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Association of sex, hygiene and drug equipment sharing with hepatitis C virus infection among non-injecting drug users in New York City

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Abstract

Background: Hepatitis C virus (HCV) rates are higher in non-injecting drug users (NIDUs) than general population estimates. Whether this elevated HCV rate is due to drug use or other putative risk behaviors remains unclear.
Methods: Recent non-injection drug users of heroin, crack and/or cocaine were street-recruited from 2000 to 2003 and underwent an interview and venipuncture for HCV antibody assays. Multiple logistic regression analyses were used to assess correlates for HCV infection.
Results: Of 740 enrollees, 3.9% were HCV positive. The median age (intraquartile range) was 30 (35–24) years, 70% were male and 90% were Black or Hispanic. After adjustment, HCV seropositives were significantly more likely than seronegatives to be older than 30 [adjusted odds ratio (AOR) = 5.71], tattooed by a friend/relative/acquaintance [AOR = 3.61] and know someone with HCV [AOR = 4.29], but were less likely to have shared nail or hair clippers, razors or a toothbrush [AOR = 0.32].
Conclusions: Non-commercial tattooing may be a mode of HCV transmission among NIDUs and education on the potential risk in using non-sterile tattooing equipment should be targeted toward this population. While no evidence was found for HCV transmission through NIDU equipment sharing or sexual risk behavior, further research is still warranted.

Keywords: HCV transmission; Epidemiology; Intranasal drug users; Non-injection drug use; Risk behaviors

1. Introduction

While injection drug use is the major risk factor for hepatitis C virus (HCV) infection (Prevention, 1998), non-injection drug users (i.e., intranasal heroin or cocaine users and crack smokers) on average have an HCV prevalence that is higher than that of the general population (5–12% versus 2%) (Abraham et al., 1999; Alter et al., 1999; Gyarmathy et al., 2002; Hershow et al., 1998; Koblin et al., 2003; Nyamathi et al., 2002; Rosenberg et al., 2001; Shirin et al., 2000; Thomas et al., 1995; Tortu et al., 2004; Van Ameijden et al., 1993; Wada et al., 1999). The basis for this elevated prevalence is unknown, but could be due to lack of recognition of typical risk factors (i.e., injection drug use) among non-injectors. In the absence of a clear parenteral exposure(s), investigation of other modes of HCV transmission is needed.

Some researchers have hypothesized that non-injectors acquire HCV as a result of non-injection drug use practices (i.e., sharing non-injecting drug equipment), personal hygiene practices (i.e., sharing razors or clippers), non-commercial tattooing and/or high-risk sexual behaviors (Conry-Cantilena et al., 1996; Gyarmathy et al., 2002; Koblin et al., 2003; McMahon et al., 2004; McMahon and Tortu, 2003; Quaglio et al., 2003; Tortu et al., 2004, 2001; Neaigus et al., 2001). However, to date, the data for each of these hypothesized modes of transmission are conflicting and no

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reports have been published that have simultaneously assessed these modes of transmission among non-injection drug users (NIDUs).

The purpose of this study was to investigate the hypothesis that sharing non-injecting drug equipment, high-risk sexual behaviors and unhygienic practices are independently and positively associated with HCV seropositivity among NIDUs. These findings follow our preliminary work conducted among NIDUs (Koblin et al., 2003) and includes a larger sample size so that additional salient risk correlates could be examined.

2. Methods

2.1. Study population

Eligible NIDUs included persons 15–40 years of age in New York City (NYC) who acknowledged non-injection use of heroin, crack and/or cocaine at least 2–3 times in the last 2 months, but for less than 10 years and denied a history of injection drug use. Beginning August 2000, street-outreach methods that built upon street-ethnography as described elsewhere (Diaz et al., 2001) were used to recruit both injectors (for a concurrent hepatitis C cohort study among young/recent-onset injection drug users (IDUs)) and non-injectors (HOPE study) from specific NYC neighborhoods in Manhattan, Brooklyn, Queens and South Bronx known for high drug activity. Among NIDUs, no history of injection drug use (i.e., injection of illicit drugs, steroids, hormones or any other substance) was confirmed during the social and demographic portion of the baseline interview. Once injection status was determined, the participant was administered the appropriated survey instrument, e.g., Hep C risk survey or HOPE risk survey. The lack of antecubital track marks observed by the staff phlebotomist was also used to establish absence of injection drug use among participants at each study visit.

2.2. Data collection

Study participants were recruited through street-outreach in ethnographically determined high drug risk neighborhoods. Potential study participants identified through street-outreach were escorted back to the research storefront or a study mobile van to be screened for eligibility. Several steps were taken during the study to detect and minimize denial of injection history. First, the screening instrument was designed in such a way to prevent disclosure of eligibility criteria. Several other studies with various eligibility criteria were being conducted simultaneously at the same research sites and as such, it was rare for participants to be turned away due to ineligibility; this may have minimized inaccurate self-report of injection status to gain entrance into a study protocol. Second, all interviews were performed in private rooms at the research storefront or on the study van to create a comfortable, non-judgmental setting which in turn facilitated more truthful responses from participants. Third, data collected during a follow-up visit regarding injection drug use history and other eligibility criteria was double checked against baseline data to enhance the validity of the collected baseline data and minimize inclusion of injection drug users in the study population.

The interview ascertained the three following main exposure categories: (1) the use and sharing of non-injecting drug equipment, (2) sexual behaviors and (3) personal hygiene. Specifically, the use and sharing of non-injecting drug equipment was ascertained by asking participants if they shared a straw or dollar bill to sniff/snort cocaine, heroin or heroin with cocaine in the past 6 months (and if so, whether the device was blood tinged) as well as if they ever shared a crack pipe (and if so, whether the device was blood tinged).

High-risk sexual behaviors included ever-trading sex (i.e., exchanged sex for drugs/money and vice versa), ever having a sex partner who injected drugs, ever having a sex partner who indicated that he/she had hepatitis and ever noticing blood during sex. HIV serostatus was also examined as a potential covariate to provide possible evidence of sexual transmission.

Hygiene measures included ever sharing personal hygiene products such as toothbrushes, nail or hair clippers or electric/non-electric razors. The source and/or venue of tattoos or piercings were also assessed (i.e., retail store, doctor's office, friend/relative/acquaintance or prison). Finally, participants were asked if they ever lived or knew someone with HCV infection and their relationship with that person (i.e., husband/boyfriend/male lover, wife/girlfriend/female lover, sister/brother, daughter/son, mother/father, client/casual sex partner, shooting/running buddy, drug/needle dealer, friend/acquaintance or other).

Other relevant variables (based on previous reports) that were examined included type, frequency and duration of drug use as well as sociodemographics such as age, gender, race, education, income, homelessness, history of methadone maintenance and prison history (Conry-Cantilena et al., 1996; Gyarmathy et al., 2002; Koblin et al., 2003; McMahon et al., 2004; Quaglio et al., 2003; Tortu et al., 2004, 2001).

After undergoing a 45-min interviewer-administered interview, study participants underwent pre-test counseling and venipuncture for HIV, HBV and HCV serological testing. Serological tests were conducted using commercial assays (i.e., HCV Version 2.0 ELISA and Chiron RIBA HCV 3.0 SIA) and interpreted using standard criteria. HCV serostatus collected at baseline served as the outcome measure for this analysis.

2.3. Statistical analysis

For categorical variables, proportions were calculated for descriptive statistics, while medians with intraquartile ranges were used for continuous variables. Cross-tabulations of HCV antibody status by covariates of interest were examined using odds ratios with 95% confidence intervals to help

guide interpretation. Medians and/or commonly used cut points (based on previous studies) were used to categorize all continuous data. Multiple logistic regression with HCV serostatus as the outcome was used to simultaneously control for confounding and explore plausible interactions. Putative confounders included age, race, education, prison history, income, homelessness and drug type. Interaction terms between gender and sexual behavior variables were examined as well as interaction between knowing someone with HCV and the three following exposures: (1) having been tattooed by a friend/relative/acquaintance, (2) sharing non-injecting drug equipment and (3) high-risk sexual practices.

Given the broad scale of variables explored and the expected small number of cases of HCV, separate logistic regression models were fitted for each of the three main exposure categories of interest (the use and sharing of non-injecting drug equipment, sexual behavior and personal hygiene) to limit the number of variables explored simultaneously in a given model. All of the above-mentioned potential confounders were explored and controlled for in each of the three regression models as needed. In addition, for each exposure category, all measures with a *p*-value at or below 0.2 during cross-tabulations were considered during final model building procedures utilizing stepwise backward elimination. Likelihood ratio tests were used to assess whether the inclusion of specific interaction terms improved the fit of the final model. Variables that demonstrated statistical significance in each final model were used further to build the most parsimonious final model. SAS Version 9.0 was used to conduct all of the analyses.

3. Results

Of the 755-recruited NIDUs, 15 subjects who responded with conflicting information on the risk survey regarding their injection drug use history were excluded from the analyses. After exclusion of these 15 subjects, 28 (3.9%) of 722 participants were HCV positive at baseline. Seventy percent of participants were male and 90% were either Black or Hispanic (Table 1). The median age (interquartile range) of participants was 30 (35–24) years old with approximately 57% of study subjects reporting to have completed less than a high school education, and 84% reporting a yearly income at or below US$ 5000. Being older than 30 years of age (OR = 4.57) was the sole sociodemographic characteristic associated with HCV seropositive status.

Table 2 shows bivariate analyses assessing the relationship between drug use behaviors and HCV serostatus at baseline. HCV seropositives were more likely than seronegatives to have sniffed/snorted heroin daily (OR = 2.24), to have shared a crack pipe when blood was present (OR = 12.78) and more than twice as likely to have smoked heroin with crack (OR = 2.27). In Table 3, sexual behaviors and current HIV serostatus was examined in relation to HCV serostatus. HCV seropositives were more likely than seronegatives to be HIV seropositive at baseline (OR = 2.64) and to have had a sex partner tell them he/she had hepatitis (OR = 3.95). In terms of other social circumstances that may indirectly contribute to HCV infection, as shown in Table 3, HCV seropositives were more likely than seronegatives to report knowing someone else with HCV (OR = 3.18) and to have a friend/acquaintance with HCV (OR = 3.32). Finally, Table 4 shows that HCV seropositives were less likely than seronegatives to have had a piercing from a retail store (OR = 0.31), or to have shared nail or hair clippers, razors or a toothbrush (OR = 0.37). No other hygiene practice examined was found to differ by HCV serostatus.

Table 5 shows as a final comprehensive model that considered each variable that significantly contributed to the final regression model. The three logistic models corresponding to use and sharing of non-injecting drug equipment, sexual behavior and hygiene practices are not shown. The use and sharing of non-injecting drug equipment as well as sexual

Table 1
Sociodemographic factors associated with HCV seropositive status among non-injecting drug users, New York City, 2000–2003 ($N = 740$)

Sociodemographic factor	N[a] (%)	HCV$^+$ (%)	OR	95% CI
Age				
≤30	391 (54.2)	1.5	1.00	
>30	331 (45.8)	6.7	4.57***	1.83, 11.41
Race/ethnicity				
Black	304 (42.2)	3.0	1.00	
Hispanic/Latino	346 (48.0)	5.5	1.90**	0.85, 4.28
White/other[b]	71 (9.8)	0.0	–	–
Gender				
Female	212 (29.8)	5.2	1.00	
Male	500 (70.2)	3.4	0.64	0.30, 1.40
Education completed				
≥High school or GED	311 (43.2)	4.2	1.00	
<High school	409 (56.8)	3.7	0.87	0.41, 1.86
Total yearly income				
≤US$ 5000	602 (83.4)	3.8	1.00	
>US$ 5000	120(16.6)	4.2	1.09	0.41, 2.94
Blood transfusion before 1991				
No	713 (96.4)	3.8	1.00	
Yes	27 (3.7)	3.7	0.98	0.13, 7.47
Ever been in methadone maintenance program				
No	619 (83.6)	3.5	1.00	
Yes	121 (16.4)	5.0	1.42	0.56, 3.57
Ever incarcerated				
No	509 (68.8)	3.1	1.00	
Yes	231 (31.2)	5.2	1.69	0.78, 3.63
Ever been homeless				
No	149 (20.2)	3.4	1.00	
Yes	590 (79.8)	3.9	1.17	0.44, 3.13

[a] Column does not add up to 740 due to missing data.
[b] Asian/Pacific Islander, Native American/Eskimo/Aleutian, mixed and other.
* $p < 0.20$.
** $p < 0.10$.
*** $p < 0.05$.

Table 2
Drug use behaviors associated with HCV seropositive status among non-injecting drug users, New York City, 2000–2003 ($N = 740$)

Behavior	N[a] (%)	HCV$^+$ (%)	OR	95% CI
Sniffed/snorted cocaine[b]				
<Daily	629 (5.3)	4.3	1.00	
≥Daily	93 (12.9)	1.1	0.24	0.03, 1.80
Shared straw or dollar bill to sniff/snort cocaine[c]				
No	468 (64.8)	3.6	1.00	
Yes	254 (35.2)	4.3	1.20	0.55, 2.60
Sniffed/snorted heroin[b]				
< Daily	574 (79.5)	3.1	1.00	
≥ Daily	148 (20.5)	6.8	2.24**	1.01, 4.96
Shared straw or dollar bill to sniff/snort heroin[c]				
No	592 (82.0)	4.1	1.00	
Yes	130 (18.0)	3.1	0.75	0.26, 2.20
Sniffed/snorted heroin and cocaine[c]				
<Daily	545 (75.5)	3.3	1.00	
≥Daily	177 (24.5)	5.6	1.75*	0.79, 3.87
Shared straw or dollar bill to sniff/snort heroin with cocaine[c]				
No	672 (93.1)	3.7	1.00	
Yes	50 (6.9)	6.0	1.65	0.48, 5.67
Smoked crack[b]				
<Daily	565 (78.2)	4.1	1.00	
≥Daily	157 (21.8)	3.2	0.77	0.29, 2.07
Shared crack pipe when blood present[c]				
No	717 (99.6)	3.8	1.00	
Yes	3 (0.4)	33.3	12.78*	1.12, 145.29
Ever smoke heroin with crack				
No	577 (81.4)	3.1	1.00	
Yes	132 (18.6)	6.8	2.27**	1.00, 5.18

[a] Column does not add up to 740 due to missing data.
[b] Past 2 months.
[c] Drug type variable was only measured over the past 6 months.
* $p < 0.20$.
** $p < 0.10$.
*** $p < 0.05$.

Table 3
Sexual behaviors and social circumstances associated with HCV seropositive status among non-injecting drug users, New York City, 2000–2003 ($N = 740$)

Behavior/social circumstance	N[a] (%)	HCV$^+$ (%)	OR	95% CI
IDU sex partner(s)				
No	696 (94.0)	3.6	1.00	
Yes	44 (6.0)	6.8	1.96*	0.57, 6.77
Sex partner(s) with hepatitis[b]				
No	716 (96.8)	3.5	1.00	
Yes	24 (3.2)	12.5	3.95**	1.10, 14.11
Traded sex[c,d]				
No	538 (72.7)	4.3	1.00	
Yes	202 (27.3)	2.5	0.59	0.21, 1.52
HIV$^+$				
No	650 (90.2)	3.4	1.00	
Yes	71 (9.8)	8.5	2.64***	1.03, 6.73
Ever notice blood during sex				
No	446 (63.2)	4.5	1.00	
Yes	260 (36.8)	2.7	0.59	0.25, 1.41
Know someone with HCV				
No	592 (80.0)	2.7	1.00	
Yes	148 (20.0)	8.1	3.18***	1.47, 6.87
Lived with someone with HCV				
No	677 (94.2)	3.6	1.00	
Yes	42 (5.8)	9.5	2.86**	0.95, 8.67
Have a friend/acquaintance with HCV				
No	622 (86.8)	3.1	1.00	
Yes	95 (13.2)	9.5	3.32***	1.46, 7.58

[a] Column does not add up to 740 due to missing data.
[b] Self-report.
[c] Past 2 months.
[d] Exchanged sex for drugs/money and vice versa.
* $p < 0.20$.
** $p < 0.10$.
*** $p < 0.05$.

behavior variables were not significant in their respective logistic regression models after controlling for potentially confounding variables, i.e., age. However, in both hygiene and comprehensive models, being HCV seropositive was significantly associated with being older (AOR = 5.71), having been tattooed by a friend/relative/acquaintance (AOR = 3.61), knowing someone with HCV (AOR = 4.29), but inversely associated with sharing nail or hair clippers, razors or a toothbrush (AOR = 0.32). Interaction terms did not improve the fit of the comprehensive model.

4. Discussion

Among this NYC population of non-injecting drug users, neither sharing of non-injecting drug equipment such as straws and pipes nor high-risk sexual practices were associated with HCV seropositive status. Although our bivariate associations were suggestive of a role of these practices, these associations did not persist after adjustment for age. Having been tattooed by a friend or relative did emerge as a significant risk correlate for HCV infection as well as knowing someone with HCV infection. Alternatively, an independent inverse association between HCV infection and ever sharing personal hygiene products such as nail or hair clippers, razors or a toothbrush was observed.

In terms of non-injecting drug equipment sharing, Tortu et al. (2004) examined risk correlates for HCV infection among female NIDUs and found that ever sharing both oral and intranasal non-injecting drug equipment was associated with HCV seropositivity, while McMahon et al. (2004) showed the presence of HCV RNA in the nasal secretions of an intranasal drug user. These findings provide evidence for sharing non-injecting drug equipment as a plausible mechanism for HCV transmission. However, similar to our study, Gyarmathy et al. (2002) did not find an association between equipment sharing and HCV seroprevalence in their study among non-injecting heroin users. It is plausible that differences in the way that non-injecting drug equipment sharing was measured in the above-mentioned studies con-

Table 4
Hygiene practices associated with HCV seropositive status among non-injecting drug users, New York City, 2000–2003 ($N = 740$)

Practice	N[a] (%)	HCV$^+$ (%)	OR	95% CI
Source of tattoo				
No tattoo	443 (62.6)	3.4	1.00	
Retail store	90 (12.7)	2.2	0.65	0.15, 2.89
Friend/relative/acquaintance	69 (9.7)	7.3	2.23*	0.78, 6.34
Prison	106 (15.0)	3.8	1.13	0.36, 3.44
Source of piercing				
No piercing	216 (29.2)	6.0	1.00	
Doctor's office	3 (0.4)	0.0	–	–
Retail store	305 (41.2)	2.0	0.31***	0.12, 0.83
Friend/relative/acquaintance	194 (26.2)	4.1	0.67	0.27, 1.66
Prison	22 (3.0)	4.5	0.74	0.09, 5.97
Ever share electric razor				
No	657 (91.1)	3.6	1.00	
Yes	64 (8.9)	6.2	1.75	0.59, 5.23
Ever share non-electric razor				
No	642 (89.0)	4.0	1.00	
Yes	79 (11.0)	2.5	0.61	0.14, 2.64
Ever share nail or hair clippers				
No	400 (55.5)	5.3	1.00	
Yes	321 (44.5)	2.2	0.40**	0.17, 0.96
Ever share toothbrush				
No	668 (92.6)	3.7	1.00	
Yes	53 (7.4)	5.7	1.54	0.45, 5.29
Ever share razor or hair clippers or nail clippers or toothbrush				
No	386 (53.5)	5.4	1.00	
Yes	335 (46.5)	2.1	0.37***	0.15, 0.88

[a] Column does not add up to 740 due to missing data.
* $p < 0.20$.
** $p < 0.10$.
*** $p < 0.05$.

tributed to conflicting study results. Establishing accurate and uniform non-injecting equipment sharing measures could perhaps reconcile these study differences. Conducting qualitative research involving the actual practices and the social context in which equipment sharing is practiced may help with identifying such measures. Thus, further investigation of HCV transmission through non-injection equipment sharing is still warranted.

Also noteworthy is the lower HCV prevalence observed among this study sample as compared to other observed NIDU populations (5–12% versus 3.9%) (Abraham et al., 1999; Alter et al., 1999; Gyarmathy et al., 2002; Hershow et al., 1998; Koblin et al., 2003; Nyamathi et al., 2002; Rosenberg et al., 2001; Shirin et al., 2000; Thomas et al., 1995; Tortu et al., 2004; Van Ameijden et al., 1993; Wada et al., 1999). This difference in HCV prevalence is likely attributed to the fact that NIDUs in this study tended to be younger than NIDU respondents in prior studies. Evidence of the link between younger age and HCV prevalence among NIDUs was observed in our study and others (Tortu et al., 2004).

The absence of an association between HCV infection and high-risk sexual behavior was observed in this NIDU population, including the absence of interactions by gender. These findings concur with the Centers for Disease Control and

Table 5
Multiple logistic regression of the relationship between three primary exposure categories and HCV seropositive status among non-injecting drug users, New York City, 2000–2003 ($N = 740$)

Predictor	Crude OR (95% CI)	Adjusted OR[a] (95% CI)
>30 years old vs. ≤30 years old	4.57*** (1.91, 12.28)	5 .71*** (2.04, 15.95)
Tattooed by a friend/relative/acquaintance vs. no tattoo	2.27* (0.80, 6.46)	3.61*** (1.15, 11.26)
Ever share razor or hair clippers or nail clippers or toothbrush vs. never	0.37*** (0.15, 0.88)	0.32*** (0.17, 0.81)
Know someone with HCV vs. not	3.18*** (1.47, 6.87)	4.29*** (1.84, 10.00)

[a] Adjusted for age, race, education, prison history, income and drug type.
* $p < 0.20$.
*** $p < 0.05$.

Prevention's assertion that "sexual transmission of HCV appears to occur, but that the virus is inefficiently spread through this manner" (Prevention, 1998). However, whether the absence of evidence supporting sexual transmission in this study was due to underreporting of sexual risks or sexual transmission being masked by other concurrent risk behaviors not captured in this study is unknown. When participants were asked about sexual behavior, they were informed that "having sex" was defined as anal, oral and vaginal sex. Thus, we were unable to measure the effect of anal sex on HCV seropositive status. Future HCV research of both sexual and equipment sharing among NIDUs should include measurement of social desirability to offer evidence of possible underreporting of sexual behaviors (Latkin and Vlahov, 1998; Latkin et al., 1993).

The potential for personal hygiene practices to contribute to HCV transmission surfaces from this study. Consistent with previous research (Gyarmathy et al., 2002; Hellard et al., 2004; Ko et al., 1992; Post et al., 2001; Samuel et al., 2001), a positive association between HCV infection and having been tattooed by a friend or relative was observed. Haley and Fischer (2001) conducted a study among patients visiting an orthopedic spinal clinic who were unaware of their HCV status and estimated that non-commercial tattooing accounted for 11% of HCV infections. The fact that approximately 10% of this NIDU population reported being tattooed by a friend or relative coupled with the strong independent association between non-commercial tattooing and HCV infection, underscores the need for future research to determine public health risk of non-commercial tattooing among this population and other populations that may obtain tattoos from non-commercial settings.

Contrary to what may have been expected, an independent inverse association of ever sharing nail or hair clippers, razors or a toothbrush with HCV infection was observed. We originally considered this type of casual contact as being sufficient for HCV transmission given the high efficiency of transmission of HCV (Hagan and Des Jarlais, 2000). However, a significant protective effect for sharing personal hygiene products persisted in this analysis, which could perhaps be explained by residual confounding by socioeconomic status (SES). While we attempted to control for education, homelessness and income, the level of refinement of these SES variables may have been insufficient to differentiate the varying levels of the extreme low SES that characterized this study population. For example, NIDUs who do not share personal hygiene products may represent a relatively low SES subgroup that may not have access to such items. Alternatively, those who share and have access to razors and toothbrushes may be of a higher SES. Thus, members of lower risk networks may be less likely to be HCV positive, and the converse may be the case for higher risk networks. Considering the lack of sharing personal hygiene items is indeed a proxy measure of SES and not a direct measure of sharing potentially HCV infected hygiene products would change how the association between personal hygiene and HCV infection might be viewed. Unfortunately, the data collected are insufficient to make clear this distinction, which emphasizes the need for additional studies that capture varying levels of low SES as well as access to these items.

Although this study was a large NIDU study, possibly the largest to date among NIDU studies investigating HCV transmission, several limitations should be acknowledged. Using a cross-sectional design prevents temporality of associations from being determined. Also, the extent to which results from this study can be generalized to other drug users is unknown. Another limitation pertains to the use of comprehensive measures of sexual behavior instead of type specific variables (i.e., anal sex versus oral sex versus vaginal sex) that may better elucidate the relationship between sexual behavior, particularly anal sex and HCV transmission.

In addition, the use of non-injection equipment sharing measures pertaining to the last 6 months may not be the best measure of non-injection equipment sharing practices. Furthermore, even though steps were taken to help reduce the potential for inclusion of injectors in this study, the strong link between HCV infection and injection drug use would indicate that even the slightest occurrence of misclassification of injection history could alter our estimates. Therefore, future research that includes circumstances that contribute to denial of injection status among NIDUs is needed so that more appropriate study methods (e.g., recruitment, survey development) and analysis (e.g., adjusting for potential confounders, sample restriction based on indicators of previous injection) can be employed to better address HCV risk among non-injectors.

In summary, non-injecting drug use equipment sharing may still remain as a plausible route for HCV transmission, even though an association between HCV infection and sharing non-injecting drug equipment did not persist in this study population. More refined measures of non-injection drug equipment sharing such as frequency and duration of these practices as well as the social context in which these behaviors tend to occur should be explored among larger samples of drug users by drug type and route of administration (i.e., crack smokers only and/or snorters). This study found no direct evidence for sexual transmission of HCV, yet it is conceivable that the emergence of knowing someone with HCV as a significant risk correlate for HCV infection may keep the door open to consideration of sexual transmission of HCV as well as other potentially sensitive information. Given that non-commercial tattooing did emerge as a potential mode of HCV transmission among NIDUs and is consistent with prior studies (Gyarmathy et al., 2002; Hellard et al., 2004; Ko et al., 1992; Post et al., 2001; Samuel et al., 2001; Haley and Fischer, 2001), public health educational efforts should be undertaken among this population regarding the potential for HCV transmission when using non-sterile tattooing equipment. Future studies aimed at identifying hygiene, sexual and equipment sharing risk correlates for HCV infection among vulnerable populations of NIDUs should qualitatively and quantitatively examine the setting/practice of non-injection

drug use, access to and sharing of hygiene products, and the role of sexual risk in the presence of each potential mode of HCV transmission.

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