Prevalence and Incidence of HIV, Hepatitis B Virus, and Hepatitis C Virus Infections Among Males in Rhode Island Prisons

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Objectives. We evaluated prevalence and intraprison incidence of HIV, hepatitis B virus, and hepatitis C virus infections among male prison inmates.

Methods. We observed intake prevalence for 4269 sentenced inmates at the Rhode Island Adult Correctional Institute between 1998 and 2000 and incidence among 446 continuously incarcerated inmates (incarcerated for 12 months or more).

Results. HIV, hepatitis B virus, and hepatitis C virus prevalences were 1.8%, 20.2%, and 23.1%, respectively. Infections were significantly associated with injection drug use (odds ratio = 10.1, 7.9, and 32.4). Incidence per 100 person-years was 0 for HIV, 2.7 for HBV, and 0.4 for HCV.

Conclusions. High infection prevalence among inmates represents a significant community health issue. General disease prevention efforts must include prevention within correctional facilities. The high observed intraprison incidence of HBV underscores the need to vaccinate prison populations. (*Am J Public Health.* 2004;94:1218–1223)

Concerns exist that jails and prisons could serve as reservoirs that could amplify transmission of infectious diseases in the wider community as inmates who become infected behind bars are released. Such reservoirs would be formed by the high prevalence of infections such as HIV, hepatitis B virus (HBV), and hepatitis C virus (HCV) among inmates, particularly those with a history of injection drug use. Injection drug users in the general community have elevated rates of HIV, HBV, and HCV infections compared with the general population.[1,2] Injection drug use, a known risk factor for these infections, has been reported in some studies to be present in as much as one third of convicts entering prison.[3] Of these infections identified in prison, 85% have been associated with preincarceration behaviors.[4] Infections within the reservoir could be amplified by high-risk behaviors occurring in prison, such as drug use and sexual activity. Further amplification in the community might occur as newly infected inmates are released and then infect individuals in different social networks. The restrictive nature of the prison environment and the scarcity of clean syringes and condoms probably heighten the hazards associated with high-risk activities, thus increasing the risk of transmission from infected to uninfected inmates.[5] Rates of drug use and sex within prisons are difficult to estimate with precision. Some previous findings indicated that 12% of inmates injected drugs and 33% were sexually assaulted while incarcerated[6,7]; however, the rate of consensual sex is more difficult to estimate. The effects of intraprison transmission are not limited to those incarcerated: given the average lengths of stay in jails (< 3 months) and in prisons (2–3 years), the risk for continued transmission extends to the general community to which the ex-offender returns. Thus, interventions addressing infection prevention in prisons affect the larger community outside the prison walls.

During the first decade of the HIV epidemic, numerous surveys estimating prevalence rates in different US correctional systems revealed that the highest rates were found among the eastern seaboard states.[8] Several studies that examined HIV incidence within the prison setting (i.e., intraprison transmission) reported rates that were lower than expected, ranging from 0 to 4.2 per 1000 person-years.[9–11] A study of HCV incidence in men in prison found a rate of 1 per 100 person-years.[12] A similar incidence for HBV was reported from studies in both Tennessee and New Mexico prisons.[13,14] These studies indicated that transmission does occur but is probably less frequent than might be expected. In Europe, reports of outbreaks of HIV and other infections in correctional settings have demonstrated that efforts to identify and control infections in this setting are important.[15,16]

Since these earlier studies were completed, the size of the prison population in the United States has more than doubled, and the proportion of inmates held for drug-related crimes also has increased.[17] Concurrently, community HIV prevalence has expanded and the prevalence of hepatitis viruses, especially HCV, has remained elevated among injection drug users, with rates generally exceeding 80%.[18,19] In addition, prison-related outbreaks of hepatitis B have been reported.[20] The purpose of this study was to update and extend information about the prevalence and within-prison incidence of HIV, HBV, and HCV infections among sentenced male inmates in the Rhode Island Correctional Institute.

METHODS

Study Setting

The Rhode Island Adult Correctional Institute has 1 intake processing center for individuals who have been arrested as well as those who have been sentenced, thus functioning as both a jail and a prison facility. Approximately 15 000 men are processed through intake each year, 3000 of whom are sentenced. The average daily census is also approximately 3000. The median age at intake is 41 years, and the racial/ethnic

distribution is 56% White, 29% Black, and 14% Hispanic. The median sentence length is 3 years.

Prevalence Study

Our sample was composed of sentenced inmates who were processed through intake between February 1998 and February 2000. In 1988, HIV testing became mandatory for all sentenced inmates in the state of Rhode Island, although before the mandate more than 90% of inmates consented to HIV testing at intake. For the purposes of this study, excess sera from mandatory HIV testing were collected and stored for all sentenced inmates. Serum specimens were linked to demographic variables (age and race/ethnicity) as well as to standard medical intake data, including self-reported alcohol and drug use, injection drug use, and overt signs of drug use (e.g., being visibly intoxicated, having track marks). HIV results were abstracted from mandatory testing records contained in prison charts. Names and unique identifiers were removed before testing. All testing for HBV, HCV, and human T-cell lymphotrophic virus I and II was done off site after identifiers were removed. Inmates were considered to be HBV seropositive if their serum tested positive for antibody to hepatitis B core (anti-HBc). To estimate how many recent infections were occurring in this population, we also tested samples for hepatitis B surface antigen (HBsAg). A specimen was considered HCV seropositive if it was reactive to at least 2 HCV antigen bands that were encoded by different parts of the HCV genome. Antibody to human T-lymphotrophic virus I/II was assayed from residual sera that were obtained during only the first year of the study because of the low prevalence observed.

Incidence Study

One half of the residual sera collected from each individual was separated, linked to demographic data, and stored untested with an identifier to serve as the baseline blood sample to evaluate incidence. Male inmates with stored baseline specimens who were continuously incarcerated for more than 12 months (without work release) were eligible for the incidence study sample. Incidence was determined by testing serial specimens from each inmate—1 specimen at baseline (intake) and 1 at follow-up. Twelve months postintake was chosen as the follow-up interval both to account for individuals who may have become HIV infected shortly before intake but who were still within the seroconversion window (i.e., the first 6 months following infection) and to ensure that individuals who became HIV infected within the first 6 months of incarceration would be past the seroconversion window at incidence testing (an additional 6 months). Eligible inmates were approached by an outreach worker and underwent informed consent and venipuncture for the follow-up serum specimen. Standard pre- and posttest counseling was administered. Inmates had the choice of having their follow-up test results added to the prison medical records or making an appointment with the prison physician. We offered this option as a service to participants so that it would be clear to them that our study was separate from the prison medical system. We did not document who did or did not choose to take advantage of the option of placing their results in the medical records.

To determine incidence, serial samples were linked before identifiers were removed prior to testing for HIV, HBV, and HCV. Incident case individuals were defined as those who were seronegative at intake and seropositive at follow-up. For individuals with incident cases for whom samples were available the paired samples were subjected to reverse blood type testing to verify that they were indeed from the same person. To determine whether the participant could have been within the period of early infection at intake (when antibodies are negative), baseline samples were retested for HIV RNA and HCV RNA. For inmates with incident HBV cases, IgM anti-HBc marker testing was performed to document recent seroconversion. Institutional review board approval was obtained from all participating institutions.

Laboratory Testing

Testing for antibody to HIV was performed with commercial enzyme-linked immunosorbent assays (ELISA) (DuPont, Wilmington, Del) confirmed by Western blot. HBV antibodies were assayed with commercial EIAs for total anti-HBc (Corzyme; Abbott Laboratories, Abbott Park, Ill) and HbsAg (Auszyme; Abbott). Anti-HCV was assayed with Ortho HCV version 3.0 ELISA (Ortho-Clinical Diagnostics, Raritan, NY). To ensure that seroconversions were from the same individual, serum protein phenotype analyses were performed.[10] To exclude infections in the seroconversion window at intake, baseline specimens from seroconverters were assayed with polymerase chain reaction (PCR) for all infections (Amplicor HIV-1 monitor test [Roche Diagnostics, Branchburg, NJ] for titers of HIV RNA, Amplicor HBV monitor test quantitative PCR [Roche Diagnostics] for titers of HBV DNA, and Amplicor HCV monitor test [Roche Diagnostics] for titers of HCV RNA).

Analyses

We evaluated whether seasonal variations in prevalence occurred during the 2 years of our study period by calculating HIV, HBV, and HCV prevalence in 3-month intervals. A formal test for trend was performed with logistic regression in which time (by calendar quarters) was a categorical variable or covariate and each infection group (i.e. HIV, HBV, HCV) was analyzed separately as the independent variable (i.e, the outcome). Time in quarters also was included as an indicator variable to test for individual differences compared with the first quarter.

To estimate prevalence, sentenced men were counted only once, regardless of their number of intakes throughout the study period. Racial/ethnic groups were White, Black, Hispanic, and Other (Asian and American Indian). Age at intake was categorized into 4 age groups to minimize reverse identification of inmates. Drug use was subdivided into 3 groups based on drug use history or on evidence of needle marks: injection drug users (IDUs), non–injection drug users, and non–drug users.

Odds ratios (ORs), with each type of infection as the outcome and demographic and medical variables as the exposure, were calculated to determine factors associated with infection. Chi-square tests and 95% confidence intervals (CIs) were used to guide interpretation. Multivariate logistic regression models were constructed with variables found to be significant in univariate analyses to further examine significant predictors of HIV, HBV,

and HCV prevalence, respectively, with control for other variables. Incidence was calculated with person-time techniques (which take into account the sum of each individual's time at risk and the sum of time that each person remained under observation), and time contributed to follow-up was calculated as the interval between intake and the date of the second venipuncture. To confirm that the entire follow-up time was "incarcerated time," we cross-checked with the prison master database to ensure that only inmates with continuous incarceration (i.e., no work release or recidivism) were included.

RESULTS

Of 5390 sequential individual intakes, we obtained residual sera from 5244 (97.3%). The 5244 intakes occurred among 4269 unique individual men. The intake sample obtained and the subset sample for whom drug use was noted were demographically similar to the overall intake population (data not shown).

As shown in Table 1, prevalence was 1.8% (95% CI=1.37, 2.19) for HIV, 20.2% (95% CI=18.95, 21.35) for HBV, and 23.1% (95% CI=21.79, 24.31) for HCV. Prevalence of each infection by calendar quarter of entry showed no significant temporal trend (data not shown).

Univariate Analyses of HIV Seroprevalence

An HIV test result was available for 3932 (92.1%) of the 4269 men in our sample, of whom 98.7% had complete risk behavior information. The demographics of those tested and those not tested were statistically similar, although untested individuals were more likely to be HCV seropositive (OR=1.4; 95% CI=1.09, 1.78) and to have had a prior incarceration (OR=1.5; 95% CI=1.16, 1.96).

Men who were HIV-seropositive at intake were more likely than HIV-uninfected men to be Black or Hispanic, to be older than 40 years, and to be IDUs, but they were less likely to report alcohol use. HIV was not associated with repeat incarcerations.

Univariate Analyses of HBV Seroprevalence

An HBV test result was available for all 4269 inmates. HBV-infected inmates were more likely than uninfected inmates to be of Other (Asian/American Indian) race/ethnicity, to be aged 40–49 years, and to report injection drug use, but they were less likely to report alcohol use, noninjection drug use, and recidivism. HBsAg seropositivity at baseline was 3.1% (134 of 4269).

Univariate Analyses of HCV Seroprevalence

HCV results were available for all but 5 inmates (4264 of 4269). HCV-infected inmates were more likely than uninfected individuals to be White, to be aged 40–49 years, to be IDUs, and to have been previously incarcerated during our study period; however, alcohol use and noninjection drug use were inversely associated with HCV infection.

Adjusted Risk Correlates of Bloodborne Pathogens

In the final multivariate model (Table 2), HIV infection remained significantly associated with Black and Hispanic race/ethnicity, age older than 40 years, and injection drug use. HBV infection was significantly associated with Black, Hispanic, and Other race/ethnicity; age over 30; and injection drug use. HCV infection was significantly associated only with increasing age over 30 and injection drug use.

Intraprison Incidence

Of 4269 men, 1170 were continuously incarcerated for at least 12 months; 583 inmates were unavailable because they were released before they could be approached for participation in the study. Of the 587 inmates available for the incidence study, 446 (76%) consented to venipuncture. Demographic characteristics of those who accepted and those who declined venipuncture were statistically similar. All serial samples were confirmed to be from the same individuals, all of whom were uninfected at baseline. HIV incidence was 0 per 693.7 person-years of follow-up with an upward 95% CI bound of 4 per 1000 person-years.[21] HBV seroincidence was 15 per 564.6 person-years of follow-up, or 2.7 per 100 person-years (95% CI=1.57, 3.58). Of the 5 participants who had sera available for PCR testing, all were found to have an undetectable HBV viral load at baseline. Twelve inmates had excess sera from the second serial sample for immunoglobulin M antibody testing, and 5 tested positive. Three seroconverters overlapped between these 2 groups, thus confirming intraprison transmission for 7 HBV incident cases. HCV seroincidence was 2 per 550.9 person-years, or 0.4 per 100 person-years (95% CI=0.05, 1.44). Table 3 shows the HBV and HCV incidence among men overall and by race/ethnicity and injection drug use. Inmates with incident HBV cases were more likely (although not significantly) to be non-White and to report injection drug use.

DISCUSSION

The major finding of this study was that rates of bloodborne infections among men entering the Rhode Island State prison system indicate cause for continuing public health concern. Although HIV infection was relatively low in this study compared with earlier studies of other eastern seaboard states such as Maryland[2] and New York,[22] the infection rate was similar to what has been previously reported from Rhode Island.[23,24] The prevalence of HBV and HCV at intake was high and was within the same range as findings reported in other US prison settings: 29.5% for HBV prevalence in Tennessee[13] and 37% for HCV prevalence in Maryland.[12] The incidences of HIV and HCV infection were consistent with the earlier literature,[1,12] indicating that although intraprison transmission may occur, it is relatively uncommon in US prisons. By comparison, the incidence rate of 2.7 per 100 person-years for HBV infection was higher than both the incidences reported in 2 earlier studies[13,14] and the national incidence of 2.8 per 100 000 person-years calculated from National Notifiable Disease Surveillance System data.[25] Whether this incidence indicates a high rate of ongoing transmission or represents an isolated outbreak that occurred during the course of the study cannot be determined from our data; however, a recent report in another state prison of an incidence of 3.8% indicates that ongoing transmission of HBV among inmates is a concern.[26] Our data and that of other studies[20,27,28] suggest that activities to prevent transmission of hepatitis in a correctional setting are important for both inmates and correctional staff. Although our data suggest that concerns about prisons

TABLE 1—Intake Characteristics of Male Prisoners, by HIV, Hepatitis B Virus, and Hepatitis C Virus Seroprevalence: Rhode Island, 1998–2000

	HIV			Hepatitis B Virus			Hepatitis C Virus		
	n	% Positive (n)	Odds Ratio (95% Confidence Interval)	n	% Positive (n)	Odds Ratio (95% Confidence Interval)	n	% Positive (n)	Odds Ratio (95% Confidence Interval)
Overall prevalence	3932	1.8 (70)	. . .	4269	20.2 (860)	. . .	4264	23.1 (983)	. . .
Race/ethnicity									
White	2270	0.5 (19)	1.0	2449	19.4 (476)	1.0	2446	26.9 (659)	1.0
Black	987	4.0 (39)	5.2 (2.93, 9.05)	1093	19.2 (210)	1.0 (0.82, 1.18)	1093	16.8 (184)	0.6 (0.46, 0.66)
Hispanic	646	1.9 (12)	2.4 (1.14, 4.95)	693	23.1 (160)	1.3 (1.02, 1.53)	691	19.8 (137)	0.7 (0.55, 0.83)
Other	27	3.7 (1)	4.8 (0.62, 37.43)	32	43.8 (14)	3.2 (1.60, 6.54)	32	9.4 (3)	0.3 (0.09, 0.93)
Age, y									
< 30				2058	9.8 (221)	1.0	2055	7.9 (162)	1.0
30 to < 40[a]	3256	1.3 (42)	1.0	1463	26.2 (383)	3.3 (2.72, 3.95)	1462	33.7 (493)	6.0 (4.90, 7.22)
40 to < 50[a]	676	4.1 (28)	3.3 (2.04, 5.37)	600	38.3 (230)	5.7 (4.61, 7.15)	599	48.3 (289)	10.9 (8.68, 13.67)
≥ 50				148	31.1 (37)	4.2 (2.86, 6.08)	148	26.4 (39)	4.2 (2.80, 6.23)
Alcohol use									
No	2686	2.1 (55)	1.0	3004	21.5 (645)	1.0	3000	24.3 (729)	1.0
Yes	1246	1.2 (15)	0.6 (0.33, 1.04)	1265	17.0 (215)	0.8 (0.63, 0.89)	1264	20.1 (254)	0.8 (0.67, 0.92)
Injection drug use									
No	3439	1.0 (35)	1.0	3481	14.8 (516)	1.0	3478	14.7 (512)	1.0
Yes	443	7.7 (34)	8.1 (4.99, 13.11)	454	59.3 (269)	8.4 (6.78, 10.30)	453	82.8 (375)	27.9 (21.45, 36.17)
Noninjection drug use									
No	3135	2.1 (65)	1.0	3459	21.5 (745)	1.0	3454	25.2 (869)	1.0
Yes	797	0.6 (5)	0.3 (0.12, 0.74)	810	14.2 (115)	0.6 (0.49, 0.75)	810	14.1 (114)	0.5 (0.40, 0.60)
No drug use									
No	1290	3.1 (40)	1.0	1598	28.7 (459)	1.0	1596	36.7 (585)	1.0
Yes	2642	1.1 (30)	0.4 (0.22, 0.58)	2671	15.0 (401)	0.4 (0.38, 0.51)	2668	14.9 (398)	0.3 (0.26, 0.35)
Recidivism									
No	3223	1.8 (57)	1.0	3476	20.5 (714)	1.0	3473	21.5 (746)	1.0
Yes	709	1.8 (13)	1.0 (0.57, 1.91)	793	18.4 (146)	0.9 (0.72, 1.06)	791	30.0 (237)	1.6 (1.32, 1.86)

[a]Age for HIV-infected group was condensed into a binary variable (< 40 or ≥ 40) because of small numbers.

serving as an amplifying reservoir for HIV and HCV might be overstated, these data are indicative of significant ongoing HBV transmission. No other studies published to date have provided such extensive confirmatory data regarding transmission among prison inmates.

Since 1982,[29] the Advisory Committee on Immunization Practices has recommended hepatitis B vaccination for inmates of long-term correctional facilities and IDUs, and the Centers for Disease Control and Prevention in a 2003 report reiterated this suggestion, strongly advising the vaccination of all inmates without proof of vaccination or serological evidence of immunity to infection.[30] At the time of our study, Rhode Island prisons did not offer hepatitis B vaccination to their inmates. However, Rhode Island is not alone among correctional settings in not providing hepatitis B vaccine as standard practice to inmates. A recent survey found that of 36 responding US correctional systems, only 2 provided routine hepatitis B vaccination, 9 offered no vaccination, and the rest offered vaccination to selected inmates.[31] Costs, the challenges of completing vaccination series in a transient population, and an already high prevalence of the disease within known risk groups[13] are the main barriers to routine hepatitis B vaccination within corrections facilities. Vaccination should be initiated even when completion of the series cannot be ensured, however, because protective levels of antibody develop after a single dose of hepatitis B vaccine in 30%–50% of healthy young adults and after 2 doses of vaccine in 75% of healthy young adults.[30]

The argument for vaccinating prison populations is salient because the risk of intraprison HBV transmission among currently incarcerated individuals is not trivial. Thus, the risk of HBV exists both for the already incarcerated population and for those newly incarcerated. Furthermore, 73% of our study sample was released within 12 months of intake. Earlier studies of persons released from prison indicate that incarceration represents a sentinel event and that on release, relapse to risky behaviors occurs rapidly, increasing risk in the general community.[32,33] Thus, the prison

TABLE 2—Adjusted Odds of HIV, Hepatitis B Virus, and Hepatitis C Virus Seroprevalence Among Male Prisoners, by Intake Characteristics: Rhode Island, 1998–2000

Variable	Odds Ratio (95% Confidence Interval)		
	HIV	Hepatitis B Virus	Hepatitis C Virus
Race/ethnicity			
White	1.0	1.0	1.0
Black	8.07 (4.44, 14.70)	1.57 (1.27, 1.95)	0.85 (0.67, 1.08)
Hispanic	3.25 (1.52, 6.95)	2.06 (1.62, 2.61)	1.08 (0.82, 1.42)
Other	5.49 (0.60, 50.17)	6.01 (2.54, 14.24)	0.15 (0.02, 1.22)
Age, y			
< 30	. . .	1.0	1.0
30 to < 40[a]	1.0	3.13 (2.54, 3.85)	6.93 (5.40, 8.88)
40 to < 50[a]	2.84 (1.66, 4.86)	5.62 (4.37, 7.22)	12.50 (9.38, 16.65)
≥ 50	. . .	5.67 (3.73, 8.62)	6.40 (3.98, 10.28)
Injection drug use			
No	1.0	1.0	1.0
Yes	10.06 (5.96, 16.99)	7.86 (6.28, 9.84)	32.44 (24.07, 43.71)

[a]Age for HIV was condensed into a binary variable (< 40 or ≥ 40) because of small numbers.

TABLE 3—Incidence of Hepatitis B Virus and Hepatitis C Virus Infection Among Male Prisoners, Stratified by Intake Characteristics: Rhode Island, 1998–2000

Variable	n	No. Positive	Person-Years	Incidence Rate[a] (95% Confidence Interval)	Rate Ratio (95% Confidence Interval)
Hepatitis B virus infection					
Total	348	15	564.6	2.7 (1.57, 4.45)	. . .
Race/ethnicity					
Non-White	181	9	293.3	3.1 (0.01, 1.67)	1.4 (0.50, 5.16)
White	167	6	271.3	2.2 (0.01, 2.23)	1.0
Injection drug use[b]					
Yes	23	3	36.7	8.2 (1.69, 23.96)	3.1 (0.05, 9.25)
No	213	9	346.3	2.6 (1.19, 4.93)	1.0
Hepatitis C virus infection					
Total	337	2	550.9	0.4 (0.05, 1.44)	. . .
Race/ethnicity					
White	149	1	241.6	0.4 (0.01, 2.23)	1.3 (0.21, 7.91)
Non-White	188	1	309.3	0.3 (0.01, 1.67)	1.0
Injection drug use[b]					
Yes	217	1	18.2	5.5 (0.14, 30.65)	18.3 (3.13, 119.81)
No	11	1	352.7	0.3 (0.01, 1.67)	1.0

[a]Incidence rate per 100 person-years.
[b]Values do not add up to total owing to missing data.

setting is an appropriate venue in which to provide general public health prevention programs. As we have shown, the prison setting is also an ideal venue for access to injection drug users: 35% of our population either self-reported or had visible signs (i.e., track marks) of injection drug use. Few settings offer such efficient access to this otherwise hidden population for the purpose of providing public health services.

Our incidence results cannot be extended to the entire incarcerated population, in particular those with shorter sentences. Jail populations experience shorter sentences than prison populations. HIV prevalence has been reported to be higher in jails than prisons,[24] however, one national study which controlled for geographic location found no significant differences in intake HIV prevalence between jail and prison populations.[34] On the basis of these studies, it is unclear whether shorter sentences pose additional risk and whether further studies are required. Our findings underscore the importance of providing HIV and hepatitis prevention services in the corrections setting, particularly among men. US Census 2000 data show that almost 2 million adult men aged 18–64 years are incarcerated at any given time. Men are 15 times more likely to be incarcerated than are women, relative to their numbers in the overall US population, and in 2001, 10% of Black men aged 25–29 years were incarcerated.[35] The size of the US male population that is incarcerated demands regular monitoring of bloodborne infections both to determine the burden of disease existing within the incarceration setting and to access a population at risk that is not isolated from the community at large. The communities to which inmates return often have problems (mental and chronic illness, poverty, violence) with which to contend,[36] further compounding the consequences of missed prevention opportunity for incarcerated, high-risk groups. Practical challenges associated with administering hepatitis B vaccination in prisons should be considered in relation to the benefits this intervention would afford.

Offering hepatitis B vaccination in prisons must be a public health priority, given the impact of infected individuals on the incarcerated population and, beyond the prison walls, on the transmission of HIV, HBV, and HCV in the communities to which inmates return. ■

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Contributors

G. Macalino conceived the study, supervised all aspects of its implementation, and led the writing. D. Vlahov conceived the study, provided scientific guidance, synthesized analyses, and assisted with writing. S. Sanford led the data management of the study and performed most of the analyses. S. Patel assisted with the analyses, conceptualization, and literature review of the article. K. Sabin provided technical assistance and problem solving in the execution of the study. C. Salas executed all aspects of the study's implementation and oversaw the daily operations of the study. J. Rich established links between the study and the Rhode Island prison and provided guidance in the implementation of the project.

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All procedures and human participant protections related to this study were approved by the local institutional review boards of The Miriam Hospital, the Johns Hopkins University Bloomberg School of Public Health, and the Centers for Disease Control and Prevention.

References

1. Santana Rodriguez OE, Male Gil ML, HernandezSantana JF, Liminana Canal JM, Martin Sanchez AM. Prevalence of serologic markers of HBV, HDV, HCV and HIV in non-injection drug users compared to injection drug users in Gran Canaria, Spain. *Eur J Epidemiol.* 1998;14:555–561.

2. Centers for Disease Control and Prevention. AIDS associated with injection drug use—United States 1995. *MMWR Morb Mortal Wkly Rep.* 1996;45:392–396.

3. Crofts N, Stewart T, Hearne P, et al. Spread of bloodborne viruses among Australian prison entrants. *BMJ.* 1995;301:285–288.

4. Vlahov D, Brewer TF, Munoz A, et al. Temporal trends of human immunodeficiency virus type-1 (HIV 1) infection among inmates entering a statewide prison system, 1985–1987. *J AIDS.* 1989;2:283–290.

5. Koulierakis G, Gnardellis C, Agrafiotis D, et al. HIV risk behavior correlates among injecting drug users in Greek prisons. *Addiction.* 2000;95:1207–1216.

6. Nacci PL, Kane TR. Sex and sexual aggression in federal prisons. In: Levinson R, ed. *Progress Report.* Washington, DC: Federal Bureau of Prisons; 1982: 7–12.

7. Decker MD, Vaughn WK, Brodie JS, et al. Seroepidemiology of hepatitis B in Tennessee prisoners. *J Infect Dis.* 1984;150:450–459.

8. Hammett TM. *Update 1989: AIDS in Correctional Facilities.* Washington, DC: National Institute of Justice; 1990.

9. Kelly PW, Redfield RR, Ward DL. Prevalence and incidence of HTLV-III infection in a prison. *JAMA.* 1986;256:2198–2199.

10. Brewer TF, Vlahov D, Taylor E, et al. Transmission of HIV-1 within a statewide prison system. *AIDS.* 1988;2:363–367.

11. Horsburgh CR Jr, Jarvis JQ, MacArthur T, et al. Seroconversion to human immunodeficiency virus infection in prison inmates. *Am J Public Health.* 1990;80: 209–210.

12. Vlahov D, Nelson KE, Quinn TC, et al. Prevalence and incidence of hepatitis infection among male prison inmates in Maryland. *Eur Epidemiol.* 1993:9:566–569.

13. Decker MD, Vaughn WK, Brodie JS, et al. Incidence of hepatitis B in Tennessee prisoners. *J Infect Dis.* 1985;152:214–217.

14. Hull HF, Lyons LH, Mann JM, et al. Incidence of hepatitis B in the penitentiary of New Mexico. *Am J Public Health.* 1985;75:1213–1214.

15. Taylor A, Goldberg D, Emslie J, et al. Outbreak of HIV infection in a Scottish prison. *BMJ.* 1995;310: 289–292.

16. Stark K, Bienzle U, Vonk R, et al. History of syringe sharing in prison and risk of hepatitis B virus, hepatitis C virus, and human immunodeficiency virus infection among drug users in Berlin. *Int J Epidemiol.* 1997;26:1359–1365.

17. Drucker E. Population impact of mass incarceration under New York's Rockefeller drug laws: an analysis of years of life lost. *J Urban Health.* 2002;79: 434–435.

18. Levine OS, Vlahov D, Nelson KE. Epidemiology of hepatitis B virus infections among injecting drug users: seroprevalence, risk factors, and viral interactions. *Epidemiol Rev.* 1994;16:418–436.

19. Behrendt C, Kendig N, Dambita C, et al. Voluntary testing for human immunodeficiency virus (HIV) in a prison population with a high prevalence of HIV. *Am J Epidemiol.* 1994;139:918–925.

20. Centers for Disease Control and Prevention. Hepatitis B outbreak in a state correctional facility, 2000. *MMWR Morb Mortal Wkly Rep.* 2001;50:529–532.

21. Selvin S. *Statistical Analysis of Epidemiologic Data.* 2nd ed. New York, NY: Oxford University Press; 1996.

22. Weisfuse IB, Greenberg BL, Back SD, et al. HIV-1 infection among New York City inmates. *AIDS.* 1991;5: 1133–1138.

23. Rich JD, Dickinson BP, Flanigan TP, et al. Prevalence and incidence of HIV among incarcerated women in Rhode Island. *J AIDS.* 1999;22:161–166.

24. Maruchak LM. HIV in prisons and jails, 1999. Washington, DC: US Dept of Justice; July 2001. NCJ 187456. Available at: http://www.ojp.usdoj.gov/bjs/abstract/hivpj99.htm. Accessed August 11, 2002.

25. Centers for Disease Control and Prevention. Summaries of notifiable diseases in the United States, 2001. *MMWR Morb Mortal Wkly Rep.* 2003:50;1–21.

26. Khan A, Simard E, Wurtzel H, et al. The prevalence, risk factors, and incidence of hepatitis B virus infection among inmates in a state correctional facility. Paper presented at: 129th Annual Meeting of the American Public Health Association; October 21–25 2001, Atlanta, Ga.

27. Hutchinson SJ, Goldberg DJ, Gore SM, et al. Hepatitis B outbreak at Glenochil prison during January to June 1993. *Epidemiol Infect.* 1998;121:185–191.

28. Gore SM, Bird AG. No escape: HIV transmission in jail. *BMJ.* 1993;307:147–148.

29. Centers for Disease Control and Prevention. Recommendations of the Immunization Practices Advisory Committee (ACIP). Inactivated hepatitis B virus vaccine. *MMWR Morb Mortal Wkly Rep.* 1982:31; 317–322, 327–328.

30. Weinbaum C, Lyerla R, Margolis HS; Centers for Disease Control and Prevention. Prevention and control of infections with hepatitis viruses in correctional settings. *MMWR Recomm Rep.* 2003;52(RR-1):1–36.

31. Charuvastra A, Stein J, Schwartzapfel B, et al. Hepatitis B vaccination practices in state and federal prisons. *Public Health Rep.* 2001;166:203–209.

32. Nurco DN, DuPont RL. A preliminary report on crime and addiction within a community-wide population of narcotic addicts. *Drug Alcohol Depend.* 1977;2: 109–121.

33. Rich JD, Holmes L, Salas C, et al. Successful linkage of medical care and community services for HIV-positive offenders being released from prison. *J Urban Health.* 2001;78:279–289.

34. Vlahov D, Brewer TF, Castro KG, et al. Prevalence of antibody to HIV-1 among entrants to US correctional facilities. *JAMA.* 1991;265:1129–1132.

35. Beck AJ, Karberg JC, Harrison PM. Prison and jail inmates at midyear 2001. Washington, DC: US Dept of Justice; 2002. NCJ 191702. Available at: http://www.ojp.usdoj.gov/bjs/abstract/pjim01.htm. Accessed August 11, 2002.

36. Freudenberg N. Jails, prisons, and the health of urban populations: a review of the impact of the correctional system on community health. *J Urban Health.* 2001;78:214–235.