Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 84, No. 3
doi:10.1007/s11524-007-9178-2

Trends in Hepatitis B Virus, Hepatitis C Virus, and Human Immunodeficiency Virus Prevalence, Risk Behaviors, and Preventive Measures among Seattle Injection Drug Users Aged 18–30 Years, 1994–2004

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ABSTRACT *Injection drug users (IDUs) are at risk for infection with hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV). Information on time trends in prevalence of these viruses among IDUs and in behaviors influencing their transmission can help define the status of these epidemics and of public health efforts to control them. We conducted a secondary data analysis combining cross-sectional data from IDUs aged 18–30 years enrolled in four Seattle-area studies from 1994 to 2004. Participants in all four studies were tested for antibody to HIV (anti-HIV), hepatitis B core antigen (anti-HBc), and HCV (anti-HCV), and completed behavioral risk assessments. Logistic regression was used to investigate trends in prevalence over time after controlling for sociodemographic, drug use, and sexual behavior variables. Between 1994 and 2004, anti-HBc prevalence declined from 43 to 15% ($p < 0.001$), anti-HCV prevalence fell from 68 to 32% ($p < 0.001$) and anti-HIV prevalence remained constant at 2–3%. Declines in anti-HBc and anti-HCV prevalence were observed within the individual studies, although not all these declines were statistically significant. The declines in anti-HBc and anti-HCV prevalence remained significant after control for confounding. Although we did not observe coincident declines in injection equipment sharing practices, there were increases in self-reported needle-exchange use, condom use, and hepatitis B vaccination. We conclude that there has been a substantial and sustained reduction in prevalence rates for HBV and HCV infection among young Seattle IDUs, while HIV rates have remained low and stable.*

KEYWORDS *HIV, Hepatitis B, Hepatitis C, Injection drug users, Adolescents, Needle sharing, Needle exchange, Hepatitis B vaccination*

INTRODUCTION

Hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) are major causes of morbidity and mortality among injection drug users

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(IDUs). Persistent HBV and HCV infection can result in cirrhosis, liver failure, and hepatocellular carcinoma, and infection with HIV can result in serious opportunistic disease. In addition, these viruses can be transmitted from IDUs to other persons through sexual activity, perinatal exposure, or, for HBV, household contact,[1–3] extending the impact of infection among IDUs beyond drug-injecting populations.

Between 3,000 and 5,000 persons die annually from HBV-related disease in the United States.[4] The estimated number of new infections declined from 78,000 in 2001 to 51,000 in 2005.[4] In four sentinel counties reporting to CDC, 18% of acute HBV cases between 1982 and 1998 with risk factor data available were in persons reporting recent injection drug use.[5] In 2004, among acute cases reported nationally to CDC with risk factor data, 16% reported recent use of injection drugs,[6] which is approximately the same percentage as in the four sentinel counties.[7] In populations of IDUs, prevalence of HBV infection has ranged from 22 to 68%[8–11] and incidence rates of 10 and 31% per year have been reported.[8,10]

Hepatitis C virus causes an estimated 8,000 to 10,000 deaths per year.[4] The estimated number of new infections was 20,000 in 2005.[4] In 2003, 40% of persons with acute HCV in the four sentinel counties reported recent injection drug use,[7] as did 42% of acute HCV cases reported nationally to CDC in 2004 with risk factor data available.[6] Data from the late 1980s and early 1990s found HCV prevalence among persons who had been injecting 1 year or less of 65%[9] and 54%,[12] as well as 76% among those injecting less than 2 years.[13] More recent reports have found HCV prevalence from 27 to 39% among IDUs less than 30 years of age.[14–16] Incidence rates remain high, from 9 to 34% per year.[8,14–18]

Human immunodeficiency virus caused about 17,000 deaths in 2005.[1] In that year, among persons newly diagnosed with HIV infection or AIDS in the 38 areas with confidential name-based reporting, 13% reported injection drug use, 3% reported both injection drug use and male-to-male sex, and 3% reported heterosexual contact with an IDU, so 19% of HIV/AIDS cases were associated with injection drug use.[1] Estimates of the prevalence of HIV infection among US IDUs vary widely, from 2.36% in Albuquerque to 27.43% in Newark; in Seattle, the estimate was 2.97%.[19]

We combined data from four studies conducted by Public Health, Seattle and King County from June 1994 through January 2004 to ascertain 10-year trends in prevalence of HBV, HCV, and HIV infections among Seattle IDUs. Because two studies included only younger IDUs, analysis was restricted to IDUs aged 18–30 years, thus focusing on a population with relatively recent transmission. We also present trends in risk behaviors and preventive measures that might account for changes in the prevalence of these viral infections.

METHODS

Study Designs, Sampling, and Enrollment

Each of the four studies of Seattle-area IDUs (RAVEN, RAVEN II, Kiwi, and CIDUS III/DUIT) either was cross-sectional or included a baseline cross-sectional component and included a risk behavior interview, blood collection, and serologic testing. Our analysis was restricted to participants aged 18–30 years who had injected drugs within the previous 6 months. Participation in all studies required the ability to communicate in English. Study procedures were reviewed and approved by the institutional review boards of the Centers for Disease Control and Prevention, the state of Washington or the University of Washington.

Participants in the Risk Activity Variables, Epidemiology, and Network Study (RAVEN) were recruited from June 1994 through May 1997 from five drug treatment centers (27% of participants), one drug detoxification center (17%), two social service agencies (35%), and from persons entering the King County correctional facility in Seattle on drug-related charges (14%).[10] In each setting, a random-number sampling algorithm was used to select candidates for recruitment.

The Risk Activity Variables, Epidemiology, and Network Study II (RAVEN II) followed a recruitment scheme based on RAVEN methods and recruited participants through a social service center and needle-exchange program (68%), a methadone treatment center (16%), a detoxification center (11%), and the King County jail in Seattle (1%). Eligibility criteria required participants to be either aged 18–25 years, Hispanic or Native American, or a new or never user of needle exchange. Our analysis included only RAVEN II participants eligible on the basis of age who were recruited during the period March through December, 1998.

The Kiwi study recruited IDUs incarcerated in the two main King County jails, in Seattle and Kent, from September, 1998 through December, 2002.[20] Analysis for the present study was restricted to those recruited from the Seattle jail. Participants were recruited by screening all persons booked into jail during randomly selected time intervals (76%) or from inmates visiting the jail health clinics seeking HIV counseling and testing (24%). Only Kiwi participants recruited after November 1, 2000 were tested for antibodies to HCV (anti-HCV), and those recruited after January 1, 2001 were tested for antibody to HBV core antigen (anti-HBc).

The Third Collaborative Injection Drug Users Study/Drug Users Intervention Trial (CIDUS III/DUIT, or DUIT) was a multicenter behavioral intervention trial for young IDUs. Persons aged 15–30 years were recruited from May 2002 through January 2004; 57% of participants were recruited from community-based outreach, and 43% through a coupon-based peer referral system in which participants were paid to refer their injection drug using peers to the study.

Data Collection

Human immunodeficiency virus serologies were obtained throughout all studies (N=1,710). Because Kiwi participants were tested for anti-HBc and anti-HCV only during part of the study, serologic data on HBV and HCV infection were available for a total of 1,561 and 1,445 participants, respectively. Blood samples were tested for anti-HCV using a second-generation enzyme immunoassay (EIA; Abbott Laboratories, Chicago, IL, and ORTHO® HBc ELISA Test System, Ortho Clinical Diagnostics, Raritan, NJ, USA) with supplemental testing by a recombinant immunoblot assay (RIBA; Chiron Corp., Emeryville, CA, USA).[21] Hepatitis B virus infection was defined as testing positive for anti-HBc (Abbott Laboratories, Chicago, IL, USA). Tests for antibody to HIV (anti-HIV) used an EIA (either Abbott Laboratories, Abbott Park, IL, USA or Vironostika HIV 1 Micro ELISA system, Bio-Mureiux, Durham, NC, USA), with positive specimens confirmed by western blot (Novopath HIV-1 Immunopath, Biorad, Hercules, CA, USA).

Study questionnaires were administered during face-to-face interviews in RAVEN, RAVEN II, and Kiwi. Drug Users Intervention Trial participants were interviewed using audio computer-assisted self-interview (ACASI) methods. Only data from analogous questions common to all studies could be used for analysis; some responses required reclassification into a common scheme.

Reference periods for some questions varied by study. DUIT data on sharing of injection equipment referred to sharing in the past 3 months. In the other studies,

needle sharing referred to the past 30 days, whereas questions about sharing cookers or cottons and backloading referred to the past 6 months. The reference periods for recent male-to-male sex were 6 months for RAVEN, RAVEN II, and Kiwi participants recruited after September 1, 2001, 1 year for Kiwi participants recruited before September 1, 2001, and 3 months for DUIT participants. Reference periods for condom use were similar to those for male-to-male sex, except that RAVEN II data referred to the last sex partner and thus were excluded from analysis.

Statistical Analysis

Univariate comparisons of the study populations were evaluated by chi-square tests, except for age, age at first injection, and years since first injection, which were analyzed as continuous variables by ANOVA tests.

Logistic regression was used to adjust for potential confounding.[22] Logistic regression models were constructed for each virus using a dichotomous variable for seropositivity as the outcome variable. A collection of sociodemographic, drug use, and sexual behavior variables (Table 1) was identified as potential confounders. To determine appropriate variables to adjust for, these variables, categorized as listed in Table 1, were investigated in a series of logistic regression models until a subset was identified in which each variable was significantly ($p \leq 0.05$) associated with seropositivity and no other variable that was entered into the model was significant.

The significance of linear time trends in viral prevalence was evaluated on the basis of the p-value with which a continuous variable for date of interview entered a logistic regression model, based on a likelihood ratio test. Variables describing risk behaviors or preventive measures, such as needle sharing or condom use, were not included as they would yield models evaluating only that component of the time trends in viral prevalence independent of changes in the behavior. The reported p-values for trend are univariate unless otherwise noted and are based on logistic regression models containing only a continuous variable for interview date. Adjusted p-values ($p_{(\text{adjusted})}$) derive from the entry of the date of interview variable into a model containing terms for the full set of significant potential confounders for the virus being analyzed. Inclusion of variables entering the logistic regression models with p-values of 0.06–0.10 made no appreciable difference in the evaluation of time trends. To assess residual confounding, models incorporating an additional categorical term for study were analyzed. Time trends in risk behaviors and preventive measures were evaluated similarly, on the basis of the significance of the date of interview variable in univariate logistic regression models using a dichotomous representation of the relevant behavior as the dependent variable. Statistical analyses were performed using SPSS.[23]

RESULTS

Study Populations

Table 1 compares the demographic, social, drug use, and sexual behavior characteristics of the four study populations. Significant differences were found for all variables except education and, for males, a history of sex work. Substantial differences were noted in the gender distributions, with RAVEN and RAVEN II including more female participants. Participants in the two later studies, Kiwi and

TABLE 1 Population characteristics by study

	RAVEN (*N*=738) (%)	RAVEN II (*N*=81) (%)	Kiwi (*N*=351) (%)	DUIT (*N*=553) (%)	*p*-value
Age (years)					
18–20	10	37	16	21	<0.001
21–23	19	44	22	25	
24–26	30	19	25	27	
27–30	41	0	38	28	
Race/ethnicity					
White	78	84	70	71	0.001
Black	6	0	5	6	
Hispanic	6	7	11	7	
Native American	6	4	7	10	
Other/mixed	4	5	7	6	
Gender					
Male	57	49	74	71	<0.001
Female	44	51	26	30	
Education					
0–11 years	36	35	35	35	0.16
12 years	38	43	46	39	
>12 years	26	22	19	26	
Residence					
Own place	35	32	38	33	<0.001
Other's place	35	20	35	14	
Shelter, hotel, etc.	17	14	10	25	
Street	14	35	17	28	
Number of years injecting					
0–2	29	53	27	21	<0.001
3–5	22	27	26	27	
6–9	23	17	24	34	
10+	26	3	23	18	
Injection frequency					
Not injected last 30 days	16	3	28	12	<0.001
<Daily	22	21	19	45	
Daily	63	77	53	43	
Primary injection drug					
Heroin	68	88	48	61	<0.001
Speedballs	12	5	15	7	
Cocaine	11	1	9	3	
Amphetamines	11	6	28	27	
Other	1	0	1	2	
Any history of sex work					
Females ($N_{females}$=617)	32	20	52	20	<.001
Males (N_{males}=1,106)	12	0	13	11	0.13
Recent male-to-male sex (among 1,106 males)	18	5	11	13	0.03

DUIT, were more likely to report amphetamines as their most frequently injected drug, although heroin was the most commonly reported drug in all four studies.

Compared to the other studies, the RAVEN II population was younger, had been injecting for fewer years, and was more likely to report heroin as the most frequently injected drug. After excluding RAVEN II, the significant differences

TABLE 2 Time trends in prevalence of HBV, HCV, and HIV infection in Seattle injection drug users aged 18–30 years, 1994–2004

		HBV			HCV			HIV		
Year	N[a]	Anti-HBc positive (%)	Adjusted odds ratio[b]	95 % Confidence interval	Anti-HCV positive (%)	Adjusted odds ratio[c]	95% Confidence interval	Anti-HIV positive (%)	Adjusted odds ratio[d]	95% Confidence interval
1994	126	42	1.00		68	1.00		2.4	1.00	
1995	350	37	0.72	0.46–1.13	64	0.80	0.48–1.34	3.7	0.82	0.09–7.88
1996	191	26	0.49	0.29–0.82	49	0.45	0.26–0.79	3.7	1.04	0.10–10.47
1997	71	28	0.63	0.32–1.27	50	0.61	0.31–1.21	1.4	0.36	0.02–7.01
1998	107	14	0.32	0.15–0.71	33	0.35	0.17–0.70	0.9	0.58	0.29–11.79
1999	106	No data available			No data available			0	0.00	
2000	27	No data available			67	1.13	0.22–5.88	0	0.00	
2001	90	31	0.54	0.20–1.43	51	0.60	0.31–1.18	1.2	0.47	0.23–9.40
2002	361	24	0.40	0.25–0.66	39	0.31	0.19–0.53	3.1	0.94	0.10–9.35
2003	272	16	0.28	0.16–0.47	29	0.22	0.13–0.38	2.6	1.04	0.10–10.89
2004	22	15	0.23	0.06–0.88	32	0.30	0.10–0.89	4.5	0.72	0.03–15.85
Overall		27	(*N*=1,445)		47	(*N*=1,561)		2.6	(*N*=1,710)	
Significance of test for trend[e]			$p<0.001$			$p<0.001$			$p=0.79$	

[a]Refers to the number of participants with informative serologic results for at least one virus.
[b]HBV adjusted odds ratios derive from logistic regression models controlled for age, number of years injecting, injection frequency, and recent male-to-male sex.
[c]HCV adjusted odds ratios derive from logistic regression models controlled for age, education, number of years injecting, injection frequency, primary injection drug and a history of sex work in females.
[d]HIV adjusted odds ratios derive from logistic regression models controlled for age, recent male-to-male sex and a history of sex work in males.
[e]Based on entering a continuous variable for date of interview into the logistic regression model.

among the other three studies remained, although only modest absolute differences were observed in age and number of years injecting.

HBV

Hepatitis B virus prevalence declined from 42% in 1994 to 15% in 2004 (Figure 1 and Table 2) ($p < 0.001$). Declines in HBV prevalence were seen over time in the individual studies: in RAVEN (from 42 to 28%; $p = 0.001$), Kiwi (from 31 to 15%; $p = 0.40$), and DUIT (from 26 to 15%; $p = 0.03$).

In logistic regression analyses, anti-HBc seropositivity was significantly associated with older age ($p = 0.026$), number of years injecting ($p < 0.001$), injection frequency ($p = 0.001$), and recent male-to-male sex ($p=0.016$). After controlling for these variables, the odds ratio (OR) for anti-HBc seropositivity was 0.23 in 2004, compared to 1994, the reference year ($p_{(adjusted)}<0.001$) (Table 2). Inspection of the ORs and of Figure 1 suggests that the time trend during the middle years of the study period is not well approximated by a straight line. When a model

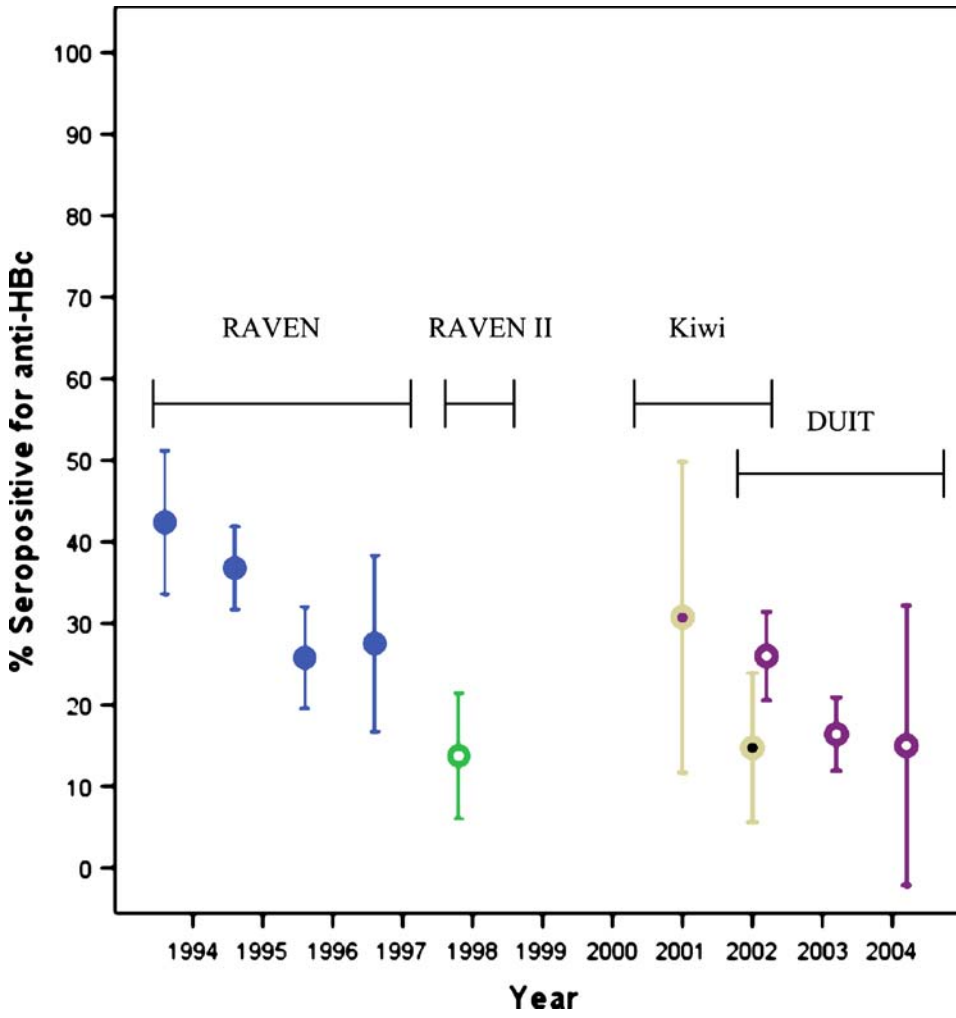

FIGURE 1. Prevalence of antibody to hepatitis B core antigen (anti-HBc) (with 95% confidence intervals) among Seattle injection drug users aged 18–30 years, by study: 1994–2004.

was analyzed which also included a term identifying which of the four studies each subject participated in, the declines over time remained statistically significant ($p_{(adjusted)}$=0.01); the study term was not significant ($p_{(adjusted)}$=0.13).

HCV

Figure 2 and Table 2 illustrate a decline in HCV prevalence by year, from 68% in 1994 to 32% in 2004 ($p<0.001$). The decline was statistically significant among RAVEN participants (68 to 50%; $p<0.001$), but not among participants in Kiwi (67 to 48%; $p=0.11$) or DUIT (36 to 32%; $p=0.16$).

Older age ($p<0.001$), lower educational attainment ($p<0.001$), number of years injecting ($p<0.001$), injection frequency ($p=0.004$), and a history of sex work in females ($p=0.013$) were associated with anti-HCV seropositivity. Primary injection drug (the drug most frequently injected) was also associated with anti-HCV seropositivity ($p<0.001$), with both cocaine (OR=0.56) and amphetamine

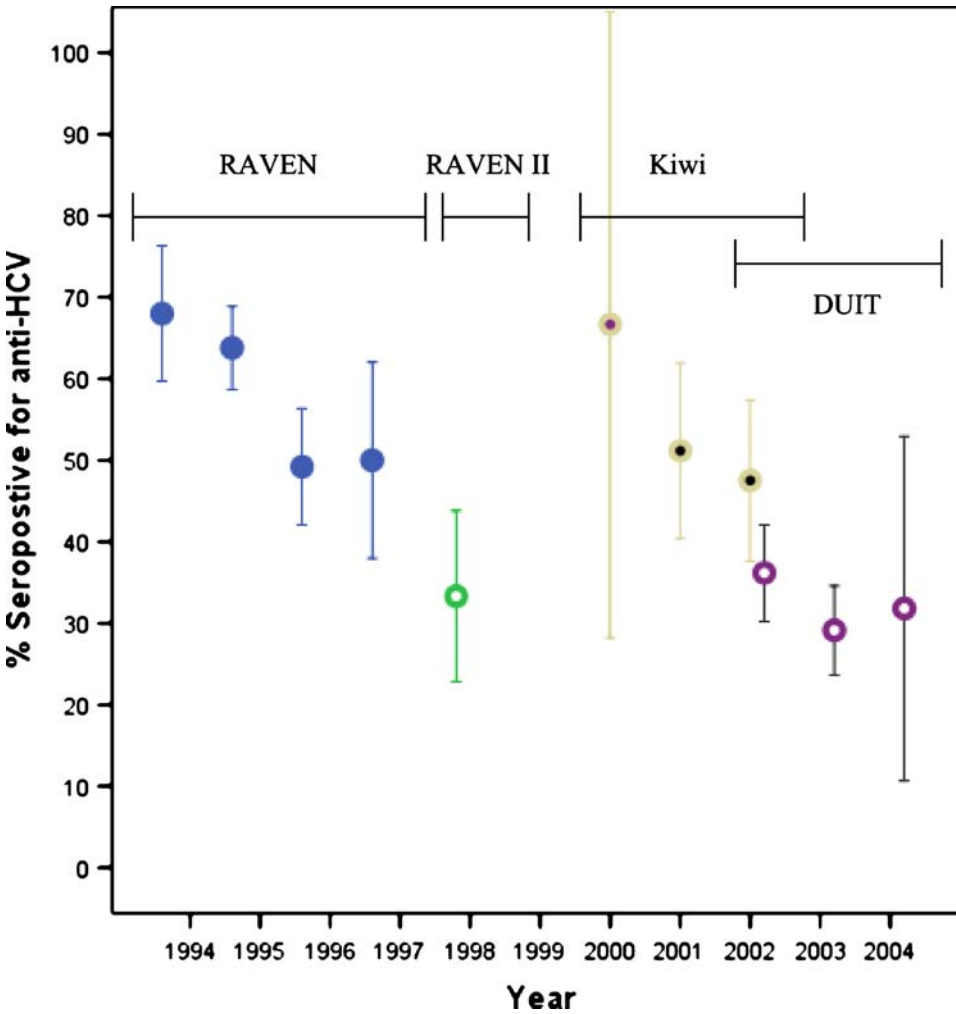

FIGURE 2. Prevalence of antibody to hepatitis C virus (anti-HCV) (with 95% confidence intervals) among Seattle injection drug users aged 18–30 years, by study: 1994–2004.

(OR=0.41) injectors significantly less likely to be seropositive than the baseline heroin users. After controlling for these variables, the OR for anti-HCV seropositivity was 0.30 in 2004 compared to 1994, the reference year ($p_{(adjusted)}$ <0.001)(Table 2). When a term for study was included in the model, the decline in seroprevalence remained statistically significant ($p_{(adjusted)}$=0.002); the study term was also significant ($p_{(adjusted)}$<0.001), suggesting the potential for residual confounding associated with the individual studies.

HIV

Anti-HIV prevalence across all studies was 2.6%. Men reporting recent male-to-male sex comprised 22 (49%) of the 45 anti-HIV seropositive participants but made up only 8% of the total study population. In contrast, only 9% of persons seropositive for anti-HBc reported recent male-to-male sex. Older age ($p = 0.006$), recent male-to-male sex ($p < 0.001$), and a history of sex work in males ($p = 0.001$) were significantly associated with anti-HIV seropositivity in the logistic regression

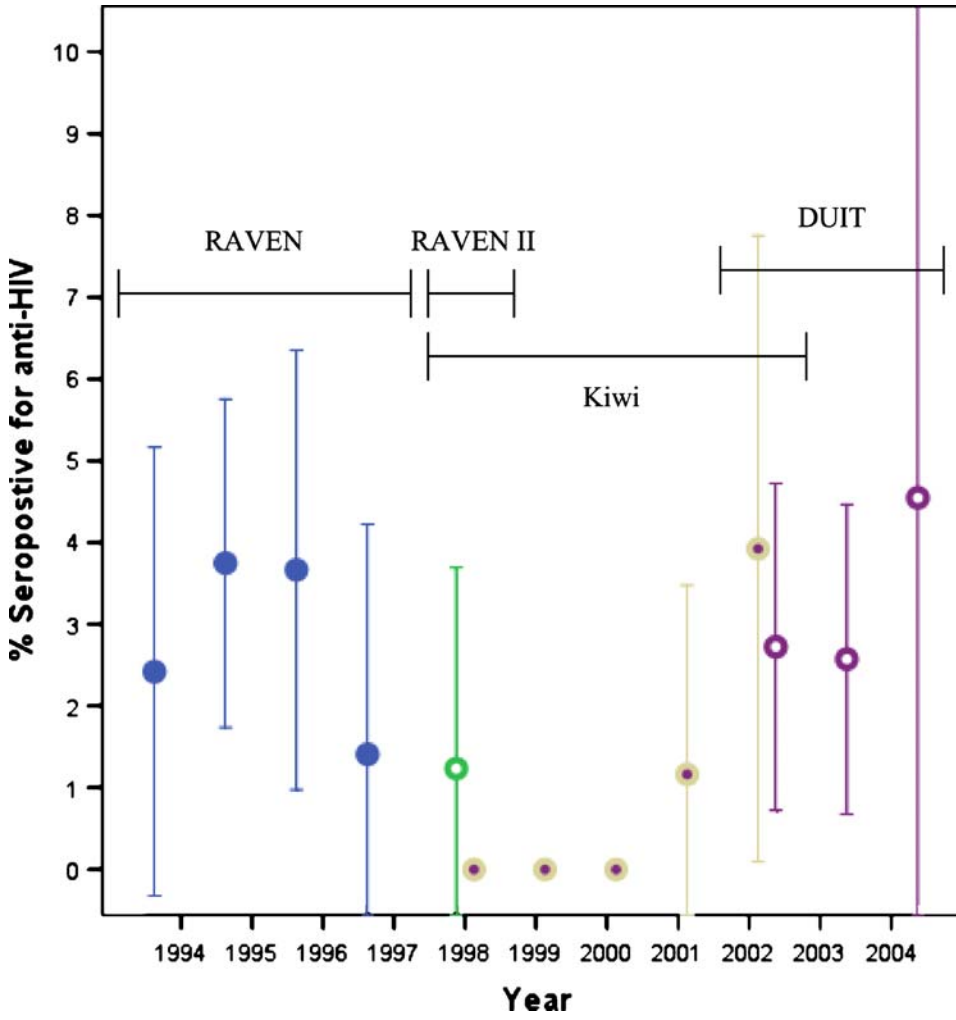

FIGURE 3. Prevalence of antibody to HIV (anti-HIV) (with 95% confidence intervals) among Seattle injection drug users aged 18–30 years, by study: 1994–2004.

models (Table 2). There was no evidence of a change in HIV prevalence over time ($p_{(adjusted)}$=0.79) (Figure 3).

TRENDS IN RISK BEHAVIORS

We found no evidence of a trend in the proportion of participants reporting any recent injection with a needle that had been previously used by someone else ($p = 0.75$) (Figure 4), despite an increase in the proportion reporting that needle exchange was their primary source of new needles, from 48% in 1994 to 68% in 2004 ($p < 0.001$) (Figure 5).

The data indicated an increase in sharing of cookers over the study period ($p < 0.001$) (Figure 6). More detailed analyses indicated an increase in cooker sharing between 1994 and 1998 ($p = 0.01$) and no evidence of a trend between 1999 and 2004 ($p = 0.33$). Similar patterns were observed for sharing cottons and

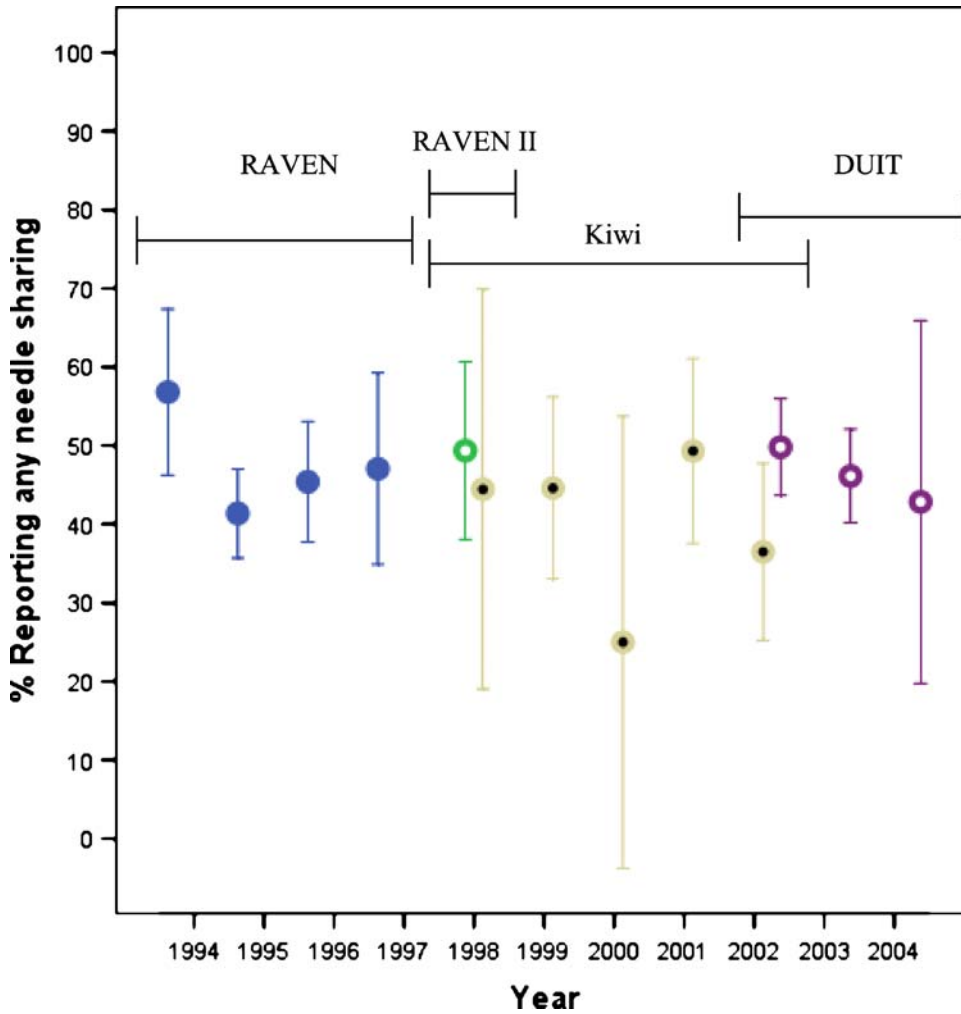

FIGURE 4. Any recent injection with a needle previously used by someone else (with 95% confidence intervals) among Seattle injection drug users aged 18–30 years, by study: 1994–2004.

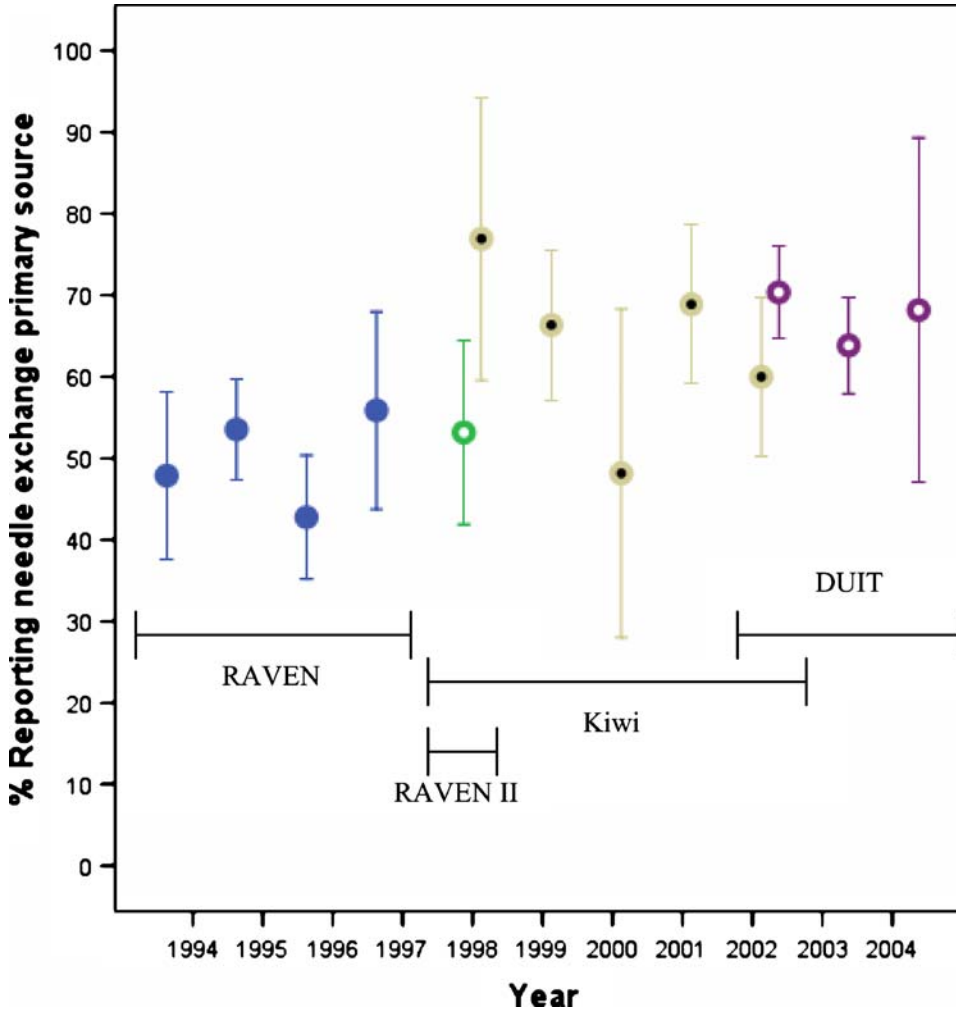

FIGURE 5. Needle exchange as the primary source of new needles (with 95% confidence Intervals) among Seattle injection drug users aged 18–30 years, by study: 1994–2004.

backloading, with a rise in the early years ($p = 0.004$ and < 0.001, respectively) and no trend later ($p = 0.62$ and 0.53, respectively).

TRENDS IN PREVENTIVE MEASURES

Hepatitis B Vaccination

The proportion of participants self-reporting any hepatitis B vaccination before study enrollment increased over the 10 years of data collection (Figure 7). Trends in vaccination rates were different in the different studies; an interaction term between study and date of interview was significant ($p_{(\text{interaction})} < 0.001$). RAVEN participants reported rates between 17 and 21% with no evidence of a time trend ($p = 0.49$). Among Kiwi participants, vaccination rates increased from zero (0/26 participants) in 1998 to 41% (42/102 participants) in 2002 ($p < 0.001$). DUIT

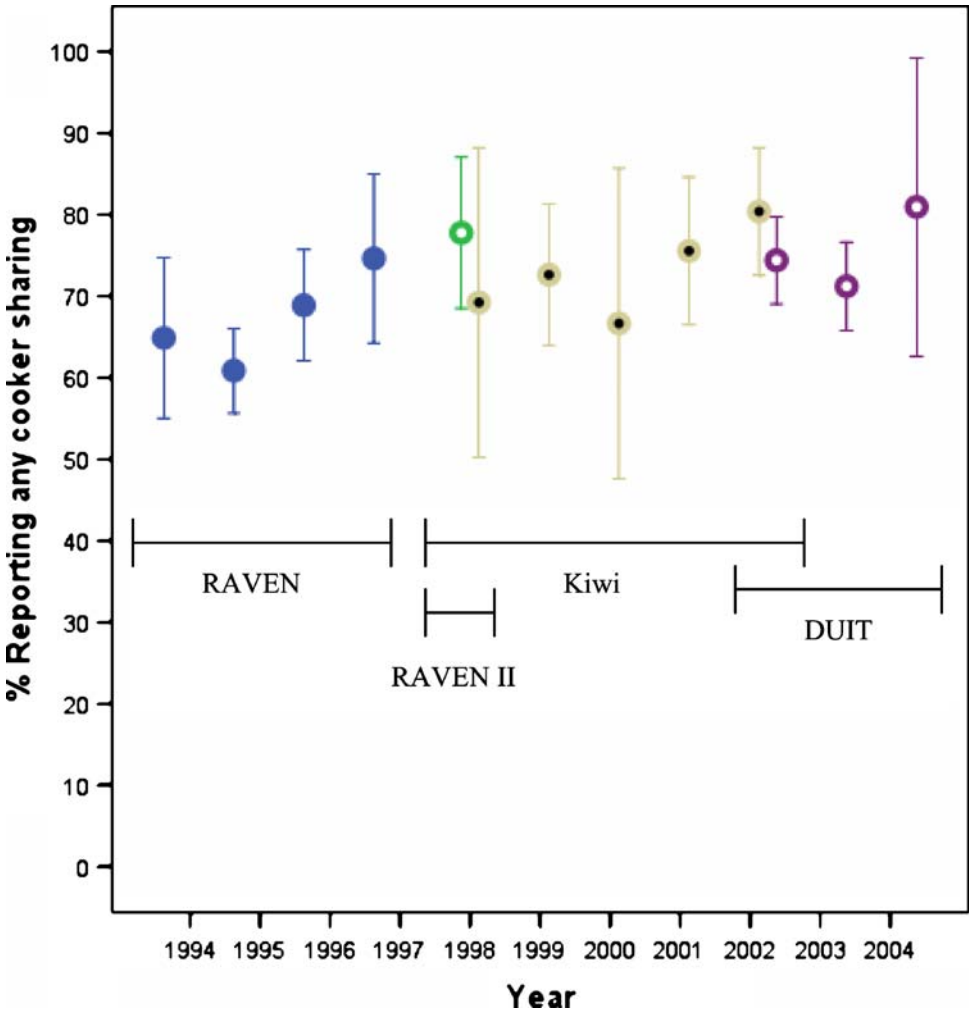

FIGURE 6. Any recent sharing of cookers (with 95% confidence Intervals) among Seattle injection drug users aged 18–30 years, by study: 1994–2004.

participants reported vaccination rates between 50 and 54%, with no evidence of a trend ($p = 0.46$).

Condom Use

Analysis was confined to the 1,300 sexually active participants. Trends in reporting of any use of condoms in recent vaginal or anal sex varied among the studies (Figure 8) ($p_{(\text{interaction})} < 0.001$). Among RAVEN participants, 54–63% reported condom use, with no evidence of a time trend ($p = 0.72$). The proportion of Kiwi participants reporting condom use increased from 10% in 1997 to 51% in 2002 ($p < 0.001$). In DUIT, the percentage varied from 49 to 54% with no evident trend ($p = 0.22$).

HIV and HCV Testing

Overall, 86% of participants reported they had been tested for HIV infection before interview. Among the Kiwi and DUIT participants queried, 73% reported a prior

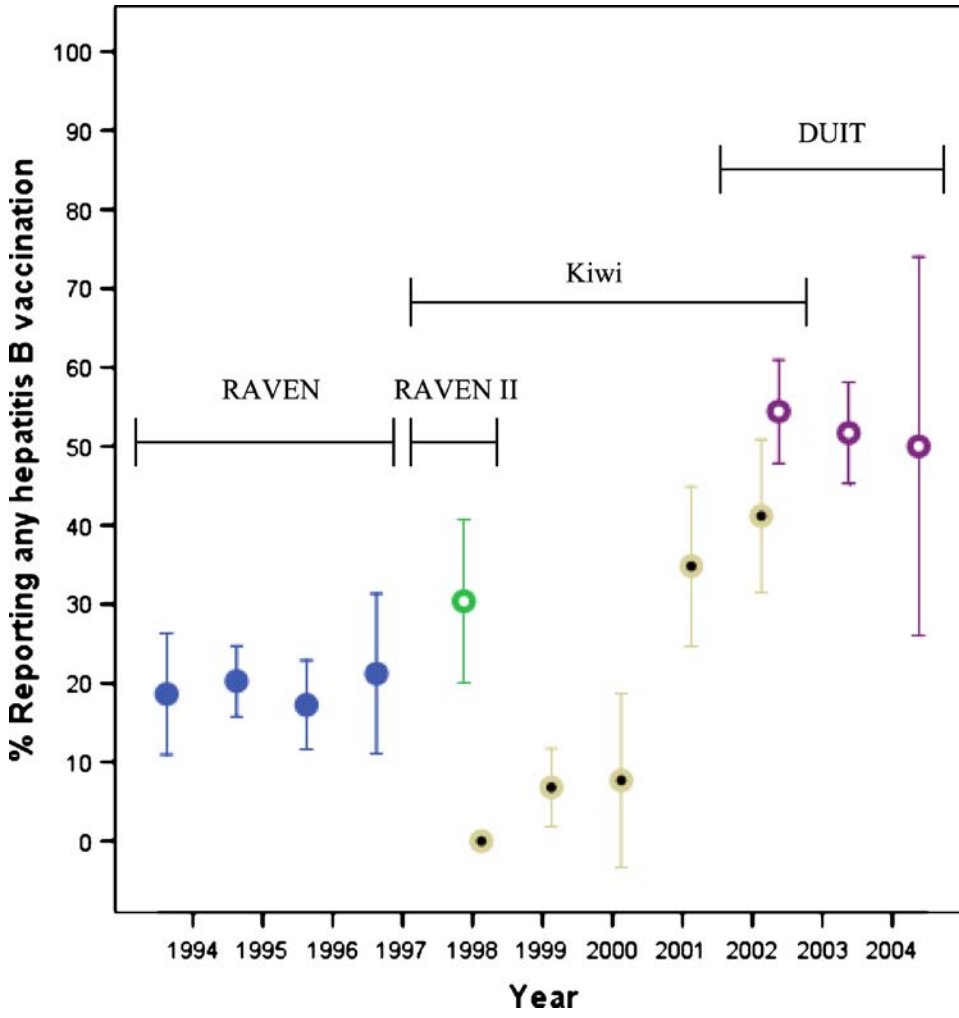

FIGURE 7. Any hepatitis B vaccination (with 95% confidence intervals) among Seattle injection drug users aged 18–30 years: 1994–2004.

test for HCV infection. When DUIT participants were asked if in the last 3 months they had chosen not to share needles based on knowledge that their drug-sharing partner was HCV infected, 29% responded that they had. In addition, 21% reported that they had not shared needles because they knew their partner was HIV-infected.

DISCUSSION

In our analysis, the prevalence of both HBV and HCV infection declined by about half among young IDUs in Seattle during 1994–2004, while HIV prevalence remained low. Two observations support our argument that these declines are not an artifact of differences among the component study populations. First, the declines were significant after controlling for potentially confounding variables, and they remained significant after control for residual confounding associated with the study in which subjects participated. Second, decreases in prevalence were observed

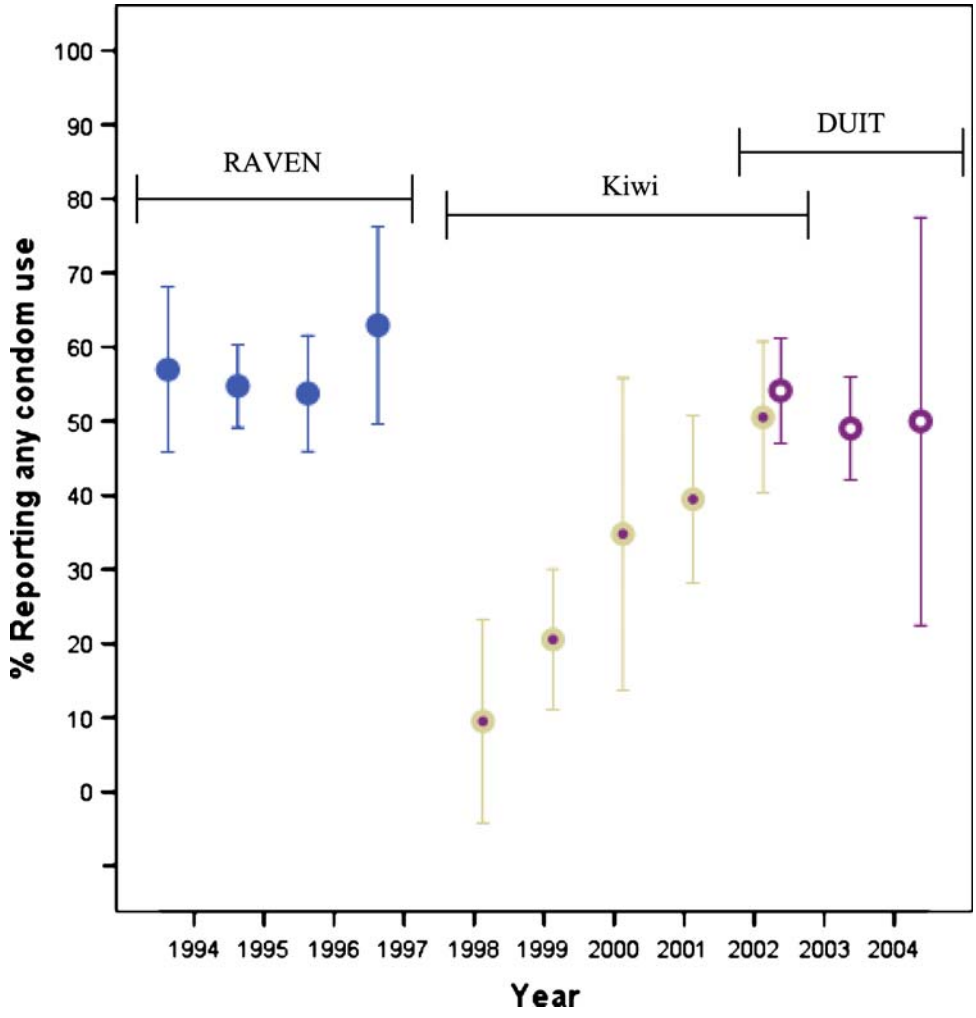

FIGURE 8. Any recent use of condoms during vaginal or anal sex (with 95% confidence Intervals) among Seattle injection drug users aged 18–30 years reporting anal or vaginal sex: 1994–2004.

over time within each of the studies, although not all of these declines were statistically significant.

Our results are consistent with a report documenting a decrease in HCV prevalence, from 91% in 1990–1991 to 62% in 2000–2001, among persons entering a drug detoxification program in New York City.[17] Decreases in HCV[24] and HBV[25] infection incidence during ongoing follow-up in IDU cohort studies have also been reported in Baltimore, possibly due to retention of lower-risk IDUs over time. International data have shown declines in HCV prevalence in Scotland[26] and Australia,[27,28] though prevalence patterns in these countries may differ from those in the United States. It will be of interest to determine to what extent the declines in HBV and HCV infection prevalence we observed have occurred among other IDU populations throughout the United States.

We observed no decrease in needle sharing, or sharing of cookers or cottons, or backloading, which are potentially significant components of blood-borne pathogen transmission,[15,16,29] even though increasing proportions of Seattle area participants

reported needle exchange as their primary source of new needles. According to internal Seattle King County Public Health reports, between 1994 and 2004, the annual volume of needles exchanged increased from 750,000 to almost 2 million and the number of needle-exchange sites increased from five to eight.

The different time periods for reporting of sharing of injection equipment among the four studies included in this analysis could have influenced the pattern of time trends. For instance, even if the proportion of IDUs sharing needles were constant, a higher proportion would be expected to report needle sharing over a longer reference period. Thus, the longer reference period of the DUIT study (3 months vs. 30 days in the other studies) could potentially yield spuriously higher rates of sharing and mask a decline, had it occurred. For indirect sharing of injection equipment, the shorter reference period of the DUIT study (3 months vs. 6 months in the other studies) could have had the opposite effect.

The ever/never sharing variables used in these studies may have been too crude to reflect subtle behavioral changes. However, ever/never variables have recorded significant reductions in sharing in the late 1980s to early 1990s in Baltimore[30] and New York.[31] It is interesting to note no change in ever sharing of syringes was found among IDUs in a New York drug treatment facility from 1990 to 2001,[32] while HCV and HIV prevalence declined markedly.[17] The latter finding raises the possibility that the declines we observed were the delayed result of behavioral changes occurring before the beginning of the study period.

Another possibility is that IDUs are decreasing their risk of infection by selective choice of injection equipment-sharing partners. The reported high levels of HIV testing, and, in recent years, of HCV testing, make it possible for IDUs to practice such serosorting. In the DUIT study, 20–30% of participants reported having made a decision not to share a needle based on knowledge of a partner's HCV or HIV positive status. A finding that HIV-infected IDUs in New York were less likely than HIV-negative persons to engage in distributive needle sharing suggests they may have practiced such serosorting.[32] Further studies should evaluate the extent to which IDUs are serosorting.

Hepatitis B vaccination rates increased in the Kiwi study population during the late 1990s, in contrast to low vaccination rates reported among IDUs elsewhere in the United States.[11,33–36] It would be of interest to know how vaccinated participants came to be vaccinated. Vaccination was offered at times by the needle exchange. Adolescent hepatitis B vaccination was available in teen clinics at Seattle high schools and through Group Health Cooperative, a large local HMO. However, we have no data on the extent to which participants were vaccinated through these programs.

None of the study participants were young enough to have been vaccinated as infants, first recommended in 1991.[37] After a recommendation for universal hepatitis B vaccination of adolescents in 1995,[38] it became a school requirement in Washington State in 1997 to vaccinate 11 and 12 year olds; only 24 DUIT participants were subject to this requirement. In 1999, the Advisory Committee on Immunization Practices recommended hepatitis B vaccination for all adolescents up to age 19 years,[39] which would have included 13% of study participants. However, this recommendation was not accompanied by any mandate or program. The prevalence of vaccination in our study population does not appear to be primarily a product of programs universally mandating vaccination.

We noted an increase in condom use among young Seattle IDUs enrolled in the Kiwi study between 1998 and 2002. The pattern of the time trend in condom use

resembles that for hepatitis B vaccination. This suggests that multiple preventive measures were being adopted concurrently among young Seattle IDUs. Nonetheless, as has been reported in other IDU populations,[40–43] absolute levels of condom use remained modest.

As with other studies of IDUs, the clandestine nature of injection drug use complicates efforts to ascertain the extent to which study participants reflect the universe of young Seattle IDUs. Systematic changes over time in the characteristics of recruits within each study could conceivably account for the observed trends within individual studies. However, if progressively different subpopulations were being sampled in the course of the individual studies, the pattern of HBV, HCV, and HIV seroprevalence in the different subpopulations sampled would need to reflect, in register, the overall trends we observed, which seems unlikely. Our measures of risk behavior and prior vaccination and testing are based on self-report and could be influenced by participants' desire to respond in a socially desirable way. Nonetheless, participants reported high levels of sharing of injection equipment. If socially desirable reporting was a substantial factor, DUIT participants, using the more private reporting methods of ACASI might be expected to report higher levels of risk behaviors than persons interviewed face-to-face,[44] which was not observed.

We can only conjecture the effects of the decline we observed on future prevalence rates as the cohort ages. Data from the full Kiwi study population, which is not restricted to persons under 30 years old, indicate that among persons who have injected 6–10 years HCV seroprevalence was 57% and among those injecting 11–20 years the figure was 79%. Thus, even among persons injecting for longer periods of time, HCV infection was not universal. It seems reasonable to predict lower prevalence rates than these as the members of the present study population age. Even with widespread eventual infection, a delay in seroconversion offers a window of opportunity for future developments in treatment and vaccination to reduce morbidity and mortality among IDUs.

Because the three viruses differ in the relative importance of sexual and parenteral modes of transmission, our results suggest that multiple factors influenced the observed trends. The increases reported in preventive measures likely contributed to our findings for the three viruses: needle-exchange use for all three viruses, condom use for HIV and HBV, and vaccination for HBV. Although our data do not allow us to identify with certainty any specific programs that are responsible for the declines, they do suggest that HCV and HBV are amenable to control by public health efforts. Despite declines, the prevalence of HCV and HBV infection remains substantial among Seattle IDUs and sharing of injection equipment is widespread. There is ample opportunity for improvement preventive measures to further reduce risk behaviors and increase hepatitis B vaccine coverage.

ACKNOWLEDGEMENTS

The funding for this work came from the following sources: RAVEN—National Institute on Drug Abuse (1RO1DA08023), Centers for Disease Control and Prevention (U62/CCU006260); RAVEN II—National Institute on Drug Abuse (DA08023, DA 11447 & DA15026); Kiwi—Centers for Disease Control and Prevention (U62/CCU006260); DUIT/CIDUS III—funding was through a cooperative agreement with the Centers for Disease Control and Prevention. *Disclaimer* The findings and conclusion in this report are those of the authors and do not necessarily reflect the views of the Centers for Disease Control and Prevention.

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