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Correlates of Hepatitis C Virus Infection in the Targeted Testing Program of the New York City Jail System: Epidemiologic Patterns and Priorities for Action

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Abstract

Objective: The objective of this study was to understand predictors of hepatitis C virus (HCV) antibody positivity in a large urban jail system in New York City.

Methods: We examined demographic characteristics, risk behaviors, and HCV antibody prevalence among 10 790 jail inmates aged 16 to 86 who were screened from June 13, 2013, to June 13, 2014, based on birth cohort or conventional high-risk criteria. We used logistic regression analysis to determine predictors of HCV antibody positivity.

Results: Of the 10 790 inmates screened, 2221 (20.6%) were HCV antibody positive. In the multivariate analysis, HCV antibody positivity was associated most strongly with injection drug use (IDU; adjusted odds ratio [aOR] = 35.0; 95% confidence interval [CI], 28.5-43.0). Women were more likely than men to be infected with HCV (aOR = 1.3; 95% CI, 1.1-1.5). Compared with non-Hispanic black people, Hispanic (aOR = 2.1; 95% CI, 1.8-2.4) and non-Hispanic white (aOR = 1.7; 95% CI, 1.5-2.1) people were more likely to be infected with HCV. Non-IDU, recidivism, HIV infection, homelessness, mental illness, and lower education level were all significantly associated with HCV infection. The prevalence rate of HCV infection among a subset of inmates born after 1965 who denied IDU and were not infected with HIV was 5.6% (198 of 3529). Predictors of HCV infection among this group included non-IDU as well as being non-Hispanic white, Hispanic, recidivist, and homeless.

Conclusion: These data reveal differences in HCV infection by sex, race/ethnicity, and socioeconomics in a large jail population, suggesting that a focused public health intervention is required and that universal screening may be warranted. Further sensitivity and cost-benefit analyses are needed to make this determination.

Keywords
HCV, jail, corrections

Hepatitis C virus (HCV) is a major public health problem in the United States. The National Health and Nutrition Examination Survey (NHANES; 2003-2010) estimated that 1.3% of the US population, or approximately 3.6 million people, are HCV antibody positive.[1] A limitation of NHANES data, which are based on national household surveys, is the exclusion of high-risk populations, including people who are incarcerated or homeless.[2] With the addition of these populations, the true number is conservatively estimated to be as high as 4.6 million. The highest number of HCV-infected people excluded by the NHANES are in correctional

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institutions; >500 000 cases are excluded.[3] This exclusion is particularly relevant because of the high rates of HCV in US prisons and jails. In 2016, the national estimate of overall HCV antibody prevalence in US prisons was 17.4%, ranging by state from 9.6% in Nebraska to 41.1% in New Mexico.[4] Two studies conducted in jails demonstrated prevalence rates of 16.4% (St Louis, Missouri) and 13% (San Francisco, California; Chicago, Illinois; and Detroit, Michigan, combined).[5,6] A more recent study examining an HCV testing and linkage-to-care program in North Carolina and South Carolina jails showed that 11.9% of people in jail were HCV antibody positive.[7] Because HCV prevalence rates in correctional institutions are 10 to 20 times higher than the national average, jails and prisons are an important reservoir for HCV infection and crucial sites for public health interventions.

To operationalize the response to the HCV epidemic in the US correctional system, jails need to be differentiated from prisons. Jails are shorter-term facilities for people awaiting trial or serving sentences ≤1 year. More than 3000 jails in the United States hold 731 000 people at any given time,[8] which approaches the population of San Francisco and is larger than the population of Detroit. Moreover, US jails have 12 million admissions per year, which is 19 times the number of admissions in state and federal prisons.[9] Failure to intervene in US jails, coupled with high turnover rates to and from the community, may facilitate the transmission of HCV infection in the neighborhoods to which inmates return after release.[10,11] A thorough understanding of the correlates of HCV infection in jail settings is critical to understanding patterns of community transmission and developing targeted interventions to reduce the risk of transmission after release.

The New York City jail system is the second largest in the United States, with approximately 60 000 admissions per year and an average daily census of 10 000. The Bureau of Correctional Health Services of New York City Health + Hospitals is responsible for the medical and mental health care of inmates in New York City jails. People receive a comprehensive medical intake at jail admission and subsequent preventive and acute medicine and mental health encounters. The large volume of high-risk people circulating through the jail system affords a critical opportunity for identifying cases of HCV infection. Short lengths of stay, however, complicate the identification process. About half of inmates are released after <2 weeks, and one-quarter are released after <72 hours.

Guidelines for HCV screening in correctional institutions are evolving. The US Preventive Services Task Force[12] and combined Infectious Diseases Society of America and American Association for the Study of Liver Diseases guidelines recommend HCV screening for all people who were ever incarcerated.[13] The Federal Bureau of Prisons Clinical Practice Guidelines recommend opt-out screening for all sentenced inmates, as well as inmates regardless of sentencing status who (1) have a reported history of HCV infection without previous medical records to confirm the diagnosis, (2) have elevated alanine aminotransferase levels of unknown etiology, (3) have evidence of extrahepatic manifestations of HCV infection, or (4) are on chronic hemodialysis.[14] No HCV screening guidelines are available specifically for jail settings. In 2012, a minority of correctional institutions provided routine HCV screening, and screening strategies were a mix of opt-in, opt-out, or mandatory screening.[15] HCV screening practices in correctional settings have not been summarized since the release of highly effective, direct-acting antiviral medications for HCV infection.

In 2012, the Centers for Disease Control and Prevention recommended testing for people born between 1945 and 1965 (ie, the birth cohort) because the prevalence rate of HCV infection based on NHANES data was 3.3% in this group; this rate was 5 times higher than among adults born in other years and accounted for 76.5% of the total prevalence in the United States.[16] Birth cohort screening was initiated in June 2013 in the New York City jail system. After implementation of birth cohort screening, we identified a prevalence rate of 20.6% among those screened based on birth cohort and risk factor criteria. Additionally, although we found that HCV antibody prevalence was correlated overall with increasing age, a substantial number of HCV cases were identified among people who were born after 1965.[17]

The objective of this study was to describe the correlates of HCV infection in the New York City jail population after the initiation of birth cohort screening. To date, the correlates of HCV infection in jail settings have been poorly characterized. Because of rapid, frequent turnover between jail populations and the community, we argue that understanding the correlates of HCV infection in jail populations is crucial to (1) identify transmission patterns in the surrounding community and (2) target high-risk groups for focused public health intervention.

Methods

This cross-sectional study focused on people who were incarcerated in the New York City jail system and tested by correctional health providers using a targeted opt-out birth cohort and risk factor–based screening strategy from June 13, 2013, to June 13, 2014. We extracted data on demographic characteristics, jail admission, and discharge dates from electronic health records (EHRs). We abstracted data on medical health, mental health, and substance use directly from medical intakes in the EHR. We performed testing using the Abbott EIA 2.0 HCV antibody test (Abbott Laboratories, Abbott Park, Illinois) and transmitted the results to the EHR. We included people who were tested whether the result was reported as positive or negative. We removed indeterminate results. For people who were tested more than once during the study period, we used the most recent antibody test result. We excluded from analysis people with missing intake data or information that was not available within 30 days of intake. We obtained institutional review board approval for

this study from the New York City Department of Health and Mental Hygiene.

We examined the association between HCV infection and variables of interest for the screened population using logistic regression analysis. We defined our dependent variable dichotomously as a positive or negative HCV antibody test. Independent variables included birth year, sex, race/ethnicity, recidivism, self-reported drug use, infection with human immunodeficiency virus (HIV), homelessness, mental illness, and education level. We analyzed age in 2 ways. First, we created a dichotomous variable to compare those born after 1965 with the 1945-1965 birth cohort. Second, we grouped birth years by decade (after 1985, 1976-1985, 1966-1975, 1956-1965, 1946-1955, and before 1946) to provide additional detail. To preserve a fixed duration in birth intervals, we included 1945 (the first year of the birth cohort) in the category "before 1946." We categorized race/ethnicity as non-Hispanic black, Hispanic, non-Hispanic white, Asian American/Pacific Islander, or other. We defined drug use as using any illicit substance by any route currently or historically, including marijuana, and coded it as no drug use, non–injection drug use (non-IDU), or injection drug use (IDU). We defined recidivism as having >1 incarceration from April 15, 2011 (date of EHR initiation), until the end of the study period (June 13, 2014). We dichotomized education level by whether or not the respondent completed high school (12th grade).

We determined significance in bivariate analyses by using Wald χ^2 tests, with significance defined as $P < .05$. We examined multivariate logistic regression models to estimate odds ratios and 95% confidence intervals for predictors associated with HCV antibody positivity. The models incorporated independent variables that were significant in bivariate analyses at $P < .05$. We examined these models for the entire study sample and also for those born after 1965 without well-established risk factors or associations frequently used as markers for HCV screening, including IDU and HIV infection. The first model adjusted for birth years in decades, sex, race/ethnicity, substance use, recidivism, homelessness, HIV status, homelessness, mental illness, and high school graduation. The second model adjusted for birth years in decades, race/ethnicity, IDU status, recidivism, and homelessness. We performed statistical analysis using SAS version 9.3.[18]

Results

During the study period, 56 590 people were incarcerated in New York City jails, 8560 of whom (15.1%) were born between 1945 and 1965. As reported elsewhere, correctional health providers ordered 12 365 HCV antibody tests during the study period, 1509 of which were duplicate, indeterminate, or refused.[17] Additionally, 66 people were missing elements of intake data. Therefore, 10 790 people were screened and had complete intake data, including positive or negative results, 5456 (50.6%) of whom were part of the birth cohort, 5269 (48.8%) of whom were born after 1965, and 65 (0.6%) of whom were born before 1945.

Of the 10 790 people in the cohort, 2221 (20.6%) were HCV antibody positive (Table 1). Most were male (9275 of 10 790, 86.0%); 5631 (52.2%) were non-Hispanic black; 3439 (31.9%) were Hispanic; and 1368 (12.7%) were non-Hispanic white. More than half of those tested (n = 6174, 57.2%) reported non-IDU; 2657 (24.6%) reported no drug use; and 1959 (18.2%) reported IDU. Of these groups, HCV antibody positivity was found in 1324 of 1959 (67.6%) who reported IDU, 722 of 6174 (11.7%) who reported non-IDU, and 175 of 2657 (6.6%) who reported no drug use. Of the 10 790 respondents, 4599 (42.6%) reported not having a high school diploma; 3744 (34.7%) reported mental illness; and 998 (9.2%) reported being homeless. Of these groups, HCV antibody positivity was found in 1038 of 4599 (22.6%) respondents who reported not having a high school diploma, 1003 of 3744 (26.8%) who reported mental illness, and 298 of 998 (29.9%) who reported being homeless. HCV coinfection was present in 331 of 1197 (27.7%) people who reported HIV infection. Recidivism was found in 1414 (13.1%) people in the sample, and these people had the highest prevalence of HCV infection (497 of 1414, 35.1%).

The multivariate logistic regression model that included the entire study sample showed a significant association between HCV antibody positivity and being female, being born before 1986 (with increasing odds ratios by decade, with the exception of those born before 1946), being Hispanic and non-Hispanic white rather than non-Hispanic black, reporting IDU and non-IDU, having a history of recidivism, being infected with HIV, homelessness, mental illness, and not completing high school ($P < .001$; Table 2). In a multivariate logistic regression analysis for the subset of inmates born from January 1, 1945, onward, with age as a dichotomous variable for those born between 1945 and 1965 and those born after 1965, the adjusted odds ratio for birth cohort membership was 3.0 (95% confidence interval, 2.7-3.5).

For the 3529 inmates who were born after 1965 and denied IDU and HIV infection, we conducted a second multivariate logistic regression analysis to understand the prevalence of HCV antibody positivity and predictors among this group. The prevalence of HCV antibody positivity was 5.6%, and a second logistic regression analysis showed that HCV antibody positivity was significantly associated with being born before 1986, being non-Hispanic white or Hispanic rather than non-Hispanic black, homelessness, non-IDU, and having a history of recidivism (Table 3).

Discussion

These data from a large urban jail population reinforce IDU as the best predictor of HCV antibody positivity. More than two-thirds of those who reported IDU were HCV antibody positive, a rate that is similar to rates reported in noncorrectional settings.[19] Because low HCV-related case fatality rates and long-lasting serostatus result in a direct correlation

Table 1. Demographic characteristics and bivariate associations of New York City jail inmates testing antibody positive for HCV, June 13, 2013, to June 13, 2014

Characteristics	Inmates, No. (%)		*P* Value[a]
	Screened[b] (n = 10 790)	Testing HCV Antibody Positive[c] (n = 2221)	
Median age (range), y	48 (16-86)	50 (18-86)	
Birth year			<.001
>1985	1400 (13.0)	83 (5.9)	
1976-1985	1652 (15.3)	367 (22.2)	
1966-1975	2217 (20.5)	525 (23.7)	
1956-1965[d]	4566 (42.3)	876 (19.2)	
1946-1955[d]	868 (8.0)	341 (39.3)	
<1946	87 (0.8)	29 (33.3)	
Sex			
Male	9275 (86.0)	1856 (20.0)	<.001
Female	1515 (14.0)	365 (24.1)	
Race/ethnicity			
Non-Hispanic black	5631 (52.2)	712 (12.6)	<.001
Hispanic	3439 (31.9)	1017 (29.6)	
Non-Hispanic white	1368 (12.7)	461 (33.7)	
Asian American/Pacific Islander	138 (1.3)	9 (6.5)	
Other	214 (2.0)	22 (10.3)	
Drug use[e]			
Injection drug use	1959 (18.2)	1324 (67.6)	<.001
Non–injection drug use	6174 (57.2)	722 (11.7)	
No drug use	2657 (24.6)	175 (6.6)	
Homelessness[e]	998 (9.2)	298 (29.9)	<.001
Recidivism	1414 (13.1)	497 (35.1)	<.001
Mental illness[e]	3744 (34.7)	1003 (26.8)	<.001
Never completed high school[e]	4599 (42.6)	1038 (22.6)	<.001
Human immunodeficiency virus infection	1197 (11.1)	331 (27.7)	<.001

Abbreviation: HCV, hepatitis C virus.
[a]Significance between risk groups.
[b]Percentages may not total to 100 because of rounding.
[c]Row percentages.
[d]Birth cohort.
[e]Based on self-report.

between duration of IDU and HCV prevalence,[20] the observed age-related increase in HCV antibody positivity[17] may be a function of cumulative risk resulting from increased exposure to IDU over time. Nearly 60% of people with HCV infection in our study reported IDU: because fear of self-incrimination and lack of confidentiality may prevent inmates from reporting IDU, this percentage may underestimate the number of inmates who inject drugs.[21] Other routes of drug administration were more weakly associated but may have also contributed to cumulative exposure to HCV infection over time. Biological and epidemiologic associations have been demonstrated for snorting[22,23] and smoking[24] illicit substances, particularly crack and cocaine.

We observed a higher prevalence of HCV infection among incarcerated females than among incarcerated males. This epidemiologic pattern has been reported elsewhere in the United States[25,26] and internationally[27] and is thought to be caused by the higher rates of IDU and exchange of sex for money and drugs among females.[28] Data were not available on sexual partnerships or histories of transactional sex for our sample; however, these relationships may be more prominent in jail settings because of prostitution- and drug-related arrests. Another possible explanation is iatrogenic transmission through blood transfusions before widespread screening in the early 1990s.[29] This transmission might have affected women disproportionately because of transfusions during childbirth. Further characterization of these relationships in this population should be studied to refine priorities for action among jailed women.

Non-Hispanic black people had the highest prevalence of HCV infection in the United States in the NHANES data (2.2%).[30] In our sample, however, non-Hispanic white people had the highest prevalence of HCV infection overall, followed by Hispanic people. In the multivariate logistic regression analysis, Hispanic people had the highest adjusted odds for HCV infection. Recent data from the Hispanic Community Health Study / Study of Latinos help elucidate this finding.[31] This study found an HCV prevalence rate of 4.5% in the Bronx, New York, which was substantially higher than the HCV prevalence rate in the other study sites, including San Diego, Chicago, and Miami. Men and women of Puerto Rican descent who lived in the Bronx had the highest HCV

Table 2. Multivariate regression analysis showing adjusted odds ratios of hepatitis C virus antibody positivity for New York City jail inmates tested from June 13, 2013, to June 13, 2014 (n = 10 790)

Variable	Adjusted[a] Odds Ratio (95% Confidence Interval)
Birth year	
After 1985	1.0 [Reference]
1976-1985	3.2 (2.4-4.2)
1966-1975	5.0 (3.8-6.7)
1956-1965[a]	7.8 (5.9-10.3)
1946-1955[a]	26.7 (19.6-36.5)
Before 1946	23.8 (11.8-43.9)
Sex	
Male	1.0 [Reference]
Female	1.3 (1.1-1.5)
Race/ethnicity	
Non-Hispanic black	1.0 [Reference]
Hispanic	2.1 (1.8-2.4)
Non-Hispanic white	1.7 (1.5-2.1)
Asian American/Pacific Islander	0.6 (0.3-1.3)
Other	0.6 (0.4-1.1)
Substance use	
No drug use	1.0 [Reference]
Injection drug use	35.0 (28.5-43.0)
Non–injection drug use	2.0 (1.6-2.4)
Recidivism	1.7 (1.4-2.0)
HIV infection	1.5 (1.3-1.8)
Homelessness	1.4 (1.2-1.7)
Mental illness	1.2 (1.1-1.4)
Never completed high school	1.2 (1.1-1.4)

Abbreviation: HIV, human immunodeficiency virus.
[a]Adjusted for birth years in decades, sex, race/ethnicity, substance use, recidivism, homelessness, human immunodeficiency virus status, homelessness, mental illness, and high school graduation status.

Table 3. Multivariate regression analysis showing adjusted odds ratios of hepatitis C virus antibody positivity for non-IDU, non-HIV-infected patients born after 1965, New York City jails, June 13, 2013, to June 13, 2014 (n = 3529)

Variable	Adjusted[a] Odds Ratio (95% Confidence Interval)
Birth year	
Before 1985	1.0 [Reference]
1976-1985	4.1 (2.3-7.2)
1966-1975	5.5 (3.2-9.4)
Race/ethnicity	
Non-Hispanic black	1.0 [Reference]
Hispanic	3.6 (2.5-5.2)
Non-Hispanic white	5.6 (3.5-8.9)
Non-IDU	2.4 (1.6-3.8)
Recidivism	3.6 (2.4-5.5)
Homelessness	2.0 (1.3-3.2)

Abbreviations: HIV, human immunodeficiency virus; IDU, injection drug use.
[a]Adjusted for birth years in decades, race/ethnicity, IDU status, recidivism, and homelessness.

prevalence rates overall: 14.1% for men and 4.2% for women.[31] Hispanic people constitute 33% of the inmate population in the New York City jail system, and >70% of people released to the community from New York City jails return to areas with the greatest socioeconomic and health disparities, particularly the Bronx and Central Brooklyn.[32] The interrelationship of poverty, substance use disorders, and incarceration among Hispanic people, particularly in the Bronx, may account for the observed independent risk for HCV infection conferred by Hispanic ethnicity in this large urban jail setting.

In contrast, the regression analysis for the subset of non-IDU, non-HIV-infected people in jail who were born after 1965 demonstrates that non-Hispanic white race/ethnicity best predicted HCV antibody positivity. Similar trends were demonstrated in other correctional settings and likely represent shifts in the epidemiology of IDU in surrounding communities.[11,26] Increases in HCV infection among young non-Hispanic white people transitioning from prescription opioids to IDU in particular have been reported.[33] Although the second regression analysis included only those denying IDU, fear of incrimination may be particularly prevalent in this group. However, further investigation is required to make that determination.

Other than IDU and birth during 1946 to 1955, recidivism was most predictive of HCV infection in the adjusted regression model, followed by homelessness and mental illness. The relationship among recidivism, homelessness, and mental illness has been described[34,35] and linked to increased rates of HCV infection.[11,36] The association between these factors and HCV infection in our study provides further evidence that homeless and mentally ill people who are caught in cycles of active drug use and reincarceration are at high risk for HCV infection.

Although the ability to comment on universal screening using these data is limited, a substantial percentage of HCV antibody–positive people were younger than the birth cohort and denied a history of IDU. This group represents a large number of jailed people who appear to lack well-recognized risk factors for HCV infection. This finding may support recent calls for universal screening in correctional settings[27,37]; however, further sensitivity analyses of the current targeted screening strategy in correctional settings should be performed to assess the efficacy of this strategy in identifying HCV antibody–positive people. Because duplicate HCV antibody testing in correctional settings has been noted,[38] increased efforts in patient notification, use of EHRs, and health system integration will be required to be cost effective. Birth cohort screening in correctional settings needs to be further scrutinized because the largest proportion of the incarcerated population in the United States was born between 1976 and 1980 and the HCV birth cohort will age out.[4]

Limitations

A major limitation of this study was that screening was based on birth cohort and health care providers' assessments of risk. Therefore, the prevalence of HCV infection was likely

overestimated, particularly among those born after 1965. We were also unable to describe the number of people with chronic HCV infection because we used HCV antibody positivity for this analysis rather than HCV viral loads. Additionally, we based risk factor data on self-report, and intake screenings lacked key elements, such as duration of IDU, sex with people who inject drugs, exchange of sex for drugs or money, and a history of tattoos, piercings, or transfusions. Therefore, the relative contribution of these factors to HCV antibody positivity in this population is unclear.

Conclusion

This study provides a breadth of data on demographic characteristics and correlates of HCV antibody positivity in a large jail setting; many of these data are missing in other studies, and they are especially important for developing further guidelines on HCV testing for the cohort of people born after 1965. Additionally, the correlates of HCV infection identified in our study support targeted public health interventions, such as HCV education, harm reduction, and treatment as prevention, among certain subgroups. Last, higher HCV prevalence rates among the homeless, the mentally ill, those with lower education levels, and those with histories of recidivism should be viewed as an opportunity for intervention because, for HIV infection,[39] linking and engaging these groups to HCV care may have collateral benefits if services such as addiction medicine, psychiatry, and primary care are integrated after inmates are released from incarceration.

Declaration of Conflicting Interests

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