 (0.24–0.79)	0.52 (0.29–0.92)
Group N	0.40 (0.19–0.82)	0.42 (0.20–0.86)	0.39 (0.18–0.82)	0.41 (0.19–0.86)	0.45 (0.22–0.93)
Group U	0.69 (0.40–1.21)	0.72 (0.41–1.25)	0.62 (0.35–1.11)	0.64 (0.36–1.14)	0.69 (0.39–1.20)
Group M	Ref	Ref	Ref	Ref	Ref
Number of injection	–	1.002 (1.000–1.004)	–	–	–
Injected cocaine	–	–	1.11 (0.79–1.54)	–	–
Injected speedball	–	–	–	0.74 (0.54–1.01)	–
Number of injection partner	–	–	–	–	1.04 (1.01–1.07)

Data from INSPIRE study conducted in four US cities (Baltimore, Miami, New York, and San Francisco) from 2001 to 2005
Ref reference category

of sexual serosorting, and suggest that some of HIV-positive IDUs do limit risky injection practices to seroconcordant partners. Very few (<10%) reported injecting exclusively with HIV-negative partners. However, unlike the finding on sexual serosorting, injection risk among this group was not necessarily the lowest; about 60% reported engaging in injection risk behavior with their HIV-negative partners.

Almost half of the sample had injection partners of unknown HIV status and more than 10% had HIV-positive and HIV-negative partners but no partners of unknown HIV status. Injection risk, including the number of injection partners, was higher among the groups with partners of mixed HIV status than groups that had either exclusively HIV-positive or exclusively HIV-negative injection partners. These groups also reported higher frequencies of injection, using greater numbers of different substances, and were also more likely to inject stimulants such as cocaine or crack and "speedball" than the group that had exclusively HIV-positive injection partners or the group that had exclusively HIV-negative injection partners. Despite these differences in risk behaviors, the four groups were not significantly different from each other with respect to socio-demographic and psychosocial factors.

At first glance, the finding that the group with any unknown status injection partners (group U) was riskier than groups that had either exclusively HIV-positive (group P) or exclusively HIV-negative injection partners (group N) appeared to be consistent with the previous finding on sexual partner sorting.[16] The finding could mean that not knowing the HIV status of all injection partners is related to risky injection behavior. However, an alternative explanation is that the greater number of injection partners reported in group U may be simultaneously associated with not knowing the HIV status of all of their injection partners and also with greater risky injection behavior, and the number of injection partners may in fact be the factor driving risk behavior. Indeed, when the number of injection partners was controlled for in a model examining the differences between group U and other groups, the group differences in risky injection behavior (between groups U and P and also between groups U and N) became no longer significant. Moreover, the number of injection partners was a significant predictor of risky injection behavior. It is noteworthy that controlling for factors such as number of injections and injection of cocaine/crack or speedball did not fully eliminate the group differences although injection of cocaine/crack and speedball did eliminate the difference between groups U and N. It appears that unlike in the context of sexual risk taking, participants in group U may be more likely to engage in risky injection behavior not because they do not know all of their partners' HIV status but because they have more injection partners (and thus have more opportunity to engage in risk behavior).

The findings that the group with HIV-positive and HIV-negative injection partners, but no partners of unknown HIV status (group M), is equally risky as group U and also is riskier than groups P and N suggests that once again, having knowledge of all injection partners may not lead to safer injection behavior. Moreover, in contrast to the difference between group U and other groups mentioned above, the differences between group M and groups P and N were not explained by any of the factors including number of injection partners. The finding suggests that some untested factors may drive the risk behavior of those with injection partners of *known* mixed HIV status. More data are needed to fully understand this group and to provide explanations for why having injection partners of *known* mixed HIV status should be associated with risk.

This study has the following limitations. First, the data are cross-sectional, thus, no causal relationships can be established between partner selection and risk behavior. Second, the data were drawn from a convenience sample of HIV-positive IDUs enrolled in an intervention trial, and thus the findings cannot be generalized to a broader population of HIV-positive IDUs. Third, although choosing injecting partners of a particular HIV status may be intentional (e.g., choosing to inject only with HIV-positive partners), in reality, some participants may have met injection partners who happened to be of particular HIV status. Although we assessed partner's HIV status from the questions asking how many of their partners told them that they were HIV-positive or HIV-negative, etc., the accuracy of partner's HIV status (whether the participants accurately recalled what their partners had told them or whether the partners had accurate knowledge of their HIV status) is uncertain. The issue of accurate recall of partner's HIV status may be an issue particularly when a person has many injection partners. Lastly, our study measures did not include the serostatus for hepatitis C, which is readily transmitted by risky injection practices and prevalent among IDUs.[17,29] It should be noted that serosorting by HIV status does not preclude HCV infection and implications of HIV serosorting on HCV infection should be further considered.

Despite these limitations, this study broadens the scope of earlier work on serosorting of sexual partners among HIV-positive IDUs. Our analysis suggests that injection serosorting (i.e., limiting risky injection behavior to seroconcordant partners) appeared to be occurring among some, but not an overwhelming majority of HIV-positive IDUs. We also found that HIV-positive IDUs who do not limit injection partners to persons of a particular HIV status were more likely than those who adopt such a partner sorting strategy to engage in risky injection or substance-use behaviors. However, we also found that having knowledge of HIV status of all injection partners per se did not appear to be as important as having knowledge of all sexual partners' HIV status in its association with risk behavior. These findings suggest that interventions targeting HIV-positive IDUs may need to focus on those who do not utilize any partner sorting strategies and to identify and address the underlying factors that may be driving their risk behaviors (e.g., greater number of injection partners), rather than focusing on knowing the HIV status of all injection partners. To our knowledge, this study is one of the first to explore HIV status-based selection of injection partners and to examine its association with risk behaviors. This study represents a beginning to understanding potential processes of serosorting and other partner-selection strategies of IDUs. With more sophisticated measures of serosorting, future research should be able to more clearly identify the patterns of sexual and injection partner selection among HIV-positive IDUs. Such information may further inform the development of novel preventive intervention strategies for the population.

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