

# “To Share or Not to Share?” Serosorting by Hepatitis C Status in the Sharing of Drug Injection Equipment Among NHBS-IDU2 Participants

Bryce D. Smith,<sup>1</sup> Amy Jewett,<sup>2</sup> Richard D. Burt,<sup>3</sup> Jon E. Zibbell,<sup>1</sup> Anthony K. Yartel,<sup>4</sup> and Elizabeth DiNenno<sup>5</sup>

<sup>1</sup>Division of Viral Hepatitis, Centers for Disease Control and Prevention, Atlanta, Georgia; <sup>2</sup>Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee; <sup>3</sup>Public Health Seattle and King County, Seattle, Washington; <sup>4</sup>Centers for Disease Control and Prevention Foundation, Atlanta, Georgia; and <sup>5</sup>Division of HIV/AIDS Prevention, Centers for Disease Control and Prevention, Atlanta, Georgia

(See the editorial commentary by Kim and Page on pages 1929–31.)

**Background.** Persons who inject drugs (PWID) are at high risk for acquiring hepatitis C virus (HCV) infection. The Centers for Disease Control and Prevention estimates there are 17 000 new infections per year, mainly among PWID. This study examines injection equipment serosorting—considering HCV serostatus when deciding whether and with whom to share injection equipment.

**Objective.** To examine whether injection equipment serosorting is occurring among PWID in selected cities.

**Methods.** Using data from the National HIV Behavioral Surveillance System-Injection Drug Users (NHBS-IDU2, 2009), we developed multivariate logistic regression models to examine the extent to which participants' self-reported HCV status is associated with their injection equipment serosorting behavior and knowledge of last injecting partner's HCV status.

**Results.** Participants who knew their HCV status were more likely to know the HCV status of their last injecting partner, compared to those who did not know their status (HCV+: adjusted odds ratio [aOR] 4.1, 95% confidence interval [CI], 3.4–4.9; HCV–: aOR 2.5, 95% CI, 2.0–3.0). Participants who reported being HCV+, relative to those of unknown HCV status, were 5 times more likely to share injection equipment with a partner of HCV-positive status (aOR 4.8, 95% CI, 3.9–6.0).

**Conclusions.** Our analysis suggests PWID are more likely to share injection equipment with persons of concordant HCV status.

**Keywords.** hepatitis C virus; serosorting; injection drug use; sharing injection equipment.

The Centers for Disease Control and Prevention (CDC) estimates that 4.1 million Americans have been infected with the hepatitis C virus (HCV) with 75%–80% of those chronically infected [1]. While CDC recommends routine antibody testing for persons at risk of HCV exposure [2], recent studies estimate 40%–85% of HCV-infected

persons are unaware of their infection status [3–5]. This lack of awareness has important consequences for disease prevention because knowledge of HCV status is often a prerequisite to making health-promoting behavioral changes and treatment decisions.

HCV prevalence has reached epidemic proportions in the United States and is endemic among persons who inject drugs (PWID). HCV is primarily by percutaneous exposure to contaminated blood, making injection drug use (IDU) the leading cause of incidence in the United States. HCV prevalence among PWID resides between 30% and 70%, depending on frequency and duration of use, and incidence ranges from 16%–42% per year [6–8].

Received 23 April 2013; accepted 13 June 2013; electronically published 16 October 2013.

Correspondence: Bryce D. Smith, PhD, 1600 Clifton Rd, MS G-37, Atlanta, GA 30333 (bsmith6@cdc.gov).

The Journal of Infectious Diseases 2013;208:1934–42

Published by Oxford University Press on behalf of the Infectious Diseases Society of America 2013. This work is written by (a) US Government employee(s) and is in the public domain in the US.

DOI: 10.1093/infdis/jit520

With such high prevalence of infection, recent attention has focused on factors that influence a person's decision to share or not to share injection equipment (IE). One such factor is *serostatus*, particularly the question as to whether knowing one's HCV status, and that of a prospective partner, affects a person's decision to share IE. We suggest the complex relationship between a person's serostatus and their decision to share IE can be illuminated, in part, through the concept of *serosorting*.

Serosorting occurs when viral serostatus serves as a determining factor in a person's choice of sex or drug-injecting partners and in the selection of behaviors stemming from that choice. The term has traditionally been used to describe men who have sex with men (MSM), who deliberately select sex partners based on their own and their prospective partner's human immunodeficiency virus (HIV) serostatus [9]. Here, serostatus is characterized as a type of measure whereby people choose a sexual partner based on their own and their partner's HIV status and then base the extent of their sexual activity on that knowledge for the specific purpose of reducing the risk of acquiring or transmitting HIV.

While serosorting has been used most notably to describe the sexual choices of MSM, researchers have recently found similar trends among PWID [10–12]: one study in Seattle reported PWID were more likely to share injection equipment with the last injecting partner of concordant status [10]; an investigation in San Francisco found those who perceived their injecting partner to be HCV-positive were less likely to engage in receptive needle sharing [11]; and in Baltimore, HIV-positive participants reported being less likely to serosort than HIV-negative participants [12]. Bearing in mind these city-specific trends, this study expands their scope by examining injection equipment serosorting among PWID on a national scale. Specifically, we examine the relationships between participant's self-reported HCV status and (a) injection equipment sharing behavior, (b) knowledge of last injecting partner's HCV status (known/unknown), and (c) last injecting partner's HCV status (positive/negative).

## METHODS

### National HIV Behavioral Surveillance System (NHBS)

NHBS is a community-based survey that conducts interviews in triennial cycles among MSM, heterosexuals at increased risk for HIV infection, and PWID. Its purpose is to track the prevalence of and trends in HIV-related risk behaviors, including sex and injection drug use, and to record levels of HIV testing and the use of HIV prevention services among persons at high risk for HIV transmission such as PWID [13]. The second IDU cycle (NHBS-IDU2) was conducted between September and December 2009 and employed respondent-driven sampling (RDS) [14] to target individuals from social networks that can serve as seeds to recruit their peers into the study. Participating

sites included in this analysis were located in Atlanta, Baltimore, Boston, Chicago, Dallas, Denver, Detroit, Houston, Los Angeles, Miami, Nassau, Newark, New Orleans, New York, Philadelphia, San Diego, San Francisco, San Juan, Seattle, and Washington, DC. Across the 20 sites, 10 352 respondents were eligible for NHBS-IDU2 and participated in the study. The current study was restricted to 9690 participants with valid responses to questions concerning their HCV status and the HCV status of their last injection equipment sharing partner within the previous 12 months.

### Outcome Measures

The outcomes of interest were (a) injection equipment sharing behavior, (b) knowledge of last injecting partner's HCV status (known/unknown), and (c) last injecting partner's HCV status (positive/negative). The HCV status of respondent and respondent's last injecting partner were both self-reported by the respondent. The HCV status of respondent's last injection partner was derived from the following questions: "The last time you injected with this person (last sharing partner in past 12 months), did you know if they had been tested for hepatitis C?" and if yes, "What was the result of their hepatitis C test?" Respondents were also asked a series of questions with respect to their injection equipment sharing behaviors over the previous 12 months. Equipment sharing was defined to include the reuse of syringes, filters, cookers, water, and the practice of dividing drugs with a syringe (eg, backloading or frontloading). We categorized equipment sharing behavior in 2 different ways. For exploratory bivariate analysis, we dichotomized this variable as *shared* vs *did not share*. We also categorized the same outcome as a 4-level multinomial response variable for subsequent advanced analysis: *shared with HCV-negative partner*, *shared with HCV-positive partner*, *shared with partner of unknown HCV status*, or *shared no injection equipment*.

### Independent Variables

The primary independent variable was respondent's HCV status. Based on a review of the literature regarding HCV and injection equipment sharing, we also included the following variables as confounders and/or independent predictors: respondent's gender, race/ethnicity, birth year (as proxy for age), education, homelessness, employment status, annual income, age at first injection, and duration of injection.

### Data Analysis

We calculated unweighted proportions to describe the characteristics of the study population. Pearson  $\chi^2$  tests were used to explore bivariate associations between all independent variables and outcome variables. Consistent with the stated objectives of this study, we developed 3 separate multivariate logistic regression models to evaluate the associations between the respondent's HCV status and the 3 outcome measures, adjusting for

all plausible confounders. First, we modeled equipment sharing (4-level response category) as the dependent variable in a multinomial logistic regression; participants who shared equipment with their last injecting partner of negative, positive, or unknown HCV status were compared to those who did not share. This model was based on the full analytic population ( $n = 9690$ ). In the second model, we restricted our analysis to respondents who reported sharing equipment ( $n = 4542$ ) and modeled respondent's knowledge of last injecting partner's HCV status (known/unknown) as the dependent variable. In the third model, we further restricted the analysis to respondents who reported awareness of their last injecting partner's HCV status ( $n = 1712$ ), and modeled last injection partner's HCV status (positive/negative) as the dependent variable. In all 3 models, respondent's HCV status was the primary explanatory variable. Data were analyzed using SPSS v.18 (IBM, Chicago, IL). We did not account for potential variance inflation induced by the RDS design, due to the limitation of the statistical software used; RDS is a relatively new methodology and is not currently incorporated into multivariate procedures available in standard statistical software.

## RESULTS

Of the NHBS-IDU2 participants, 9690 respondents self-reported both their HCV status and the HCV status of their last injecting partner. Of all participants, 7270 (75.0%) reported knowing their HCV status and 4128 (56.8%) of those reported HCV positivity. Nearly 47 percent of all participants ( $n = 4542$ ) reported sharing equipment with their last injecting partner in the previous 12 months, and of those 37.7% ( $n = 1712$ ) said they were aware of the HCV status of their last sharing partner. The demographic characteristics of participants are shown in Table 1. Approximately 71.8% were male, 21.6% Hispanic, 46.8% non-Hispanic black, and 27.1% non-Hispanic white. Respondents were born between 1930 and 1991, with a mean of 1963 (ie, approximately 46 years of age). About 13.3% of respondents were employed, 57.3% were unemployed, and 24.1% were disabled for work. More than 61% of respondents reported ever being homeless, and 32.1% reported injecting before the age of 18 years.

### Association Between Participant's HCV Status and Sharing Equipment With Last Injection Partner

In bivariate analysis, all independent variables, with the exception of injection duration, were significantly associated with participant's equipment sharing behavior (Table 1). Following multivariate adjustment in a multinomial logistic regression, HCV-negative participants, compared to those of unknown HCV status, were more likely to share equipment with an HCV-negative injecting partner vs not sharing (adjusted odds ratio [aOR] 2.0, 95% confidence interval [CI], 1.6–2.6) (Table 2). Similarly, the odds of sharing with an HCV-positive

partner, vs not sharing, is increased nearly 5-fold (aOR 4.8, 95% CI, 3.9–6.0) for HCV-positive participants relative to those of unknown HCV status. In contrast, respondents with known HCV status, compared to those of unknown HCV status, were less likely to share with a partner of unknown HCV status vs not sharing (HCV-positive: aOR .8, 95% CI, .7–.9; HCV-negative: aOR .6, 95% CI, .5–.7). Other variables found to be significantly related to injection equipment sharing behavior after multivariate adjustment were gender, race/ethnicity, birth year, education, history of homelessness, employment, and age at first injection (Table 2).

### Association Between Participant's HCV Status and Knowledge of Sharing Partner's HCV Status

The results of multivariate logistic regression analysis examining the relationship between participant's self-reported HCV status and knowledge of last injecting partner's HCV status are presented in Table 3. Among respondents who shared injection equipment, those who knew their HCV status were more likely to know their last injecting partner's HCV status compared to those with unknown HCV status: HCV-negative participants (aOR 2.5, 95% CI, 2.0–3.0) were more than 2 times and HCV-positive participants (aOR 4.1, 95% CI, 3.4–4.9) were more than 4 times more likely to have knowledge of their last partner's HCV status compared to respondents who reported an unknown HCV status. Female gender, non-Hispanic white race/ethnicity, educational attainment of high school or more, disabled status, and higher annual income were also positively associated with knowledge of last partner's HCV status. Non-Hispanic black race/ethnicity and history of homelessness were associated with lack of knowledge of last partner's HCV status.

### Association Between Participant's HCV Status and Sharing Partner's HCV Status

Table 4 shows the results of a multivariate logistic regression model examining the association between participant's self-reported HCV status and last injecting partner's HCV status. Among the respondents who shared injection equipment and reported knowing their last injecting partner's HCV status, HCV-positive persons (aOR 4.6, 95% CI, 3.2–6.4) were nearly 5 times more likely to report their last injecting partner's HCV status as positive relative to persons with an unknown HCV status. By comparison, HCV-negative persons (aOR .4, 95% CI, .3–.6) were 60% less likely to report their last injecting partner's HCV status as positive relative to persons with an unknown HCV status. Non-Hispanic black participants were less likely to report their injecting partner's HCV status as positive compared to Hispanics. Participants with a history of homelessness and those born from 1930 to 1954, respectively, were more likely to report their injecting partner as HCV positive relative to persons who had never been homeless and those born between 1975 and 1991.

**Table 1. Demographic Characteristics of Study Participants, NHBS Injection Drug Users Second Cycle, 2009**

| Participant Characteristic               | All Participants<br>(N = 9690 <sup>a</sup> ) |      | Shared Equipment<br>With Last Injection<br>Partner (N = 4542) |      | Did Not Share<br>Equipment With Last<br>Injection Partner<br>(N = 5148) |      | P Value <sup>b</sup> |
|--|--|------|---|------|---|------|----------------------|
|  | no.  | %    | no.   | %    | no.   | %    |                      |
| <b>Gender</b>                            |  |      |   |      |   |      |                      |
| Female                                   | 2678   | 27.6 | 1328  | 29.2 | 1345  | 26.1 | <.001                |
| Transgender                              | 55   | .6   | 27  | .6   | 28  | .5   | .624                 |
| Male                                     | 6961   | 71.8 | 3187  | 70.2 | 3774  | 73.3 | Ref                  |
| <b>Race/ethnicity</b>                    |  |      |   |      |   |      |                      |
| Non-Hispanic Black                       | 4528   | 46.8 | 2011  | 44.3 | 2517  | 48.9 | <.001                |
| Non-Hispanic White                       | 2623   | 27.1 | 1279  | 28.2 | 1344  | 26.1 | .283                 |
| Other <sup>c</sup>                       | 434  | 4.5  | 193   | 4.3  | 241   | 4.7  | <.05                 |
| Hispanic                                 | 2090   | 21.6 | 1052  | 23.2 | 1038  | 20.2 | Ref                  |
| <b>Birth Year</b>                        |  |      |   |      |   |      |                      |
| 1965–1974                                | 2195   | 22.7 | 1104  | 24.3 | 1091  | 21.2 | .176                 |
| 1955–1964                                | 3621   | 37.4 | 1656  | 36.5 | 1965  | 38.2 | <.001                |
| 1945–1954                                | 2001   | 20.7 | 827   | 18.2 | 1174  | 22.8 | <.001                |
| 1930–1944                                | 127  | 1.3  | 39  | .9   | 88  | 1.7  | <.001                |
| 1975–1991                                | 1746   | 18.0 | 916   | 20.2 | 830   | 16.1 | Ref                  |
| <b>Educational attainment</b>            |  |      |   |      |   |      |                      |
| High school graduate                     | 6361   | 65.7 | 2873  | 63.3 | 3488  | 67.8 | <.001                |
| Less than high school                    | 3327   | 34.3 | 1668  | 36.7 | 1659  | 32.2 | Ref                  |
| <b>Ever homeless</b>                     |  |      |   |      |   |      |                      |
| Yes                                      | 5929   | 61.2 | 3116  | 68.6 | 2813  | 54.6 | <.001                |
| No                                       | 3759   | 38.8 | 1424  | 31.4 | 2335  | 45.4 | Ref                  |
| <b>Employment status</b>                 |  |      |   |      |   |      |                      |
| Unemployed                               | 5550   | 57.3 | 2750  | 60.5 | 2800  | 54.4 | <.001                |
| Disabled for work                        | 2339   | 24.1 | 1049  | 23.1 | 1290  | 25.1 | .086                 |
| Other                                    | 511  | 5.3  | 202   | 4.4  | 309   | 6.0  | .359                 |
| Employed                                 | 1289   | 13.3 | 540   | 11.9 | 749   | 14.5 | Ref                  |
| <b>Annual income<sup>d</sup></b>         |  |      |   |      |   |      |                      |
| \$0–\$14 999                             | 7462   | 77.4 | 3552  | 78.2 | 3910  | 76.0 | Ref                  |
| \$15 000 or more                         | 2177   | 22.6 | 966   | 21.3 | 1211  | 23.5 | <.01                 |
| <b>Age at first injection use, years</b> |  |      |   |      |   |      |                      |
| <18                                      | 3110   | 32.1 | 1518  | 33.4 | 1592  | 30.9 | Ref                  |
| 18–24                                    | 3580   | 37.0 | 1711  | 37.7 | 1869  | 36.3 | .406                 |
| ≥25                                      | 2991   | 30.9 | 1309  | 28.8 | 1682  | 32.7 | <.001                |
| <b>Injection duration</b>                |  |      |   |      |   |      |                      |
| 0–5 y                                    | 1071   | 11.1 | 505   | 11.1 | 566   | 11.0 | Ref                  |
| 6–15 y                                   | 2145   | 22.2 | 1053  | 23.2 | 1092  | 21.2 | .300                 |
| 16–25 y                                  | 2010   | 20.8 | 968   | 21.3 | 1042  | 20.2 | .594                 |
| >26 y                                    | 4455   | 46.0 | 2012  | 44.3 | 2443  | 47.5 | .240                 |
| <b>Self-reported HCV status</b>          |  |      |   |      |   |      |                      |
| Negative                                 | 3142   | 32.4 | 1262  | 27.8 | 1880  | 36.5 | <.001                |
| Positive                                 | 4128   | 42.6 | 2127  | 46.8 | 2001  | 38.9 | <.01                 |
| Unknown                                  | 2420   | 25.0 | 1153  | 25.4 | 1267  | 24.6 | ref                  |

Abbreviations: HCV, hepatitis C virus; NHBS, National HIV Behavioral Surveillance System.

<sup>a</sup> Not all information was available for every participant.

<sup>b</sup> P value for  $\chi^2$  test of categorical variables.

<sup>c</sup> All other race/ethnic groups including persons identifying with multiple races/ethnicities.

<sup>d</sup> 2010 poverty guideline (2-person family = \$14 570).

**Table 2. Adjusted Odds Ratios for the Association Between Participant's Self-reported HCV Status and Injection Equipment Sharing Behavior, NHBS Injection Drug Users Second Cycle (N = 9612<sup>a</sup>), 2009**

| Participant Characteristic           | Shared With<br>HCV(−) Partner vs<br>No Sharing | Shared With HCV(+)<br>Partner vs No Sharing | Shared With HCV<br>(Unknown) Partner vs<br>No Sharing |
|--------------------------------------|--|---|---|
|                                      | Adjusted <sup>b</sup> OR (95% CI)              | Adjusted <sup>b</sup> OR (95% CI)           | Adjusted <sup>b</sup> OR (95% CI)                     |
| <b>Self-reported HCV status</b>      |  |   |   |
| Negative                             | 2.0 (1.6, 2.6) <sup>c</sup>                    | .8 (.6, 1.1)                                | .6 (.5, .7) <sup>c</sup>                              |
| Positive                             | 1.1 (.9, 1.5)                                  | 4.8 (3.9, 6.0) <sup>c</sup>                 | .8 (.7, .9) <sup>c</sup>                              |
| Unknown                              | Ref  | Ref   | Ref   |
| <b>Gender</b>                        |  |   |   |
| Female                               | 1.7 (1.4, 2.0) <sup>c</sup>                    | 1.7 (1.5, 2.0) <sup>c</sup>                 | .9 (.8, 1.0)  |
| Male                                 | Ref  | Ref   | Ref   |
| <b>Race/ethnicity</b>                |  |   |   |
| Black                                | .8 (.7, 1.1)                                   | .6 (.5, .7) <sup>c</sup>                    | 1.2 (1.1, 1.4) <sup>d</sup>                           |
| White                                | 1.1 (.9, 1.4)                                  | 1.1 (.9, 1.4)                               | .8 (.7, .9)   |
| Hispanic                             | Ref  | Ref   | Ref   |
| <b>Birth year</b>                    |  |   |   |
| 1930–1944                            | .4 (.1, 1.0)                                   | .7 (.3, 1.5)                                | .4 (.2, .7) <sup>c</sup>                              |
| 1945–1954                            | .5 (.3, .8) <sup>d</sup>                       | .8 (.5, 1.2)                                | .6 (.5, .8) <sup>c</sup>                              |
| 1955–1964                            | .5 (.3, .7) <sup>c</sup>                       | .9 (.6, 1.2)                                | .8 (.6, 1.0) <sup>e</sup>                             |
| 1965–1974                            | .7 (.5, .9) <sup>e</sup>                       | 1.0 (.8, 1.3)                               | .9 (.8, 1.1)  |
| 1975–1991                            | Ref  | Ref   | Ref   |
| <b>Educational attainment</b>        |  |   |   |
| High school graduate                 | 1.2 (1.0, 1.4)                                 | 1.0 (.9, 1.2)                               | .8 (.7, .9) <sup>c</sup>                              |
| Less than high school                | Ref  | Ref   | Ref   |
| <b>Ever homeless</b>                 |  |   |   |
| Yes                                  | 1.2 (1.0, 1.5) <sup>e</sup>                    | 1.7 (1.5, 2.0) <sup>c</sup>                 | 1.9 (1.7, 2.1) <sup>c</sup>                           |
| No                                   | Ref  | Ref   | Ref   |
| <b>Employment status</b>             |  |   |   |
| Unemployed                           | 1.2 (.9, 1.6)                                  | 1.2 (.9, 1.5)                               | 1.1 (1.0, 1.3)  |
| Disabled                             | 1.4 (1.0, 1.9)                                 | 1.3 (1.0, 1.7)                              | .9 (.8, 1.1)  |
| Other                                | 1.6 (1.0, 2.4) <sup>e</sup>                    | .8 (.5, 1.2)                                | .9 (.7, 1.1)  |
| Employed                             | Ref  | Ref   | Ref   |
| <b>Age at first injection, years</b> |  |   |   |
| ≥25                                  | .9 (.6, 1.2)                                   | .7 (.5, .9) <sup>d</sup>                    | 1.0 (.9, 1.2)   |
| 18–24                                | .8 (.7, 1.1)                                   | .9 (.8, 1.1)                                | 1.0 (.8, 1.1)   |
| <18                                  | Ref  | Ref   | Ref   |

Abbreviations: CI, confidence interval; HCV, hepatitis C virus; NHBS, National HIV Behavioral Surveillance System; OR, odds ratio.

<sup>a</sup> Does not include n = 78 participants with missing data for at least one of the variables in the model.

<sup>b</sup> Model adjusted for all variables shown in table plus participant's income category and injection history duration.

<sup>c</sup> <.001.

<sup>d</sup> <.01.

<sup>e</sup> <.05.

## DISCUSSION

The strong association between the HCV status of survey respondents and the HCV status of their last injection partner is evidence indicating that PWID are injection equipment serosorting. Our analysis found that PWID are injection equipment serosorting given that study participants were more likely to share injection equipment (IE) with people of concordant

HCV status. This outcome corroborates earlier findings demonstrating a correlation between a person's awareness of his/her HCV status and choice of injecting partners [10].

Serosorting is well documented in the literature but largely in the context of HIV risk reduction. Researchers focusing on the sexual choices of MSM [15, 16] have found serosorting is associated with decreased risk of HIV infection [17] and changes in the sexual behavior of MSM when it is employed as an HIV

**Table 3. Adjusted Odds Ratios for the Association Between Participant's Self-reported HCV Status and Knowledge of Last Injection Partner's HCV Status, NHBS Injection Drug Users Second Cycle (N = 4506<sup>a</sup>), 2009**

| Participant Characteristic           | Adjusted <sup>b</sup> OR (95% CI) | P Value |
|--------------------------------------|-----------------------------------|---------|
| <b>Self-reported HCV status</b>      |                                   |         |
| Negative                             | 2.5 (2.0, 3.0)                    | <.001   |
| Positive                             | 4.1 (3.4, 4.9)                    | <.001   |
| Unknown                              | Ref                               |         |
| <b>Gender</b>                        |                                   |         |
| Female                               | 1.8 (1.6, 2.1)                    | <.001   |
| Male                                 | Ref                               | ...     |
| <b>Race/ethnicity</b>                |                                   |         |
| Black                                | .5 (.4, .6)                       | <.001   |
| White                                | 1.5 (1.2, 1.8)                    | <.001   |
| Hispanic                             | Ref                               | ...     |
| <b>Birth year</b>                    |                                   |         |
| 1930–1944                            | .9 (.7, 1.1)                      | .318    |
| 1945–1954                            | .9 (.6, 1.2)                      | .317    |
| 1955–1964                            | 1.0 (.7, 1.4)                     | .914    |
| 1965–1974                            | 1.2 (.5, 2.6)                     | .715    |
| 1975–1991                            | Ref                               | ...     |
| <b>Educational attainment</b>        |                                   |         |
| High school graduate                 | 1.3 (1.1, 1.5)                    | <.001   |
| Less than high school                | Ref                               | ...     |
| <b>Ever homeless</b>                 |                                   |         |
| Yes                                  | .8 (.7, .9)                       | <.01    |
| No                                   | Ref                               | ...     |
| <b>Employment status</b>             |                                   |         |
| Unemployed                           | 1.0 (.8, 1.3)                     | .727    |
| Disabled                             | 1.5 (1.1, 1.9)                    | <.01    |
| Other                                | 1.3 (.9, 1.8)                     | .225    |
| Employed                             | Ref                               | ...     |
| <b>Annual income</b>                 |                                   |         |
| \$15 000 or more                     | 1.2 (1.0, 1.4)                    | <.05    |
| \$0–\$14 999                         | Ref                               | ...     |
| <b>Age at first injection, years</b> |                                   |         |
| ≥25                                  | .8 (.6, 1.0)                      | .079    |
| 18–24                                | .9 (.7, 1.0)                      | .097    |
| <18                                  | Ref                               | ...     |

Abbreviations: CI, confidence interval; HCV, hepatitis C virus; NHBS, National HIV Behavioral Surveillance System; OR, odds ratio.

<sup>a</sup> Does not include n = 36 participants with missing data for at least one of the variables in the model.

<sup>b</sup> Model adjusted for all variables shown in table plus participant's injection history duration.

**Table 4. Adjusted Odds Ratios for the Association Between Participant's Self-reported HCV Status and Last Injection Partner's HCV Status, NHBS Injection Drug Users Second Cycle (N = 1698<sup>a</sup>), 2009**

| Participant Characteristic           | Adjusted <sup>b</sup> OR (95% CI) | P Value |
|--------------------------------------|-----------------------------------|---------|
| <b>Self-reported HCV status</b>      |                                   |         |
| Negative                             | .4 (.3, .6)                       | <.001   |
| Positive                             | 4.6 (3.2, 6.4)                    | <.001   |
| Unknown                              | Ref                               | ...     |
| <b>Gender</b>                        |                                   |         |
| Female                               | 1.1 (.8, 1.4)                     | .539    |
| Male                                 | Ref                               | ...     |
| <b>Race/ethnicity</b>                |                                   |         |
| Black                                | .6 (.4, .8)                       | <.01    |
| White                                | 1.0 (.7, 1.3)                     | .963    |
| Hispanic                             | Ref                               | ...     |
| <b>Birth year</b>                    |                                   |         |
| 1930–1944                            | 1.6 (1.0, 2.4)                    | <.05    |
| 1945–1954                            | 2.0 (1.2, 3.6)                    | <.05    |
| 1955–1964                            | 1.8 (.9, 3.4)                     | .088    |
| 1965–1974                            | 3.9 (.9, 17.3)                    | .073    |
| 1975–1991                            | Ref                               | ...     |
| <b>Educational attainment</b>        |                                   |         |
| High school graduate                 | .9 (.7, 1.1)                      | .318    |
| Less than high school                | Ref                               | ...     |
| <b>Ever homeless</b>                 |                                   |         |
| Yes                                  | 1.5 (1.1, 1.9)                    | <.01    |
| No                                   | Ref                               | ...     |
| <b>Employment status</b>             |                                   |         |
| Unemployed                           | .9 (.6, 1.4)                      | .704    |
| Disabled                             | .8 (.5, 1.3)                      | .396    |
| Other                                | .6 (.3, 1.0)                      | .065    |
| Employed                             | Ref                               | ...     |
| <b>Annual income</b>                 |                                   |         |
| \$15 000 or more                     | 1.1 (.8, 1.5)                     | .398    |
| \$0–\$14 999                         | Ref                               | ...     |
| <b>Age at first injection, years</b> |                                   |         |
| ≥25                                  | .7 (.4, 1.1)                      | .122    |
| 18–24                                | 1.0 (.8, 1.4)                     | .839    |
| <18                                  | Ref                               | ...     |

Abbreviations: CI, confidence interval; HCV, hepatitis C virus; NHBS, National HIV Behavioral Surveillance System; OR, odds ratio.

<sup>a</sup> Does not include n = 14 participants with missing data for at least one of the variables in the model.

<sup>b</sup> Model adjusted for all variables shown in table plus participant's injection history duration.

risk-reduction strategy [18]. Serosorting has also been documented among HIV-positive PWID [19]. They have been shown to be more likely to disclose their infection status to other infected persons and more likely to seek out concordant drug-using relationships [12] than HIV-negative persons. HIV-

positive PWID in serodiscordant sexual relationships were also found to be more likely to modify their injecting and sexual behavior than participants who were HIV-negative [20] and less likely to engage in less safe drug use and risky sexual behaviors [21]. These findings demonstrate that PWID have the capacity

to employ risk reduction behaviors meant to protect their health and that of their injection partners [22,23].

In this way, serosorting can be applied to drug injection behavior when the act of choosing an injecting partner is based in part on one's own infection status and that of the prospective injecting partner's for the specific purpose of reducing the risk of acquiring or transmitting bloodborne pathogens during an injection episode. Here, serosorting can be categorized as a risk-reduction strategy when the decision to share or not to share injection equipment is influenced by serostatus and enacted by people unable or unwilling to cease injecting drugs, but who nevertheless want to protect their and their injecting partner's health when injecting drugs together. Following this logic, both the act of selecting an injecting partner of concordant infection status and the act of avoiding sharing injection equipment with a person of discordant infection status would be categorized as injecting equipment serosorting [24].

The hepatitis C literature provides a modicum of evidence that knowledge of one's own or another's HCV status can influence how or with whom people inject. One study in Seattle reported PWID were more likely to share injection equipment with the last injecting partner of concordant status [10], while in San Francisco those who perceived their injecting partner to be HCV-positive were found to be less likely to engage in receptive needle sharing [11]; and in Baltimore, HIV-positive participants reported being less likely to injection equipment serosort than HIV-negative participants [12]. The evidence, however, is not entirely positive. Numerous studies show that knowledge of one's HCV status has nominal influence on reducing behaviors that put PWID at risk for acquiring or transmitting blood-borne disease [25–27]. A study of young PWID found no association between HCV-positive status and reductions in less safe injecting practices or choice of injecting partners [28], and another found injecting partners not discriminating based on serostatus and sharing injection equipment just as frequently with sexual partners of concordant and discordant status [29].

This variation notwithstanding, our analysis of the NHBS-IDU2 data establishes a strong association between a survey respondent's knowledge of their HCV status and the selection of an injecting partner. This correlation is deduced from 4 significant findings: (1) a person knowing their HCV status was more likely to know their last injection partner's HCV status; (2) a person knowing their HCV status was less likely to share injection equipment with a partner of unknown HCV status; (3) a person knowing their HCV-negative status was more likely to share injection equipment with a partner that was also HCV-negative; (4) a person knowing their HCV-positive status was more likely to share equipment with a partner reporting an HCV-positive status. These findings suggest that PWID may be serosorting by selectively sharing injecting equipment with persons of corresponding HCV status.

This article is not intended to promote injection equipment serosorting as a HCV risk-reduction strategy for PWID but to report that participants were more likely to share syringes with persons of concordant serostatus. One problem that can be expected if injection equipment serosorting is adopted by PWID is the potential effect of incomplete knowledge of infection status. If PWID know they are anti-HCV positive but mistakenly believe they are infected (when they have actually cleared the virus and are negative for HCV RNA), they could opt to serosort injection equipment with infected persons based on this misunderstanding, placing themselves at risk. This issue highlights the importance of conducting HCV RNA tests for all HCV antibody-positive persons and ensuring that they receive and understand their results.

A similar challenge that arises when PWID serosort by injection equipment is the injecting partner's knowledge of their own HCV status. This requires both accurate knowledge and understanding by the injection partner and full disclosure of their HCV status. Although there are proven effective HIV testing and counseling interventions [30], as well as effective interventions to improve disclosure skills for HIV-positive persons [31], there are no HCV-specific interventions to improve either of these factors. Much can be learned from these established interventions, but HCV test results and counseling messages and disclosure issues require more nuanced communication given the 2-step testing process to determine HCV-infection status and the knowledge needed to understand and disclose that information to injection partners.

This study has some limitations. Unlike several previous studies of serosorting [10], the national data collected through the NHBS-IDU2 study did not include information regarding participants' *intention* to serosort. It thus remains unknown if the high level of serosorting observed in this study was driven by an intention to do so. Further research needs to be conducted to explore whether intention to serosort is based on the HCV infection status of self and other, and what other factors may be contributing to this behavior. Additional limitations were related to the participant recruitment. The lack of adjustment for the design effect of RDS may have resulted in biased prevalence estimates and artificially smaller standard errors in bivariate analysis; however, there is no consensus on the statistical methods for conducting multivariate analysis [32–37]. Moreover, participants' and their partners' HCV status were self-reported and do not represent actual prevalence, and injecting equipment serosorting behavior is based on participants' perceived HCV status. Future research should thus include analyses of serosorting behavior based on actual vs perceived HCV status. Finally, given the unexplained differences in knowledge of serostatus by gender, race, educational attainment, and homelessness, additional research should be conducted to examine these issues fully.

## CONCLUSION

Our analysis of the NHBS-IDU2 data points to the possibility that PWID are serosorting based on knowledge of their and their injecting partners' HCV status. If accurate, the ability to increase PWID's awareness of their HCV status will have important consequences for public health and disease prevention, as it could be an influential element in a person's decision to make health-promoting behavioral changes and their choice of medical treatment. In sum, increasing the proportion of PWID who are aware of their HCV status may contribute to a general increase in the adoption of risk reduction strategies by persons who inject drugs.

## Notes

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

**Contributors.** B. S. and E. D. designed the study and wrote the protocol. B. S., A. J., and J. Z. managed the literature searches and summaries of previous related work. A. J., R. B., and A. Y. undertook the statistical analysis, and B. S., A. J., J. Z., and A. Y. drafted the manuscript. All authors contributed to and have approved the final manuscript.

**Financial support.** Funding for this study was provided by Divisions of Viral Hepatitis and HIV/AIDS Prevention at the Centers for Disease Control and Prevention.

**Potential conflicts of interest.** All authors: No reported conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

## References

1. Armstrong GL, Wasley A, Simard EP, McQuillan GM, Kuhnert WL, Alter MJ. The prevalence of hepatitis C virus infection in the United States, 1999 through 2002. *Ann Intern Med* **2006**; 144:705–14.
2. Centers for Disease Control and Prevention. Recommendations for prevention and control of hepatitis C virus (HCV) infection and HCV-related chronic disease. *MMWR Recomm Rep* **1998**; 47(RR-19):1–39.
3. Roblin D, Smith BD, Weinbaum CM, et al. Hepatitis C virus screening practices and prevalence in a managed care organization. *Am J Manag Care* **2011**; 17:548–55.
4. Southern WN, Drainoni ML, Smith BD, et al. Hepatitis C testing practices and prevalence in a high-risk urban ambulatory care setting. *J Viral Hepat* **2011**; 18:474–81.
5. Wasley A, Finelli L, Bell BP, Alter MJ. The knowledge and behavior of HCV-infected persons identified in a national seroprevalence survey, United States, 2001–2004. In: 12th International Symposium on Viral Hepatitis and Liver Disease. Paris, France, **2006**.
6. Centers for Disease Control and Prevention. Viral Hepatitis Surveillance, United States 2010. [http://www.cdc.gov/hepatitis/Statistics/2010 Surveillance/PDFs/2010HepSurveillanceRpt.pdf](http://www.cdc.gov/hepatitis/Statistics/2010%20Surveillance/PDFs/2010HepSurveillanceRpt.pdf). Accessed 17 October 2013.
7. Amon JJ, Garfein RS, Ahdieh-Grant L, et al. Prevalence of hepatitis C virus infection among injection drug users in the United States, 1994–2004. *Clin Infect Dis* **2008**; 46:1852–8.
8. Hagan H, Pouget ER, Des Jarlais DC, Lelutiu-Weinberger C. Meta-regression of hepatitis C virus infection in relation to time since onset of illicit drug injection: the influence of time and place. *Am J Epidemiol* **2008**; 168:1099–109.
9. Snowden JM, Raymond HF, McFarland W. Prevalence of seroadaptive behaviours of men who have sex with men, San Francisco, 2004. *Sex Transm Infect* **2009**; 85:469–76.
10. Burt RD, Thiede H, Hagan H. Serosorting for hepatitis C status in the sharing of injection equipment among Seattle area injection drug users. *Drug Alcohol Depend* **2009**; 105:215–20.
11. Hahn JA, Evans JL, Davidson PJ, Lum PJ, Page K. Hepatitis C virus risk behaviors within the partnerships of young injecting drug users. *Addiction* **2010**; 105:1254–64.
12. Yang C, Tobin K, Latkin C. Perceived serosorting of injection paraphernalia sharing networks among injection drug users in Baltimore, MD. *AIDS Behav* **2011**; 15:16–21.
13. Gallagher KM, Sullivan PS, Lansky A, Onorato IM. Behavioral surveillance among people at risk for HIV infection in the US: the National HIV Behavioral Surveillance System. *Public Health Rep* **2007**; 122 (Suppl 1):32–8.
14. Heckathorn DD. Respondent-driven sampling II: Deriving valid population estimates from chain-referral samples of hidden populations. *Soc Probl* **2002**; 49:11–34.
15. Eaton LA, Kalichman SC, Cain DN, et al. Serosorting sexual partners and risk for HIV among men who have sex with men. *Am J Prev Med* **2007**; 33:479–85.
16. Jin F, Prestage GP, Matthews G, et al. Prevalence, incidence and risk factors for hepatitis C in homosexual men: data from two cohorts of HIV-negative and HIV-positive men in Sydney, Australia. *Sex Transm Infect* **2010**; 86:25–8.
17. Philip SS, Yu X, Donnell D, Vittinghoff E, Buchbinder S. Serosorting is associated with a decreased risk of HIV seroconversion in the EXPLORE Study Cohort. *PloS One* **2010**; 5:1–7. pii: e12662.
18. Truong HM. Increases in serosorting may prevent further expansion of the HIV epidemic among MSM in San Francisco. In: 11th conference on Retroviruses and Opportunistic Infections. Vol. 2004 Feb 8–11; 11: (abstract no. 843). San Francisco, CA, **2004**.
19. Mizuno Y, Purcell DW, Metsch LR, Gomez CA, Knowlton AR, Latka MH. Is injection serosorting occurring among HIV-positive injection drug users? Comparison by injection partner's HIV status. *J Urban Health* **2011**; 88:1031–43.
20. Weinhardt LS, Carey MP, Johnson BT, Bickham NL. Effects of HIV counseling and testing on sexual risk behavior: a meta-analytic review of published research, 1985–1997. *Am J Public Health* **1999**; 89:1397–405.
21. Casadonte PP, Des Jarlais DC, Friedman SR, Rotrosen JP. Psychological and behavioral impact among intravenous drug users of learning HIV test results. *Int J Addict* **1990**; 25:409–26.
22. Bandura A. Social cognitive theory and exercise of control over HIV infection. In: Diclemente RJ, Peterson JL, eds. *Preventing AIDS: theories and methods of behavioural interventions*. New York: Plenum Press, **1994**:25–60.
23. Wodak A, Cooney A. Do needle syringe programs reduce HIV infection among injecting drug users: a comprehensive review of the international evidence. *Subst Use Misuse* **2006**; 41:777–813.
24. Cassels S, Menza TW, Goodreau SM, Golden MR. HIV serosorting as a harm reduction strategy: evidence from Seattle, Washington. *AIDS* **2009**; 23:2497–506.
25. Kwiatkowski CF, Fortuin Corsi K, Booth RE. The association between knowledge of hepatitis C virus status and risk behaviors in injection drug users. *Addiction* **2002**; 97:1289–94.
26. Ompad DC, Fuller CM, Vlahov D, Thomas D, Strathdee SA. Lack of behavior change after disclosure of hepatitis C virus infection among young injection drug users in Baltimore, Maryland. *Clin Infect Dis* **2002**; 35:783–8.
27. Miller M, Mella I, Moi H, Eskild A. HIV and hepatitis C virus risk in new and longer-term injecting drug users in Oslo, Norway. *J Acquir Immune Defic Syndr* **2003**; 33:373–9.
28. Hagan H, Campbell J, Thiede H, et al. Self-reported hepatitis C virus antibody status and risk behavior in young injectors. *Public Health Rep* **2006**; 121:710–9.
29. Bryant J, Brener L, Hull P, Treloar C. Needle sharing in regular sexual relationships: an examination of serodiscordance, drug using practices, and the gendered character of injecting. *Drug Alcohol Depend* **2010**; 107:182–7.

30. Metcalf CA, Douglas JM Jr., Malotte CK, et al. Relative efficacy of prevention counseling with rapid and standard HIV testing: a randomized, controlled trial (RESPECT-2). *Sex Transm Dis* **2005**; 32: 130–8.
31. Kalichman SC, Rompa D, Cage M. Group intervention to reduce HIV transmission risk behavior among persons living with HIV/AIDS. *Behav Modif* **2005**; 29:256–85.
32. Heckathorn DD. Extensions of respondent-driven sampling: analyzing continuous variables and controlling for differential recruitment. *Sociol Methodol* **2007**; 37:151–208.
33. Berry M, Wirtz AL, Janayeva A, et al. Risk factors for HIV and unprotected anal intercourse among men who have sex with men (MSM) in Almaty, Kazakhstan. *PloS One* **2012**; 7:e43071.
34. Johnston LG, Malekinejad M, Kendall C, Iuppa IM, Rutherford GW. Implementation challenges to using respondent-driven sampling methodology for HIV biological and behavioral surveillance: field experiences in international settings. *AIDS Behav* **2008**; 12:S131–41.
35. Schonlau M, Liebau E. Respondent-driven sampling. *Stata J* **2012**; 12: 72–93.
36. Abramovitz D, Volz EM, Strathdee SA, et al. Using respondent-driven sampling in a hidden population at risk of HIV infection: who do HIV-positive recruiters recruit? *Sex Transm Dis* **2009**; 36:750–6.
37. Hall MG, Barrington CL, Chen SY, et al. Respondent-driven sampling and time-location: a comparison of implementation and operational challenges for HIV behavioral research. In: Population Association of America 2013 Annual Meeting. New Orleans, LA, April 11–13, **2013**.