Articles

Prevalence and Correlates of Hepatitis C Virus Infection Among Inmates Entering the California Correctional System

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To estimate the prevalence and predictors of hepatitis C virus (HCV) infection among inmates, a cross-sectional survey was conducted in 1994 among inmates entering six reception centers of the California Department of Corrections. Discarded serum samples were tested for antibodies to human immunodeficiency virus (HIV), HCV, hepatitis B core, and hepatitis B surface antigen (HBsAg). Of 4,513 inmates in this study, 87.0% were men and 13.0% were women. Among male inmates, 39.4% were anti-HCV-positive; by race/ethnicity, prevalences were highest among whites (49.1%). Among female inmates, 53.5% were anti-HCV-positive; the prevalence was highest among Latinas (69.7%). In addition, rates for HIV were 2.5% for men and 3.1% for women; and for HBsAg, 2.2% (men) and 1.2% (women). These data indicate that HCV infection is common among both men and women entering prison. The high seroprevalence of anti-HCV-positive inmates may reflect an increased prevalence of high-risk behaviors and should be of concern to the communities to which these inmates will be released.

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Hepatitis C virus (HCV), which was isolated and characterized by molecular cloning,[1] is the infectious agent in the majority of non-A, non-B hepatitis in the United States. Most cases are not associated with blood transfusions.[2] The majority of people infected with HCV may become chronically ill, and 60% of these develop chronic liver disease.[3] HCV is also a contributing cause of hepatocellular carcinoma.[4] Worldwide, the prevalence of antibodies to HCV ranges between 0.2% and 1.7%.[5] In the United States, prevalence is 1.8%.[6] An estimated 3.9 million Americans have been infected with HCV.[6]

Epidemiologic and experimental studies indicate that HCV is transmitted by the parenteral route (eg, injection drug users who share needles and syringes, health care workers with occupational exposure to blood, hemodialysis patients, and recipients of blood or blood products).[7] The highest HCV rates reported in the United States are related to injection drug use.[8] HCV may also be transmitted by other percutaneous exposures such as tattooing,[9] sexual or household contact,[10,11] transplantation of organs,[12] intranasal cocaine use,[13] and ear piercing in men.[13] The precise source of HCV infection, however, remains undetermined in approximately 10% of cases.[14]

Incarcerated populations are at risk for HCV infection by injection drug use and tattooing.[8,9,15] In countries outside the United States, prevalence rates for HCV infection among inmates have ranged from 4.6% to 50%.[9,15–21] Only one study to date has examined HCV seroprevalence among a US inmate population: Thirty-eight percent of 266 male inmates entering the Maryland prison system in 1985 and 1986 were found to be anti-HCV-positive.[22]

The purpose of our study was twofold: (1) to estimate the prevalence of infection with hepatitis C virus among inmates entering the California correctional system and (2) to identify predictors of the risk for HCV infection among this population.

Methods

The study protocol was reviewed and approved by the State of California Health and Welfare Agency, Committee for the Protection of Human Subjects.

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The site of entry into the California correctional system is determined according to the county where the crime was committed and by the type of crime. The California Department of Corrections (CDOC) has 13 reception centers (10 centers for male prisoners and 3 centers for female prisoners) where inmates are processed for entrance into the system. In California, all incoming inmates to the prison system receive a physical examination shortly after arrival at a reception center. A blood sample is obtained during the physical examination and tested for syphilis serology. The selection of reception centers for this study was made by the CDOC in collaboration with the California Department of Health Services, Office of AIDS. Facility selection was based on the following criteria: *1*) breadth of representation of urban and rural areas, *2*) high volume of inmates, *3*) regional representation, and *4*) routine blood specimen collection from all inmates for purposes other than this study.

This study included 4 of 10 reception centers where adult males are processed and 2 of 3 reception centers where adult females are processed. The four male reception centers selected were: *1*) R.J. Donovan Correctional Facility in San Diego (San Diego County), *2*) North Kern State Prison in Delano (Kern County), *3*) San Quentin State Prison in San Quentin (Marin County), and *4*) Wasco Reception Center in Wasco (Kern County). The two female reception centers selected were: *1*) California Institution for Women in Frontera (San Bernardino County) and *2*) Central California Women's Facility in Chowchilla (Madera County).

The sample size of this study was determined by using the 1994 prison population census and human immunodeficiency virus (HIV) prevalence estimates from the 1988 seroprevalence study among prisoners entering California prisons.[23] Based on a 2-tailed test for proportions, an alpha level of 0.05, statistical power of 0.80, and an attrition rate of 10% to detect a prevalence of 5%, the resulting gender-specific sample size for this study was 4,350 males and 650 females. The proportion of the sample selected from each reception center was based on the relative proportion of inmates processed at the centers on a weekly basis. Considering the actual gender-specific sample size for this study (3,926 male inmates and 587 female inmates), the final power was calculated as 0.67. The population in this study consisted of all inmates who had blood drawn in association with physical examinations upon entrance to the six reception centers from August 15, 1994 through September 9, 1994 (male inmates), and from August 15, 1994 through October 7, 1994 (female inmates). The study period for women was extended for an additional four weeks because of the relatively low number of incoming female inmates.

To obtain the least biased seroprevalence estimate of HCV among incoming inmates, we conducted a cross-sectional unlinked survey. Anonymous blood specimens collected for other purposes were tested in a manner that prevented linking test results to identifiable individuals. Sera from incoming inmates were eligible for inclusion in the study if: *1*) the specimen was drawn for syphilis serology as part of the initial admission process to the correctional facility (whether in detention status, awaiting sentencing, or convicted) and *2*) the inmate had not been incarcerated in the same facility during the survey period. Sera were tested for presence of antibody to hepatitis C virus (anti-HCV), HIV, and seromarkers of hepatitis B virus after all personal identifiers were removed.

For each subject, the public health nurses at the selected reception centers completed a standardized data collection form (Correctional Facility Seroprevalence Survey) provided by the Centers for Disease Control and Prevention. This form was completed for all eligible inmates who had a blood test ordered, even if sera could not be obtained, to allow comparison of inmates who were not tested with those who were tested for anti-HCV. Essential data collected for each eligible specimen included: sex, age group, race/ethnicity, previous incarceration information, and risk behavior information (available in some correctional facilities).

All testing was performed at the State Viral and Rickettsial Disease Laboratory in Berkeley, California. Sera were tested for the detection of antibody to hepatitis C virus by the Hepatitis C Virus Encoded Antigen (Recombinant c100-3, HC-31, and HC-34) Abbott HCV enzyme-linked immunosorbent assay (EIA) version 2.0. Sera that were reactive on the initial EIA were reported as having antibody detected. Approximately 10% of reactive specimens were then confirmed by Hepatitis C Virus Encoded Antigen/Peptide (Recombinant c33c and NS5 antigens; Synthetic 5-1-1, c100, and c22 peptides), Chiron, RIBA, HCV 3.0 Strip Immunoblot Assay.

Statistical analyses were conducted using SAS-PC version 6.10 (Statistical Analysis System for Personal Computers, Cary, NC) and Epi Info version 6.0.[24] Frequency distributions were compared using chi-square tests for independent samples. Ninety-five percent confidence intervals (CIs) for prevalences of HCV were calculated assuming a binomial distribution for the numbers testing positive. When the number testing positive was less than five, Fisher's exact limits were calculated. Prevalences in subgroups were compared using ratios of rates as estimates of relative risk. Exact binomial 95% confidence intervals were calculated for odds ratios using Epi Info version 6.0. Seroprevalences were computed excluding missing/unknown values.

We performed stepwise logistic regressions using SAS 6.10 to identify significant factors for anti-HCV-positivity. We constructed each model using a P value of 0.05 (based on the maximum likelihood ratio method) as both the entry and removal criterion. We computed adjusted odds ratios (ORs) with corresponding 95% CIs for the different levels of the significant independent covariates in the logistic regression models.[25] The results of our analyses are presented for male and female inmates separately. All two-way interactions were included in the model building process. We limited our analyses to samples from white, African American, and Latina/o inmates.

Results

During the study period, 5,279 inmates received intake physical examinations at the six reception centers

selected for the study. Of these, 97.4% (n = 5,142) had serum tested for the presence of anti-HCV. Sera were not tested for the remaining inmates (n = 137) because no blood was drawn, the quantity of the sample was not sufficient, or the specimen was not saved. Results of this paper are based on 4,513 serum specimens for white, African American, and Latina/o inmates. The remaining specimens (n = 629) were coded as other race/ethnicity (n = 216) or unidentified race/ethnicity (n = 413).

Of the 4,513 inmates, 87% (n = 3,926) were male and 13% (n = 587) were female. Male and female inmates were predominantly between 25 and 39 years of age (61.9% and 69.5%, respectively). Among male inmates, 35.9% were Latino, 32.9% African American, and 31.2% white. Among female inmates, 38.7% were white, 36.6% African American, and 24.7% Latina.

Of the 3,926 male inmates, 1,545 (39.4%; 95% CI, 37.8–40.9) were anti-HCV-positive upon entry into prison as compared with 314 of 587 (53.5%; 95% CI, 49.4–57.6) female inmates. Among male inmates, 2.5% were HIV positive and 2.2% were HBsAg positive. Among female inmates, rates were 3.1% and 1.2% for HIV and HBsAg, respectively.

The prevalence of anti-HCV positivity was highest for both male and female inmates 25 years or older (46.2% and 55.4%, respectively) (Table 1). White males had a higher prevalence (49.1%) than African Americans or Latinos. In univariate analyses of male inmates, hepatitis C infection was associated with inmates aged 25 or older who had a prior incarceration history, were HIV-positive, were anti-hepatitis B core (HBc)–positive, and were hepatitis B surface antigen (HBsAg)–positive. In univariate analyses of female inmates, HCV infection was associated with inmates aged 25 or older who were of Latina ethnicity, had a prior incarceration history, were HIV-positive, and were anti-HBc-positive (Table 1).

Table 2 shows the results of multivariate analyses of factors associated with HCV infection among male and female inmates. Among male inmates, we found anti-HBc-positivity (OR = 10.64; 95% CI, 8.91–12.72), aged 25 or older (OR = 4.01; 95% CI, 3.09–5.21), and previous incarceration history (OR = 2.28; 95% CI, 1.92–2.70) to be independent risk factors for HCV seropositivity. To be of African American race (OR = 0.35; 95% CI, 0.29–0.41) had a significant protective effect. Among female inmates, the risk factors associated with HCV infection in a multivariate model were: HIV positivity (OR = 9.35; 95% CI, 1.80–48.73), anti-HBc positivity (OR = 8.10; 95% CI, 5.44–12.10), and Latina ethnicity (OR = 1.70; 95% CI, 1.02–2.81).

Table 3 includes the results of coinfection with other serological markers among anti-HCV-positive and anti-HCV-negative male and female inmates. Among anti-HCV-positive male inmates, 27.2% had no other serological markers, and 62.2% were anti-HBc positive as compared with 84.8% and 11.3%, respectively, among anti-HCV-negative male inmates. Among anti-HCV-positive female inmates, 21.7% had no other serological markers and 68.5% were anti-HBc positive as compared with 75.8% and 20.9%, respectively, among anti-HCV-negative female inmates.

TABLE 1.— *Subgroup-Specific Hepatitis C Virus (HCV) Seroprevalence Among Inmates Entering the California Correctional System, 1994**

	Number in sample		*HCV Prevalence per 100 inmates (95% CI)*		*Odds Ratio (95% CI)*	
Subgroup	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*
Age group						
24 or younger	801	3,125	12.6 (10.4–15.1)	37.1 (25.2–50.3)	1.0	1.0
25 or older	62	525	46.2 (44.4–48.0)	55.4 (51.1–59.7)	5.96 (4.76–7.48)	2.14 (1.20–3.81)
Race/ethnicity						
White	1,223	226	49.1 (46.3–51.9)	58.1 (51.4–64.6)	1.0	1.0
African American	1,292	214	29.2 (26.7–31.7)	37.7 (31.2–44.5)	0.43 (0.36–0.50)	0.43 (0.29–0.70)
Latina/o	1,408	144	40.2 (37.6–42.8)	69.7 (61.5–77.0)	0.70 (0.60–0.82)	1.67 (1.05–2.67)
Previous incarceration						
No	1,659	245	27.0 (24.9–29.3)	47.6 (41.2–54.0)	1.0	1.0
Yes	2,088	332	49.0 (46.9–51.2)	58.6 (53.1–63.9)	2.60 (2.26–2.99)	1.56 (1.10–2.20)
HIV						
Negative	3,820	566	38.8 (37.3–40.4)	52.6 (48.4–56.7)	1.0	1.0
Positive	97	18	61.9 (51.4–71.5)	88.9 (65.3–98.6)	2.56 (1.66–3.95)	7.19 (1.57–12.1)
Anti-HBc						
Negative	2,692	312	21.7 (20.1–23.3)	31.7 (26.6–37.2)	1.0	1.0
Positive	1,231	272	78.0 (75.6–80.3)	78.6 (73.4–83.5)	12.9 (10.9–15.2)	8.1 (5.5–12.1)
HBsAg						
Negative	3,820	568	38.9 (37.3–40.5)	53.8 (49.6–57.9)	1.0	1.0
Positive	86	7	58.1 (47.0–68.7)	42.9 (9.9–81.6)	2.18 (1.39–3.44)	0.64 (0.11–3.42)

* Statistical analyses were conducted using SAS-PC version 6.10 and Epi Info version 6.0

TABLE 2.—*Multivariate Logistic Regression Analyses for Hepatitis C Virus (HCV) Seropositivity Among Male and Female Inmates Entering the California Correctional System, 1994**

Variable	Male Inmates OR (95% CI)	Female Inmates OR (95% CI)
Age group		
24 or younger	1.00	—
25 or older	4.01 (3.09–5.21)	—
Race		
Non-African American	1.00	—
African American	0.35 (0.29–0.41)	—
Non-Latina	—	1.00
Latina	—	1.70 (1.02–2.81)
Previous incarceration		
No	1.00	—
Yes	2.28 (1.92–2.70)	—
HIV		
Negative	—	1.00
Positive	—	9.35 (1.80–48.73)
Anti-HBc		
Negative	1.00	1.00
Positive	10.64 (8.91–12.72)	8.10 (5.44–12.10)

*Statistical analyses were conducted using SAS-PC version 6.10 and Epi Info version 6.0

Two hundred twelve anti-HCV reactive results were tested by a RIBA HCV 3.0 Strip Immunoblot confirmatory assay and over 90% (203) of the specimens were confirmed positive by this method.

Some correctional facilities collected risk behavior information as part of the admission process. If risk behavior data were obtained during the admission process, this information was matched for each specimen. Risk behavior information was provided for 831 (18.4%) of the 4,513 inmates. The most frequent risk behavior for HCV infection, reported in 805 (96.9%) of the 831 inmates, was injection drug use since 1978. Among the 549 male inmates who had used injection drugs since 1978, 430 (78.3%) were anti-HCV positive; among the 256 female inmates in this category, 181 (70.7%) were anti-HCV positive.

Discussion

In this study of inmates entering the California correctional system, we found that the overall prevalence of HCV infection was 41.2%, and the prevalence was higher in female inmates (53.5%) than male inmates (39.4%). This serosurvey provides public health officials with important information about HCV infection among California inmates.

Although we were able to collect risk behaviors in only 18% of the inmates, the high prevalence of HCV infection in both male and female inmates suggests that this population has engaged in high-risk behaviors. In this study, a vast majority of HCV-positive inmates reported injecting drugs since 1978. This risky behavior is also associated with transmission of other viruses such as HIV and HBV.

Our findings on HCV infection complement previous studies conducted among inmates in the United States and other parts of the world. Among male inmates in these studies, the prevalence of HCV infection has ranged from 28.0% to 49.8%.[15,16,18,19,21] In female inmates, the seroprevalence was 39.8%.[17] Some studies did not differentiate between male and female inmates.[8,15,20]

The high seroprevalence of HCV infection among inmates entering prison should be a serious concern to public health officials, health care providers, and policymakers for the following reasons: (1) infected male and female inmates may continue to engage in high-risk behaviors and infect others while in custody, (2) providing health care services for HCV-infected inmates with chronic liver disease or hepatocellular carcinoma is costly, and (3) infected inmates may transmit the disease to people in communities into which they are released.

Neither vaccine nor postexposure prophylaxis are available for HCV infection, and immunoglobulin is not recommended. The use of alpha interferon during the acute phase of hepatitis C may result in a decrease in the

TABLE 3.—*Markers for Co-infection with HIV and HBV Among Anti-HCV Positive and Anti-HCV-Negative Male and Female Inmates**

Serological Marker	Men		Women	
	Anti-HCV (+) (n = 1,545) n (%)	Anti-HCV (–) (n = 2,381) n (%)	Anti-HCV (+) (n = 314) n (%)	Anti-HCV (–) (n = 273) n (%)
No HIV or HBV markers	420 (27.2)	2,019 (84.8)	68 (21.7)	207 (75.8)
HIV(+)	60 (3.9)	37 (1.6)	16 (5.1)	2 (0.7)
Anti-HBc (+)	961 (62.2)	270 (11.3)	215 (68.5)	57 (20.9)
HBsAg (+)	50 (3.2)	36 (1.5)	3 (0.9)	4 (1.5)
Anti-HBc (+) and HIV (+)	47 (3.0)	17 (0.7)	12 (3.8)	1 (0.4)
HBsAg (+) and HIV (+)	4 (0.3)	2 (0.08)	0 (0.0)	1 (0.4)
Anti-HBc (+) and HBsAg (+) and HIV (+)	3 (0.2)	2 (0.08)	0 (0.0)	1 (0.4)

*Statistical analyses were conducted using SAS-PC version 6.10 and Epi Info version 6.0

rate of chronicity.[26] The currently recommended therapy for chronic hepatitis C is a 12- to 18-month course of alpha interferon in doses of 3 million units, three times a week; a regimen that results in sustained clearance of HCV RNA in approximately 20% of patients.[26] Recently, the Food and Drug Administration approved Rebetron Combination Therapy (Intron A [interferon alpha-2B recombinant for injection] and Rebetol [ribavirin] capsules) for use in hepatitis C patients who have not been treated with alpha interferon therapy.[27]

Primary prevention of HCV transmission depends on measures such as universal precautions in the occupational setting,[7] safer needle-using practices,[8] and routine HCV screening of blood and plasma donors and donors of organs, tissues, and semen.[7] Other primary prevention practices must include viral inactivation of plasma-derived products or the assurance that these products are HCV RNA negative by reverse transcription–polymerase chain reaction.[14] Inmate education and counseling are important in preventing HIV, HBV, and HCV infections. Counseling must be culturally appropriate and at a level of comprehension that is consistent with the learning skills of the inmate. An assessment of the risk-factor profile of all inmates entering the correctional system should be conducted. Prevention strategies designed to encourage voluntary behavior change and to facilitate effective risk-reduction counseling should be planned and implemented.

Interpretations of the results of this study are subject to limitations. We cannot be certain if the characteristics of inmates included in this study are generalizable to all inmates in the California correctional system. In 1994, the California Department of Corrections did not collect risk information from all inmates as they entered the system. Therefore, we had limited individual risk information data for determining modes of transmission of HCV. We were unable to examine inmates' past histories of sexually transmitted diseases and assess any association with HCV infection. Syphilis serology results were not available to us at the time survey data were collected. Much work remains to be done to complete our understanding of the dynamics of transmission and infection with HCV. At the state and local level, the highest priorities for epidemiologic research are to understand better the precise populations at risk of incident infections and to use this information to direct and monitor specific, prevention programs that are likely to be effective for at-risk populations. Further serosurveys and behavioral epidemiologic studies should be undertaken to monitor the seroprevalence and trends of prevalent infections in this population and to use this information to direct and monitor effectiveness of specific prevention programs for inmates.

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