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ORIGINAL PAPER

Characteristics of Persons Who Inject Drugs with Recent HIV Infection in the United States: National HIV Behavioral Surveillance, 2012

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Abstract
We evaluated characteristics associated with recent HIV infection among persons who inject drugs (PWID) from 19 U.S. cities who participated in 2012 National HIV Behavioral Surveillance. Recent infection was defined as having a reactive HIV test, a Bio-Rad Avidity index cutoff ≤ 30%, no reported HIV diagnosis ≥ 12 months before interview, and no evidence of viral suppression. Of 8667 PWID, 50 (0.6%) were recently HIV infected. Having a greater number of sex partners (≥ 2 partners vs. 0) [prevalence ratio (PR) 4.7, 95% confidence interval (CI) 1.3–17.8], injecting heroin and other drugs (PR 3.0, 95% CI 1.3–6.6) or exclusively non-heroin drugs (PR 5.9, 95% CI 1.7–20.7) compared to injecting only heroin, and having male–male sex in the past year (PR 7.1, 95% CI 3.0–16.6) were associated with recent infection. Promoting not only safe injection practices but also safe sex practices will be key to preventing new HIV infections.

Keywords HIV · Recency · HIV recent infection · HIV incidence · Persons who inject drugs

Resumen
Evaluamos las características asociadas con infección reciente de VIH entre personas que se inyectan drogas (PWID) en 19 ciudades en los Estados Unidos que participaron en la Vigilancia Nacional del Comportamiento del VIH en 2012. Infección reciente se definió como tener una prueba reactiva de VIH, un índice de avidez (ensayo *Bio-Rad*) ≤ 30%, no haber reportado un diagnóstico de VIH en ≥ 12 meses antes de la entrevista, y ninguna evidencia de supresión viral. De 8667 PWID, 50 (0.6%) fueron infectadas recientemente con VIH. Tener un mayor número de parejas sexuales (≥ 2 parejas vs. 0) [razón de prevalencia (RP) 4.7, intervalo de confianza (IC) de 95% 1.3–17.8], inyectarse heroína y otras drogas (RP 3.0, IC 95% 1.3- 6.6) o exclusivamente las drogas que no contienen heroína (RP 5.9, IC 95% 1.7–20.7) en comparación con inyectarse solamente heroína, y tener sexo hombre con hombre en el último año (RP 7.1, IC 95%: 3.0–16.6) se asociaron con infección reciente. Promover no solo las prácticas seguras de inyección, sino también las prácticas seguras de sexo será clave para prevenir nuevas infecciones de VIH.

Introduction

Identifying recent HIV infections and their associated characteristics can help to better describe subpopulations at increased risk of acquiring new HIV infections. Characterizing persons with recent HIV infections can also identify factors that may contribute to ongoing HIV transmission, as persons in early stages of HIV infection have higher viral loads, increasing the risk of transmission to others [1, 2]. Cohort studies are typically used to measure HIV incidence, yet incidence assays for cross-sectional studies have been developed in recent years [3, 4]. Utilizing incidence assays along with other biological markers permits the identification of recent HIV infections.

Persons who inject drugs (PWID) in the United States are at increased risk for infection with blood-borne pathogens, including HIV. Approximately one in ten PWID is living with HIV and many are not aware of their infection status [5]. Among a national sample of HIV-negative PWID,

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30% reported receptive syringe sharing (i.e., injecting with a syringe or needle that had already been used by someone else), 55% reported receptive injection equipment sharing (i.e., using a cooker or cotton that had already been used by someone else or using shared water for rinsing or injection), and 70% reported condomless vaginal sex [6]. Sharing injection needles/equipment and condomless sex are both known to be associated with HIV infection, yet associations based on HIV prevalence capture factors that contributed to both current and historical infections and may not uniquely describe behaviors associated with new HIV infections. In this study, we sought to describe recent HIV infections (infections likely acquired in the previous 240 days) in a national sample of PWID and examine key demographic and behavioral characteristics that may have contributed to recent HIV acquisition.

Methods

The Centers for Disease Control and Prevention's (CDC) National HIV Behavioral Surveillance (NHBS) conducts a cross-sectional behavioral survey and HIV testing among PWID every three years. In 2012, respondent-driven sampling (RDS) was used to recruit participants in 20 U.S. cities. NHBS methods have been described in detail elsewhere [7]. Eligible participants reported injecting drugs during the previous 12 months, resided in a participating city, were aged ≥ 18 years, and could complete the interview in English or Spanish. Eligible participants who consented to the survey and HIV testing were administered a standardized, anonymous questionnaire by trained interviewers and were offered an anonymous HIV test via laboratory-based testing or blood-based rapid testing with laboratory confirmation. Participants from 19 NHBS sites were also asked to consent to providing blood specimens for storage and future testing. Dried blood spots (DBS) were collected from participants who consented and DBS specimens were sent to the CDC laboratory for storage and testing. NHBS activities for the 2012 cycle were reviewed by Institutional Review Boards for each participating city.

DBS specimens from participants with a reactive HIV screening test, classified as HIV-positive, were tested with the CDC-developed Bio-Rad Avidity incidence assay (BRAI, an avidity-based modified Genetic Systems™ HIV-1/HIV-2 Plus O Immunoassay; mean duration of recency of 240 days) to identify recent infections [8, 9]. Previous studies have documented that avidity assays can overestimate HIV incidence, classifying some long-standing infections as recent infections [10], and have suggested including other biological markers such as viral load and/or self-reported historical data on date of diagnosis or antiretroviral (ARV) use as part of a multi-component algorithm [11]. We used self-reported HIV diagnosis ≥ 12 months before the interview date and HIV viral load suppression in seroreactive persons to exclude long-standing (herein referred to as non-recent) infections from those classified as recent. To do so, we further tested HIV-positive DBS specimens for HIV-1 RNA concentration using a validated Abbott m2000 Real-Time HIV-1 DBS viral load assay (Abbott Laboratories, Abbott Park, IL). Recent HIV infections were initially defined as having a reactive HIV screening test result and a BRAI avidity index cutoff ≤ 30%. Recent infections were reclassified as non-recent infections if the participant was aware of their HIV-positive status and reported their HIV diagnosis occurring ≥ 12 months before the interview date, or if the participant had evidence of viral suppression (defined as HIV-1 RNA concentration < 1000 copies/mL).

We first examined bivariate associations between recent infection and key demographic and risk characteristics to determine which factors may contribute to HIV acquisition among those at risk for infection (i.e., those recently infected and persons testing HIV-negative). A second analysis assessed the associations between key variables and recent infection among all HIV-positive participants (i.e., those recently infected compared to those with prevalent, non-recent HIV infections) in order to identify characteristics that may differ between PWID infected recently and those with established infections. Prevalence ratios (PR) and 95% confidence intervals (CI) were estimated from log-linked Poisson regression models with generalized estimating equations clustered on RDS recruitment chain. Due to small numbers of new infections, we did not consider additional confounders in this analysis. All analyses were conducted in SAS 9.4 (Cary, NC).

Results

In 2012, 9507 PWID were eligible and consented to participate in the survey and HIV testing in 19 U.S. cities. Of these, 8617 participants tested HIV-negative and 802 tested HIV-positive, consented to storage of their specimens, and provided DBS specimens for further testing at CDC. Therefore, 9419 participants were included in this analysis. Of the 802 participants with HIV-positive test results, 721 had specimens with BRAI of > 30% and were classified as having non-recent HIV infections. Of the 81 persons with BRAI-recent HIV infections, 31 reported an HIV diagnosis ≥ 12 months before the interview date and were re-classified as having non-recent HIV infections. No additional participants with BRAI-recent HIV infections had viral loads of < 1000 copies/mL that would indicate viral suppression; therefore these remained classified as having recent HIV infection.

Forty-one (82.0%) of the 50 recently infected participants had not previously tested positive for HIV infection. Nine

of the 50 recently infected were previously diagnosed with HIV but reported receiving their first HIV diagnosis less than 12 months ago (n = 7) or did not provide a diagnosis date (n = 2), and specimen quality was not sufficient for viral load testing (n = 9). In the analysis of recently infected and HIV-uninfected PWID, there were 8667 total participants and 50 (0.6%) were classified as recently infected with HIV (Table 1). Almost three-fourths (71.7%) of this sample of PWID at risk for HIV infection were men and over two-thirds (71.4%) were age 40 or older. Most participants (78.7%) lived at or below the 2012 federal poverty level and 42.8% did not have health insurance. About half of the participants (53.6%) had received an HIV test in the past 12 months. Most PWID injected heroin and other drugs (64.7%), a third (33.7%) had taken non-injection prescription opioids, and 32.4% had receptively shared syringes in the past year. Among PWID injecting heroin and other drugs, other drugs were predominantly speedball (cocaine and heroin, 79.7%) and stimulants including powdered cocaine (57.1%), crack cocaine (24.0%), and methamphetamine (22.8%). Among PWID injecting other drugs only, these were also mainly stimulants including powdered cocaine (48.5%), crack cocaine (14.8%), and methamphetamine (60.6%). Almost three-quarters (72.5%) had condomless sex in the past year and 39.8% reported having exchanged sex for drugs or money in the past year. One in ten males (10.5%) reported having sex with a man in the past year. In the bivariate analyses, injecting heroin and other drugs or only injecting drugs other than heroin, compared with injecting heroin only, were associated with recent HIV infection (injecting heroin and other drugs vs. injecting heroin only, PR 3.0, 95% CI 1.3–6.6; injecting drugs other than heroin only vs. injecting heroin only, PR 5.9, 95% CI 1.7–20.7). In addition, those who had a greater number of sex partners (≥ 2 vs. 0 partners, PR 4.7, 95% CI 1.3–17.8) and males who had male–male sex in the past 12 months (PR 7.1, 95% CI 3.0–16.6) were more likely to be recently infected.

In the second analysis of all 802 HIV-positive participants, the 50 recently infected PWID represented 6.2% of the sample (Table 2). HIV infection was more likely to be recent in PWID who were young (18–29 vs. ≥ 40 years, PR 5.4, 95% CI 2.7–10.9), white (PR 2.3, 95% CI 1.1–4.7), had a high school diploma (PR 2.2, 95% CI 1.2–4.0), did not have health insurance (PR 3.7, 95% CI 2.3–5.9), had receptively shared syringes (PR 1.7, 95% CI 1.1–2.7), had a greater number of sex partners (≥ 2 partners vs. 0, PR 6.1, 95% CI 1.4–26.0), and had condomless sex in the past 12 months (PR 2.8, 95% CI 1.6–5.0).

Discussion

We measured recent HIV infection at 0.6% among PWID at risk for HIV in our study population. Having a greater number of sex partners and having injected heroin and other drugs or exclusively other drugs were significantly associated with recent HIV infection. Among male PWID, having male–male sex in the past year was also associated with recent HIV infection.

HIV prevention among PWID has predominantly targeted reduction of injection risk [12]. While these strategies are critical to preventing new infections among PWID, our findings suggest that sexual behavior is associated with recent HIV acquisition and also remains an important mode of HIV transmission among U.S. PWID. Having a greater number of sexual partners increases the risk of acquiring HIV through sexual transmission, although sex partners may also share injection needles and equipment [13, 14]. Regardless of whether transmission may occur through sexual or injection practices with a sex partner, this finding highlights that sexual partners may be a key point of intervention for reducing new HIV infections among PWID. For example, partner-based interventions including partners' HIV testing and counseling could be adapted for PWID and incorporated into other interventions such as syringe services programs that offer HIV testing [15]. Developing partner-based interventions that access sexual networks of PWID, particularly male PWID who have sex with men, could help to encourage risk reduction through condom promotion and provision of clean needles and equipment to sex partners; these interventions could also allow for identifying and linking HIV-positive sex partners into HIV care and assessing HIV-negative partners' indications for pre-exposure prophylaxis (PrEP). Furthermore, this result emphasizes to physicians the importance of assessing sexual risk behaviors in addition to injection practices when making recommendations for PrEP for HIV-negative PWID.

Most non-heroin drugs injected in this study were stimulants, including powdered cocaine, crack cocaine, and methamphetamine. Previous research has shown that those who use stimulants exercise riskier sexual behaviors, including condomless sex [16–18]. In our study, participants who injected only drugs other than heroin and participants who injected other drugs in addition to heroin were both more likely to have a recent HIV infection, indicating that PWID who use stimulants alone or in addition to heroin may also be at increased risk of acquiring HIV. Previous evidence along with our findings suggest there may be an important connection between stimulant use, greater sexual risk behavior, and recent HIV infection, supporting the need for further investigation of these possible associations. Additionally, there may be a need to consider sexual transmission risks to PWID in prevention programs, particularly the use of stimulants alone or in combination with heroin before sex, which could lead to engaging in riskier sexual or injection behaviors.

We found that male PWID who have sex with other males experienced a higher risk of recent HIV infection, which is

Table 1 Associations between recent HIV infection and selected characteristics among persons who inject drugs at risk for HIV infection[a], National HIV Behavioral Surveillance, 2012, N = 8667

Characteristics	Total at risk[a,b]		Recently infected[b]		Prevalence ratio[c] (95% CI)
	N	Column %	n	Row %	
Sex					
Female	2453	28.3	19	0.8	1.6 (0.8, 3.0)
Male	6214	71.7	31	0.5	Referent
Age (years)					
18–29	871	10.0	6	0.7	1.3 (0.6, 2.7)
30–39	1610	18.6	11	0.7	1.2 (0.7, 2.2)
≥ 40	6186	71.4	33	0.5	Referent
Race/ethnicity					
Black/African American	3894	45.0	21	0.5	Referent
Hispanic/Latino[d]	2116	24.5	14	0.7	1.2 (0.6, 2.4)
White	2236	25.8	13	0.6	1.0 (0.5, 2.3)
Other[e]	408	4.7	2	0.5	0.9 (0.2, 3.7)
Education					
Less than high school diploma	2982	34.4	13	0.4	Referent
High school diploma or equivalent	3423	39.5	27	0.8	1.8 (0.9, 3.4)
More than high school diploma	2259	26.1	10	0.4	1.0 (0.4, 2.6)
Poverty					
At or below the federal poverty level	6771	78.7	39	0.6	Referent
Above the federal poverty level	1830	21.3	11	0.6	1.0 (0.6, 1.8)
Health insurance					
Yes	4951	57.2	26	0.5	Referent
No	3703	42.8	23	0.6	1.2 (0.7, 1.9)
Received HIV test in past 12 months					
Yes	4623	53.6	26	0.6	0.9 (0.5, 1.5)
No	3998	46.4	24	0.6	Referent
Receptively shared syringes in past 12 months					
Yes	2761	32.4	21	0.8	1.5 (1.0, 2.5)
No	5752	67.6	28	0.5	Referent
Injected Oxycontin in past 12 months					
Yes	917	10.6	4	0.4	0.7 (0.3, 1.9)
No	7747	89.4	46	0.6	Referent
Any non-injection prescription opioids in past 12 months[f]					
Yes	2920	33.7	14	0.5	0.8 (0.4, 1.4)
No	5743	66.3	36	0.6	Referent
Drugs injected in past 12 months					
Injected heroin only	2692	31.1	6	0.2	Referent
Injected heroin and other drugs[g]	5603	64.7	39	0.7	**3.0 (1.3, 6.6)**
Injected other drugs only[h]	365	4.2	5	1.4	**5.9 (1.7, 20.7)**
Number of sex partners in past 12 months					
0	1190	13.7	2	0.2	Referent
1	2696	31.1	8	0.3	1.7 (0.4, 7.6)
2 or more	4775	55.1	40	0.8	**4.7 (1.3, 17.8)**
Any condomless sex in past 12 months					
Yes	6276	72.5	35	0.6	0.9 (0.5, 1.6)
No	2378	27.5	15	0.6	Referent
Male–male sex in past 12 months (among males)					
Yes	653	10.5	14	2.1	**7.1 (3.0, 16.6)**
No	5556	89.5	17	0.3	Referent

Table 1 (continued)

Characteristics	Total at risk[a,b]		Recently infected[b]		Prevalence ratio[c] (95% CI)
	N	Column %	n	Row %	
Any exchange sex in past 12 months					
Yes	3439	39.8	27	0.8	1.7 (0.9, 3.1)
No	5210	60.2	23	0.4	Referent
Any exchange sex in past 12 months (females only)					
Yes	1097	44.8	12	1.1	2.0 (0.8, 4.6)
No	1353	55.2	7	0.5	Referent
Total	8667	100.0	50	0.6	

Statistically significant results (alpha = 0.05) shown in bold

CI confidence interval

[a]We excluded non-recent infections (HIV serology positive but not determined as recent by the avidity-based assay or had self-reported diagnosis ≥ 12 months before interview date) and analyzed individuals with recent infection and those HIV-uninfected

[b]Numbers may not sum to total due to missing values

[c]Models accounted for clustering by recruitment chain and city but were not adjusted for other covariates

[d]Hispanics/Latinos can be of any race

[e]Other races include American Indian, Alaska Native, Asian, Native Hawaiiian, other Pacific Islander, and mixed race

[f]'Non-injection prescription opioids' included Oxycontin, Vicodin, or Percocet

[g]'Injected heroin and other drugs' included heroin and one or more of the following: speedball (79.7% of PWID injecting heroin and other drugs in past year), powdered cocaine (57.1%), crack cocaine (24.0%), methamphetamine (22.8%), Oxycontin (16.1%), and/or other drugs (10.0%)

[h]'Injected other drugs only' included one or more of the following: powdered cocaine (48.5% of PWID injecting only drugs other than heroin in past year), crack cocaine (14.8%), methamphetamine (60.6%), Oxycontin (4.4%), or other drugs (5.2%)

likely a function, at least in part, of the higher biological HIV transmission probability via anal intercourse compared to vaginal intercourse and the higher HIV prevalence among MSM [19, 20]. Overall, 2.0% of PWID reporting male–male sex in the past year were recently infected with HIV and the association between male–male sex and recent HIV infection was the greatest in magnitude of all variables considered. HIV prevention efforts seeking to reduce new HIV infections among PWID may expand their impact by including male PWID who have sex with men as an important subpopulation. HIV-negative and HIV-positive male PWID who have sex with men could benefit from greater accessibility to PrEP to prevent new infection or antiretroviral therapy (ART) for treatment and to reduce the risk of transmission to others, respectively, as transmission could occur via sexual and/or injection pathways. Our findings support that physicians should strongly consider sexual indications for PrEP in addition to injection practices in their assessments with PWID, as recommended by CDC [21]. For example, it is possible that PWID who have injected drugs in the past 6 months may not have shared injection equipment with others or participated in a methadone, buprenorphine, or suboxone treatment program in the past 6 months, but rather may have engaged in specific sexual behaviors that would complete an indication for PrEP. Furthermore, existing strategies for linkage and retention on PrEP and/or in HIV care could be tailored to the particular needs of male PWID who have sex with men, who may be harder to retain on biomedical interventions over time [22].

When comparing to those with prevalent, non-recent infections, PWID with recent infections were young, white, had graduated from high school, did not have health insurance, had receptively shared syringes, had a greater number of sex partners, and were more likely to have condomless sex in the past year. Most of these associations were as expected: those with prevalent, non-recent infections were older, as HIV prevalence increases with age; were likely linked to care and therefore covered under some health insurance for HIV treatment; and had fewer injection and sexual risk behaviors potentially due to behavior change after HIV diagnosis [23]. The objective of this secondary analysis was to identify any factors that may indicate new, emerging risk behaviors by those recently HIV infected in the current epidemic compared to historical PWID infections. Our finding that PWID recently infected with HIV were more likely to be of white race and to have graduated from high school suggests a demographic shift compared to PWID who acquired HIV earlier in the epidemic, who were mostly black and who

Table 2 Associations between recent HIV infection and selected characteristics among all HIV-positive persons who inject drugs[a], National HIV Behavioral Surveillance, 2012, N = 802

Characteristics	Total[a,b]		Recently infected[b]		Prevalence ratio[c] (95% CI)
	N	Column %	n	Row %	
Sex					
Female	237	29.6	19	8.0	1.5 (0.8, 2.7)
Male	565	70.4	31	5.5	Referent
Age (years)					
18–29	23	2.9	6	26.1	**5.4 (2.7, 10.9)**
30–39	100	12.5	11	11.0	**2.3 (1.3, 4.0)**
≥ 40	679	84.7	33	4.9	Referent
Race/ethnicity					
Black/African American	466	58.2	21	4.5	Referent
Hispanic/Latino[d]	168	21.0	14	8.3	1.9 (1.0, 3.6)
White	127	15.9	13	10.2	**2.3 (1.1, 4.7)**
Other[e]	40	5.0	2	5.0	1.1 (0.3, 4.8)
Education					
Less than high school diploma	319	39.8	13	4.1	Referent
High school diploma or equivalent	298	37.2	27	9.1	**2.2 (1.2, 4.0)**
More than high school diploma	185	23.1	10	5.4	1.3 (0.5, 3.2)
Poverty					
At or below the federal poverty level	684	85.7	39	5.7	Referent
Above the federal poverty level	114	14.3	11	9.6	1.7 (1.0, 2.9)
Health insurance					
Yes	645	80.5	26	4.0	Referent
No	156	19.5	23	14.7	**3.7 (2.3, 5.9)**
Receptively shared syringes in past 12 months					
Yes	236	29.9	21	8.9	**1.7 (1.1, 2.7)**
No	554	70.1	28	5.1	Referent
Injected Oxycontin in past 12 months					
Yes	48	6.0	4	8.3	1.4 (0.6, 3.2)
No	754	94.0	46	6.1	Referent
Any non-injection prescription opioids in past 12 months[f]					
Yes	206	25.7	14	6.8	1.1 (0.6, 2.0)
No	596	74.3	36	6.0	Referent
Drugs injected in past 12 months					
Injected heroin only	152	19.0	6	4.0	Referent
Injected heroin and other drugs[g]	575	71.9	39	6.8	1.7 (0.8, 3.6)
Injected other drugs only[h]	73	9.1	5	6.8	1.7 (0.5, 5.7)
Number of sex partners in past 12 months					
0	133	16.6	2	1.5	Referent
1	226	28.2	8	3.5	2.4 (0.5, 11.2)
2 or more	442	55.2	40	9.0	**6.1 (1.4, 26.0)**
Any condomless sex, past 12 months					
Yes	364	45.4	35	9.6	**2.8 (1.6, 5.0)**
No	437	54.6	15	3.4	Referent
Male–male sex in past 12 months (among males)					
Yes	168	29.8	14	8.3	1.9 (0.9, 4.3)
No	395	70.2	17	4.3	Referent
Any exchange sex in past 12 months					
Yes	357	44.7	27	7.6	1.4 (0.8, 2.6)
No	442	55.3	23	5.2	Referent

Table 2 (continued)

Characteristics	Total[a,b]		Recently infected[b]		Prevalence ratio[c] (95% CI)
	N	Column %	n	Row %	
Any exchange sex in past 12 months (females only)					
Yes	110	46.6	12	10.9	1.9 (0.8, 4.6)
No	126	53.4	7	5.6	Referent
Total	802	100.0	50	6.2	

Statistically significant results (alpha = 0.05) shown in bold

CI confidence interval

[a]We excluded HIV-uninfected PWID and analyzed individuals with recent infection to those with non-recent HIV infections (HIV serology positive but not determined as recent by the avidity-based assay or had self-reported diagnosis ≥ 12 months before interview date)

[b]Numbers may not sum to total due to missing values

[c]Models accounted for clustering by recruitment chain and city but were not adjusted for other covariates

[d]Hispanics/Latinos can be of any race

[e]Other races include American Indian, Alaska Native, Asian, Native Hawaiiian, other Pacific Islander, and mixed race

[f]'Non-injection prescription opioid' included Oxycontin, Vicodin, or Percocet

[g]'Injected heroin and other drugs' included heroin and one or more of the following: speedball (87.5% of PWID injecting heroin and other drugs in past year), powdered cocaine (55.3%), crack (24.7%), methamphetamine (16.7%), Oxycontin (8.2%), and/or other drugs (6.8%)

[h]'Injected other drugs only' included one or more of the following: cocaine (37.0% of PWID injecting only drugs other than heroin in past year), crack (12.3%), methamphetamine (74.0%), Oxycontin (1.4%), or other drugs (2.7%)

had less than a high school education [24]. These racial and educational factors were unanticipated differences between those with recent vs. non-recent infections and indicate changing demographics in those who are recently acquiring HIV as early as 2012.

There are a few limitations to this analysis. First, the number of recent HIV infections was small and infections occurred in a diverse group of PWID across the 19 cities, limiting our ability to control for potential confounders. Our conclusions about key factors associated with recent HIV infection are therefore based on bivariate analyses only which does not take into account factors that could be confounding the associations we observed. Due to the RDS recruitment design, we chose to account for clustering by recruitment chain within city which commonly resulted in wider 95% CIs, though this offered more conservative CI widths for our measures of association. Second, behavioral data are collected through face-to-face interviews and may be subject to social desirability bias. Third, respondent-driven sampling was used to recruit participants in 19 U.S. cities with high HIV prevalence and data are unweighted; therefore, results may not be generalizable to all PWID in participating cities or to PWID in other cities or in rural areas. Particularly in rural areas, the 2015 HIV outbreak in Indiana highlights the importance of prevention strategies for syringe sharing and opioid use for rural PWID [25, 26]. Our 2012 data from urban areas suggest that in addition to providing educational and structural interventions to promote safe injection practices, prevention efforts directed toward sexual risks may be important to reducing transmissions among urban PWID. We did not find having injected prescription opioids to be significantly associated with recent infection in urban PWID. However, these data were collected a few years prior to the 2015 Indiana outbreak and did not ask about the use of other prescription opioids besides Oxycontin. Future NHBS data will consider use of other opioid drugs to better describe prescription opioid use by urban PWID. Nevertheless, these differences between rural and urban PWID are important to note as we seek to characterize recent HIV infections and the appropriate public health prevention response tailored to each of these settings.

Conclusion

Overall, our findings indicate that sexual behavior may contribute in an important way to recent HIV infections among U.S. PWID. Promoting not only safe injection practices but also safe sex practices will be key to reducing new HIV infections in this population. Opportunities for incorporating sexual education to increase condom use and reduce stimulant drug use into prevention programs

for PWID may aid in decreasing new HIV infections in this group. Additionally, partner-based interventions such as couples' HIV testing and counseling and peer-driven interventions used with sexual partners to reduce sharing of syringes/equipment and promote condom use could improve strategies for decreasing both sexual and injection risk behaviors. Lastly, male PWID who have sex with men are an important group for prevention efforts, as they experienced a high proportion of recent HIV infections in our study. Male PWID who have sex with men may have unique needs for prevention and retention in care, particularly for biomedical interventions including ART and PrEP.

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Compliance with Ethical Standards

Conflict of interest All authors have contributed to the study and manuscript and provided their approval to submit. To our knowledge, all authors have no conflicts of interest related to the submitted work.

Ethical Approval All procedures performed involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study, as approved by local institutional review boards at each study site.

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