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Prevalence, Distribution, and Correlates of Hepatitis C Virus Infection Among Homeless Adults in Los Angeles

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ABSTRACT

Objective. We documented the prevalence, distribution, and correlates of hepatitis C virus (HCV) infection among urban homeless adults.

Methods. We sampled a community-based probability sample of 534 homeless adults from 41 shelters and meal programs in the Skid Row area of downtown Los Angeles, California. Participants were interviewed and tested for HCV, hepatitis B, and HIV. Outcomes included prevalence, distribution, and correlates of HCV infection; awareness of HCV positivity; and HCV counseling and treatment history.

Results. Overall, 26.7% of the sample tested HCV-positive and 4.0% tested HIV-positive. In logistic regression analysis, independent predictors of HCV infection for the total sample included older age, less education, prison history, and single- and multiple-drug injection. Among lifetime drug injectors, independent predictors of HCV infection included older age, prison history, and no history of intranasal cocaine use. Among reported non-injectors, predictors of HCV infection included older age, less education, use of non-injection drugs, and three or more tattoos. Sexual behaviors and snorting or smoking drugs had no independent relationship with HCV infection. Among HCV-infected adults, nearly half (46.1%) were unaware of their infection.

Conclusions. Despite the high prevalence of HCV infection, nearly half of the cases were hidden and few had ever received any HCV-related treatment. While injection drug use was the strongest independent predictor, patterns of injection drug use, non-injection drug use, prison stays, and multiple tattoos were also independent predictors of HCV. Findings suggest that urgent interventions are needed to screen, counsel, and treat urban homeless adults for HCV infection.

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The hepatitis C virus (HCV) is the most common chronic blood-borne viral infection in the United States. Beginning in 1988–1994,[1] the National Health and Nutrition Examination Survey (NHANES), a survey of U.S. households, began estimating prevalence rates for hepatitis C infection in the U.S. general population for those aged 6 years and older. The most recent national prevalence estimate (based on the 1999–2002 NHANES) was 1.6%, or about 4.1 million people.[2] The primary identified means of transmission was through injection drug use. Unfortunately, the NHANES excluded large groups at high risk for HCV infection. A recent article suggested that if high-risk groups that were missed or underrepresented in NHANES (i.e., homeless or incarcerated people, Veterans, health-care workers, and those on long-term dialysis)[3] had been included, a conservative estimate of HCV in the U.S. would have been somewhat higher, at 2.0% or about 5.2 million people.[4,5] These understudied populations that constitute a significant reservoir of HCV infection can provide additional insight into the extent and correlates of HCV infection.

Recent studies suggest that homeless adults in urban areas are at particularly high risk for hepatitis C infection (19%–69%) due to high rates of risky injection drug use.[6–13] Unfortunately, these studies have usually been based on convenience, clinical, or subgroup samples, and findings may not generalize beyond the groups studied.[14]

We documented the prevalence, distribution, and risk factors for HCV infection based on a probability sample of homeless adults. This study fills an important gap in the literature by using a large representative sample of inner-city homeless adults to generate a more accurate estimate of HCV infection in an urban homeless adult population. Further, we documented the high prevalence of "hidden" (i.e., participants were unaware of their infection status) HCV infection in this group and the current unmet need for HCV screening and HCV-specific health services. Findings will inform future intervention and treatment programs aimed at preventing exposure to and transmission of HCV among homeless people and the general population.

METHODS

For the University of California at Los Angeles (UCLA)/Alcohol Research Group (ARG)/RAND Corporation Homeless Hepatitis Study (known as the UCLA/ARG/RAND Homeless Hepatitis Study), a community-based probability sample of homeless adults was recruited from the Skid Row area in downtown Los Angeles (LA), from June 2003 to February 2004.

Target population

The target population was adults who experienced homelessness during the previous night. To be eligible, participants had to be ≥18 years of age; have spent the previous night either (*1*) in a public or private shelter or (*2*) on the streets (i.e., in a public or private place not designed for, or ordinarily used as, regular sleeping accommodations for humans);[15] be English-speaking; and demonstrate cognitive competence, assessed as needed.[16]

Design

We adapted the service-sector approach to probability sampling, which has been used successfully in previous work with homeless populations[17–19] and which reportedly represents the great majority of homeless adults in urban areas (usually 85%–94%).[20–22] We constructed a sampling frame of shelters and free meal programs throughout LA's Skid Row area, which is bounded by four freeways (the Harbor, Santa Monica, Hollywood, and Interstate-5 freeways). We compiled a list of all programs that served homeless adults in the target area. From the list, all shelter and meal programs were selected to constitute the sampling frame. Treatment programs were excluded. The sampling frame consisted of 41 service programs: 19 shelter programs at 10 locations and 22 meal programs at nine locations.

We employed a two-stage representative sampling design. First, we stratified the frame by site and site-use days (i.e., days of the week on which target services were provided) as sampling units. Second, clients were sampled on selected site-use days using sampling strategies that were tailored to each site (either simple random or systematic random sampling). One site (2% of eligible sites) refused to participate.

Of 903 program clients screened for study eligibility, 586 were initially identified as eligible. Among these, 41 refused enrollment, and one could not be subsequently located. Ten were later identified as repeaters, and their second interviews were excluded. The final sample included 534 clients for an interview and blood draw completion rate of 92.7% (534/576). The combined screening and interview response rate was 83.0%.

Data collection

The RAND Survey Research Group conducted the fieldwork.[23] Interviewers briefly screened each sampled client for eligibility. Data collection took about 90 minutes and included informed consent, structured interview, pretest counseling, and serum collection.

Each participant received $30 cash for completing the interview and serum collection. Participants were then given an appointment for one week later at the

same site to obtain test results. A toll-free telephone number was provided to all participants to receive test results by phone. Participants were originally offered $10 to return for results. Subsequently, the incentive was raised to $25 to increase the return rate. The overall rate of notification of test results, either in person or by phone, was 92%. Participants informed by phone (*n*=3) were not given the second incentive. On average, notification occurred seven days after baseline (median = 7 days, mean = 25 days). Those testing positive for HCV, hepatitis B, or human immunodeficiency virus (HIV) were given appointments for follow-up medical care at one of three specific primary care clinics serving homeless people in the Skid Row area. In addition, all respondents notified in person were given a list of local clinics where they could obtain health care.

Measures

Background measures. Baseline survey data were collected through structured face-to-face 60-minute computer-assisted personal interviews (about 400 questions). Biological sex was operationalized by sex attributed at birth. Current homelessness was operationalized by having stayed in a homeless shelter or on the street during the previous night, and chronic homelessness was defined by an accumulation of 12 months or longer spent homeless since 18 years of age. Prison stays and psychiatric hospitalizations, lifetime transfusion of blood or blood products before 1990, and number of tattoos were also assessed.

Diagnostic measures. Lifetime and current (12-month) major mental and substance-use disorders were assessed by selected modules from a computerized version of the Diagnostic Interview Schedule, Version IV (DIS-IV).[24] To reduce respondent burden, a standardized, shortened version of the DIS-IV was used. For each module, questions were asked only until the participant either met minimum criteria for a specific diagnosis or was excluded from the diagnosis. Modules included assessment of major affective disorders (including depression and bipolar disorders), schizophrenia, alcohol use disorders, and drug use disorders. Drug disorders were assessed in aggregate as well as by specific classes of drugs, including opiates, cocaine, amphetamines and other stimulants, sedatives, and hallucinogens.

Self-reported substance use. Alcohol measures included recent frequent heavy drinking ("binge drinking"), defined as five or more drinks at least once per month in the previous 12 months. Drug use measures included lifetime and recent (12-month) use of marijuana, cocaine, ecstasy or other hallucinogens, sedatives and

hypnotics, methamphetamine or other stimulants, heroin (alone or combined with other drugs), and other opiates. Mode of use (e.g., injection, "snorting," or smoking) was also assessed. Lifetime injection of illicit drugs (i.e., drugs not prescribed for the user or not used as prescribed) and injections of specific drugs or combinations of drugs were also assessed. Injectors were also asked whether they had ever shared previously used or potentially contaminated injection paraphernalia (including needles or syringes, water for rinsing needles, cotton for filtering drug solutions, or "cookers" [e.g., spoons or bottle caps for dissolving drugs]), or injected drugs in a "shooting gallery" (i.e., a place where injection drug users may congregate, purchase, or inject drugs) or in another place where the participant did not know who else had used the injection paraphernalia. We also assessed history of overdose while using injection drugs (i.e., participant lost consciousness and had to be revived).

Regarding non-injection drug use, questions covered lifetime smoking of crack or any other drugs, intranasal use of cocaine or other drugs (i.e., snorting), and sharing straws for intranasal drug use.

Lifetime pattern of drug use was created as a variable with five categories, which were adapted from the three-category drug-use variable that Armstrong and colleagues used to predict HCV.[2] The five categories in the new variable were mutually exclusive, with participants assigned to the pattern of their most severe drug use. We divided non-injectors into those reporting (*1*) no drug use, (*2*) non-injection drug use (e.g., cocaine, methamphetamine, or hallucinogens) including marijuana, and (*3*) non-injection drug use excluding marijuana. Injection drug use was divided into two subgroups based on the number of different types of drugs ever injected: (*1*) single-drug injection (i.e., the participant only ever injected one specific drug [e.g., only heroin]) and (*2*) multiple-drug injection (i.e., the participant ever injected more than one specific drug [e.g., heroin and cocaine], whether separately or simultaneously [e.g., a speedball]).[18]

Separately, mixed-drug injection identified participants who had ever injected a mixture of two or more drugs.[18,25,26]

Sexual behaviors and conditions. Assessment of lifetime sexual risk behaviors included asking biological males if they had ever had sex of any kind with another man (i.e., men who have sex with men [MSM]). Lifetime sex risk also included sex work (i.e., receiving cash or drugs for sex) and a prior diagnosis of syphilis, gonorrhea, or Chlamydia. Recent (past 12 months) sexual risk behavior included sex with five or more partners.[18]

HCV history. We also assessed histories of counseling, blood testing, and treatment for HCV.

Blood test measures

Participants were tested for lifetime infection with HCV. Serum was tested for HCV antibodies using a second-generation enzyme-linked immunosorbent assay (ELISA). Per Centers for Disease Control and Prevention (CDC) recommendation, only ELISA tests with a signal-to-cutoff ratio of <3.8 required confirmation using a supplemental recombinant immunoblot assay (RIBA, 3.0 generation). Among the 155 participants who tested positive, indeterminate, or borderline-negative for HCV on the ELISA test, 20 had signal-to-cutoff ratios <3.8 and required confirmation of HCV positivity with the RIBA test.[27] Fourteen of these participants were confirmed HCV-positive, and six were coded HCV-negative, leaving 149 HCV-positive participants overall. Infectiousness and chronic HCV infection were not assessed.

Lifetime HIV infection was determined by ELISA with confirmation by Western blot testing. Serum was tested for alanine aminotransferase (ALT) as a marker of active liver disease.

Data analysis

All analyses were weighted to adjust for each participant's selection probabilities, multiple screenings, and frequency of site utilization. Sample sizes were unweighted. Using SAS®,[28] unadjusted (bivariate) associations between categorical variables and HCV infection status were tested with Chi-square and Fisher's exact statistics for the total sample and separately for injectors and non-injectors. We used odds ratios (ORs) to describe the magnitude of these associations, although the unadjusted ORs may overestimate the magnitude of the associations where HCV is common. Note that ORs do not represent risk ratios here.

To create a core multivariate model of independent predictors of HCV infection, only those variables associated with HCV with two-sided *p*-values <0.15 in unadjusted (bivariate) analyses were entered into a stepwise backward multiple logistic regression. This method was used due to the large number of variables that might be associated with HCV infection relative to the sample size. Four dummy variables representing the mutually exclusive categories of drug-use patterns described previously were forced into the stepwise model: "having injected two or more drugs," "having injected only one drug," "having used non-injection drugs including marijuana," and "having used non-injection drugs excluding marijuana." The reference category was "no reported lifetime drug use." Variables associated with HCV with *p*-values <0.05 were retained in the final multivariate model. Models were similarly constructed for mutually exclusive subgroups of participants who reported either (*1*) lifetime drug injection or (*2*) no lifetime drug injection.

Multicollinearity was found to be a problem in the regression models with two variables: multiple-drug injection (two or more drugs injected at different times or simultaneously) and mixed-drug injection (two or more drugs injected simultaneously). Consequently, both variables were forced into separate but otherwise equal regression models to identify the stronger factor; hence, multiple-drug injection was used for two of the three final logistical regression models (i.e., total sample and injector subsample). We assessed goodness of fit for all three models using the Hosmer-Lemeshow test. We used Stata® to analyze survey data to control for possible cluster effects and to utilize the sampling weights.[29]

RESULTS

Sample characteristics

The majority of the total sample was male (73.6%), black (79.7%), U.S.-born (89.9%), and older than 40 years of age (73.6%) (Table 1). The mean age was 45.8 years (data not shown). Nearly all had completed at least 10 years of education. The majority (70.8%) reported chronic homelessness, and the median aggregated time spent homeless as an adult was 2.2 years (data not shown). About two-thirds spent the previous night on the street, while only one-third were in shelters. Many participants met lifetime diagnostic criteria for major mental disorders (e.g., depression [31.8%] and schizophrenia [7.0%]) and serious substance use disorders (e.g., alcohol dependence [29.7%] and drug dependence [33.2%]).

Prevalence of HCV infection

More than one-quarter of the sample (26.7%) tested positive for HCV antibodies, indicating infection during the lifetime (Table 1). Among these participants, 5% had ALT levels that were twice the upper limit of normal, suggesting active liver disease (data not shown).

Among the total sample, 4.0% tested seropositive for HIV, including 0.7% who had tested positive for both HCV and HIV. That is, 18.7% of HIV-infected participants were also infected with HCV, and 2.8% of HCV-infected participants were also infected with HIV (data not shown).

Table 1. HCV seroprevalence, by risk factor, among urban homeless adults in downtown Los Angeles, California, 2003–2004

Variable	Sample N (percent)	HCV-positive Percent	OR (95% CI)
Total sample	534 (100.0)	26.7	
Demographics			
Age (in years)[a]			
18–39	137 (26.4)	10.4	Ref.
≥40	397 (73.6)	32.5	4.15 (2.37, 7.27)
Gender[b]			
Male	424 (79.7)	29.4	2.18 (1.20, 3.98)
Female	110 (20.3)	16.0	Ref.
Race/ethnicity			
White	71 (12.9)	25.2	Ref.
Black	373 (69.6)	27.0	1.10 (2.61, 1.98)
Latino/Hispanic	57 (11.1)	28.4	1.17 (0.54, 2.57)
Other	33 (6.4)	23.0	0.89 (0.34, 2.32)
Education[b]			
≤9th grade	53 (9.2)	46.9	Ref.
≥10th grade	481 (90.8)	24.6	0.37 (0.20, 0.69)
Veteran			
Yes	108 (19.6)	28.0	1.09 (0.66, 1.77)
No	426 (80.4)	26.3	Ref.
Born in U.S.[c]			
Yes	483 (89.9)	28.1	2.41 (1.09, 5.34)
No	51 (10.1)	14.0	Ref.
Homelessness history			
In shelter, previous night			
Yes	163 (35.2)	24.6	0.85 (0.55, 1.31)
No	27.8 (64.8)	27.8	Ref.
Chronic homelessness (≥12 months)			
Yes	393 (70.8)	28.0	1.24 (0.77, 2.01)
No	149 (29.2)	23.8	Ref.
Institutional history			
Prison, lifetime[a]			
Yes	154 (28.1)	41.5	2.75 (1.80, 4.20)
No	378 (71.9)	20.5	Ref.
Psychiatric hospitalization, lifetime			
Yes	100 (18.8)	28.4	1.11 (0.69, 1.81)
No	434 (81.2)	26.3	Ref.
Potential transmission routes			
Transfusion blood products before 1990[d]			
Yes	48 (9.5)	37.2	1.72 (0.94, 3.15)
No	484 (90.5)	25.6	Ref.
≥3 tattoos, lifetime[d]			
Yes	55 (11.2)	36.4	1.70 (0.96, 3.01)
No	465 (88.8)	25.2	Ref.
Mental health			
Major depression, lifetime[e]			
Yes	170 (31.8)	30.6	1.17 (0.94, 1.44)
No	356 (68.2)	24.5	Ref.
Schizophrenia, lifetime[e]			
Yes	38 (7.0)	27.0	1.02 (0.70, 1.48)
No	490 (93.0)	26.7	Ref.

Table 1 (continued). HCV seroprevalence, by risk factor, among urban homeless adults in downtown Los Angeles, California, 2003–2004

Variable	Sample N (percent)	HCV-positive Percent	OR (95% CI)
Drugs			
Drug dependence, lifetime[a,e]			
Yes	180 (33.2)	38.3	2.35 (1.58, 3.49)
No	348 (66.8)	20.9	Ref.
Cocaine dependence, lifetime[c,e]			
Yes	164 (29.9)	34.2	1.69 (1.13, 2.55)
No	363 (70.1)	23.5	Ref.
Amphetamine dependence, lifetime[a,e]			
Yes	33 (6.0)	52.1	3.26 (1.58, 6.73)
No	495 (94.0)	25.1	Ref.
Opiates dependence, lifetime[a,e]			
Yes	26 (5.4)	81.5	14.30 (5.45, 37.50)
No	502 (94.6)	23.5	Ref.
Injection drug use, lifetime[a]			
Yes	111 (20.4)	77.6	22.03 (12.97, 39.40)
No	423 (79.6)	13.6	Ref.
Injection drug use, past 12 months[a]			
Yes	12 (2.7)	79.6	11.55 (3.14, 42.51)
No	522 (97.3)	25.2	Ref.
Mixed-drug injection, lifetime[a,f]			
Yes	53 (9.8)	84.8	21.91 (9.90, 48.04)
No	481 (90.2)	20.3	Ref.
Drug smoker (crack or other drug), lifetime[a]			
Yes	361 (67.8)	32.1	2.63 (1.60, 4.33)
No	173 (32.2)	15.2	Ref.
Intranasal cocaine use, lifetime[a]			
Yes	207 (39.4)	35.9	2.15 (1.46, 3.18)
No	327 (60.6)	20.7	Ref.
Drug use, lifetime[a,g]			
No drug use	80 (14.2)	12.6	Ref.
Non-injection drug use, including marijuana[h]	297 (57.2)	11.1	0.86 (0.40, 1.86)
Non-injection drug use, excluding marijuana[i]	46 (8.3)	33.1	3.42 (1.36, 8.63)
Single-drug injection[j]	35 (6.5)	67.6	14.44 (5.42, 38.50)
Multiple-drug injection[k]	76 (13.8)	82.4	32.50 (13.16, 80.29)
Alcohol			
Alcohol dependence, lifetime[d,e]			
Yes	155 (29.7)	32.0	1.46 (0.97, 2.20)
No	373 (70.3)	24.4	Ref.
Binge drinking, past 12 months[b]			
Yes	221 (42.1)	32.7	1.70 (1.15, 2.50)
No	313 (57.9)	22.3	Ref.

Distribution of HCV

Total sample. In bivariate analysis of the total sample (Table 1), HCV prevalence was significantly higher among participants who were male, older (≥40 years of age), less educated, U.S.-born, former prison inmates, and lifetime injectors (especially injectors of mixed drugs). More than half (59.3%) of those with HCV infection disclosed having ever injected drugs, while 40.7% with HCV did not report this well-known HCV risk factor (data not shown).

In the total sample, HCV was also significantly higher among participants who met diagnostic criteria for drug dependence generally and for opiate dependence specifically, and among participants who reported ever smoking crack or other drugs or intranasal use of cocaine. Finally, HCV was significantly higher among MSM, as well as participants with recent binge drinking,

Table 1 (continued). HCV seroprevalence, by risk factor, among urban homeless adults in downtown Los Angeles, California, 2003–2004

Variable	Sample N (percent)	HCV-positive Percent	OR (95% CI)
Sexual behavior			
MSM, lifetime (among 424 males reporting)[c]			
Yes	79 (17.7)	39.5	1.75 (1.04, 2.94)
No	345 (82.3)	27.2	Ref.
Sex for cash, lifetime[a]			
Yes	115 (21.4)	40.1	2.26 (1.46, 3.50)
No	418 (78.6)	22.9	Ref.
Sex for drugs, lifetime			
Yes	84 (14.7)	31.1	1.30 (0.77, 2.19)
No	449 (85.3)	25.8	Ref.
Syphilis, lifetime[b]			
Yes	48 (8.4)	43.3	2.27 (1.21, 4.28)
No	486 (91.6)	25.1	Ref.
Gonorrhea, lifetime[b]			
Yes	108 (1.9)	39.4	2.10 (1.30, 3.40)
No	426 (80.9)	23.7	Ref.
Chlamydia, lifetime			
Yes	33 (6.1)	28.4	1.12 (0.50, 2.49)
No	498 (93.9)	26.3	Ref.
≥5 sex partners, past 12 months			
Yes	104 (19.5)	26.0	1.05 (0.64. 1.70)
No	429 (80.5)	28.4	Ref.

Note: Percentages are weighted; sample sizes are unweighted.

[a]$p<0.001$

[b]$p<0.01$

[c]$p<0.05$

[d]$p<0.10$

[e]Assessed with computerized Diagnostic Interview Schedule, Version IV (based on Diagnostic and Statistical Manual of the American Psychiatric Association, Version IV criteria)

[f]Mixed injection drug use (i.e., combined two or more drugs during the same injection)

[g]Categories are mutually exclusive, with participants assigned to their most severe drug-use category.

[h]Non-injection drug user who reported lifetime marijuana use

[i]Non-injection drug user who did not report lifetime marijuana use

[j]Single-drug injector

[k]Multiple-drug injector (i.e., injected more than one drug, at the same time or at different times)

HCV = hepatitis C virus

OR = odds ratio

CI = confidence interval

Ref. = reference group

MSM = men who have sex with men

lifetime syphilis or gonorrhea, and lifetime receipt of cash for sex work. HCV was only marginally higher among people with alcohol dependence and those who reported transfusion of blood products before 1990.

Injector vs. non-injector subgroups

Injectors. One-fifth of the total sample (20.4%) reported lifetime injection drug use (Table 1). Among injectors, 77.6% tested HCV-positive.

In bivariate analysis of injectors, HCV infection was significantly higher among black vs. white participants (OR=3.10) and among those who were older (OR=5.46) or had a prison history (OR=3.82) (Table 2). HCV was also significantly higher among those who had injected for more than 20 years vs. those who had injected drugs for <20 years. Compared with other injectors, the rate of HCV infection was lower among MSM injectors.

Compared with single-drug injectors, HCV rates were significantly higher among multiple-drug injectors. Bivariate analysis revealed that compared with single-drug injectors, significantly more multiple-drug injectors reported use of drug-injection paraphernalia that someone else had already used, including solutions (44.6% vs. 13.9%, $p<0.01$); water, cookers, or cotton (60.1% vs. 34.6%, $p<0.05$); and borrowed needles or syringes (57.1% vs. 26.6%, $p<0.01$). Compared with single-drug injectors, significantly more multiple-drug injectors also had injected in shooting galleries or in other places where they did not know who else had used the equipment before them (27.6% vs. 7.8%, $p<0.05$). Further, more multiple-drug injectors than single-drug injectors reported overdoses (31.3% vs. 11.0%, $p<0.05$) (data not shown).

Non-injectors. In the non-injector subgroup (Table 2), 13.6% tested positive for HCV. In bivariate analysis among non-injectors, HCV rates were significantly higher among participants who were older and less educated, used non-injection drugs (excluding marijuana), had three or more tattoos, or had a prison history.

Multivariable analysis of HCV infection

Total sample. Multivariate analysis is presented in Table 3. Pattern of lifetime drug use was associated with HCV infection. Compared with non-drug users in the total sample, multiple-drug injectors had 27.1 times the odds of HCV infection, single-drug injectors had 12.5 times the odds of HCV infection, and users of non-injection drugs (excluding marijuana) had 2.9 times the odds of HCV infection. HCV infection rates for non-injection drug users (including marijuana) did not differ from those who reported no drug use. Other important independent predictors of HCV infection for the total sample included older age, less education, and having been in prison.

While histories of intranasal drug use or smoking of crack or other drugs were significant at the bivariate level for the total sample, neither had an independent relationship with HCV in the multivariate analysis. Similarly, despite significant associations with HCV at the bivariate level, none of the sexual risk behaviors demonstrated an independent association with HCV infection after controlling for other variables.

Injector vs. non-injector subgroups

Injectors. For the lifetime injector subgroup (Table 3), HCV infection was independently associated with older age and prison history. Among injectors, ever using cocaine intranasally was protective against HCV infection.

In two separate multiple logistic regression models for injectors, neither multiple-drug injection nor mixed-drug injection was significantly associated with HCV infection, perhaps due to the small sample size of injectors.

Non-injectors. In the regression model for the residual group of reported non-injectors (Table 3), use of non-injection drugs (excluding marijuana), three or more tattoos, older age, and less education were each independently associated with HCV infection.

HCV awareness, testing, counseling, and treatment

Nearly half (46.1%) of HCV-infected participants were not aware of their infection status before we tested them. Rates of previous HCV testing were 35.5% of the total sample, 51.2% of those testing HCV-positive, and 48.9% of lifetime injectors. Most participants had never received counseling about HCV (including 72.6% of the total sample, 65.2% of those testing HCV-positive, and 60.5% of injectors) (data not shown).

Among participants who were aware of their HCV infection (i.e., they reported previous HCV diagnosis and serotested HCV-positive), 39.5% had ever been referred for HCV-related care, 5.2% had ever received HCV-related medical care, and only 3.1% were currently receiving HCV-related medical care.

DISCUSSION

Since the identification of HCV in 1989[30] and its classification as a leading emerging disease, questions persist about the intensity of its proliferation. Four times as prevalent as chronic HIV infection,[5] HCV has infected an estimated 2.7–3.9 million Americans.[2] HCV is more viable than HIV because it spreads and maintains infectiousness more easily, which contributes to its higher proliferation.[31,32] The primary identified means of transmission historically included injection drug use, blood transfusions or donated organs before 1992, hemodialysis, birth to an infected mother, needlesticks, and unsafe therapeutic injections.[33,34] Other transmission modes have also been implicated, including sexual contact, nonsterile application of tattoos and body piercings, sharing of straws used to inhale cocaine or other drugs, and smoking crack cocaine.[33,35]

HCV prevalence among homeless people in Skid Row
In this representative community-based sample of homeless adults in the Skid Row area of LA, lifetime prevalence of HCV infection was 26.7%. This rate is comparable with lower estimates reported for U.S. homeless adults based on clinical or convenience samples (19%–69%).[5,7–9,11–13,36] However, it contrasts

Table 2. HCV seroprevalence among urban homeless adults, by risk factor, stratified by drug injection: downtown Los Angeles, California, 2003–2004

Variable	Injector group			Non-injector group		
	N (percent)	HCV Percent	OR (95% CI)	N (percent)	HCV Percent	OR (95% CI)
Total sample	111 (100.0)	77.6		423 (100.0)	13.6	
Demographics						
Age (in years)		[a]			[b]	
18–39	92 (15.4)	47.5	Ref.	2,118 (9.3)	5.4	Ref.
≥40	19 (84.6)	83.2	5.46 (1.83, 16.27)	7,305 (0.8)	17.0	3.60 (1.56, 8.31)
Gender						
Male	102 (91.4)	78.1	1.33 (0.30, 5.95)	7,322 (6.7)	14.5	1.43 (0.70, 2.92)
Female	9 (8.7)	72.8	Ref.	101 (23.3)	10.6	Ref.
Race/ethnicity		[b]				
White	21 (20.9)	66.5	Ref.	50 (11.1)	6.0	Ref.
African American	73 (65.1)	86.1	3.10 (1.03, 9.35)	300 (70.7)	13.1	2.35 (0.67, 8.17)
Latino/Hispanic	13 (11.7)	64.4	0.91 (0.22, 3.84)	44 (11.0)	18.7	3.58 (0.87, 14.65)
Other	4 (3.3)	25.1	0.17 (0.01, 2.12)	29 (7.2)	22.7	4.58 (1.05, 19.90)
Education completed					[b]	
≤9th grade	15 (15.6)	79.1	Ref.	388 (7.6)	30.0	Ref.
≥10th grade	74 (84.4)	77.4	0.87 (0.70, 1.09)	35 (92.4)	12.3	0.33 (0.15, 0.74)
Veteran						
Yes	26 (20.4)	92.5	4.38 (0.85, 22.49)	82 (19.4)	10.7	0.71 (0.33, 1.53)
No	85 (79.6)	73.8	Ref.	341 (80.6)	14.3	Ref.
Born in U.S.						
Yes	106 (95.6)	80.3	15.61 (0.66, 147.11)	377 (88.5)	13.7	1.03 (0.43, 2.48)
No	5 (4.4)	20.7	Ref.	46 (11.5)	13.3	Ref.
History of homelessness						
In shelter, previous night						
Yes	32 (31.6)	77.4	0.98 (0.38, 2.55)	131 (36.1)	12.7	0.89 (0.49, 1.60)
No	79 (68.4)	77.8	Ref.	292 (63.9)	14.1	Ref.
Chronic homelessness, ≥12 months						
Yes	83 (73.7)	80.3	1.75 (0.67, 4.57)	310 (70.0)	13.8	1.04 (0.56, 1.91)
No	28 (26.3)	70.1	Ref.	112 (30.0)	13.4	Ref.
Institutional history						
Prison, lifetime		[b]			[c]	
Yes	48 (43.2)	89.3	3.82 (1.32, 11.06)	106 (24.3)	19.9	1.94 (1.07, 3.51)
No	62 (56.8)	68.5	Ref.	316 (75.8)	11.4	Ref.
Psychiatric hospitalization, lifetime						
Yes	29 (27.9)	69.9	0.56 (0.22, 1.44)	71 (16.4)	10.4	0.70 (0.31, 1.59)
No	82 (72.1)	80.6	Ref.	352 (83.6)	14.3	Ref.
Potential transmission						
Transfusion blood products before 1990						
Yes	18 (14.3)	86.1	1.92 (0.43, 8.60)	30 (8.2)	15.5	1.17 (0.45, 3.08)
No	93 (85.7)	76.2	Ref.	391 (91.8)	13.5	Ref.
≥3 tattoos, lifetime					[b]	
Yes	12 (12.5)	70.2	0.65 (0.18, 2.32)	43 (10.9)	26.7	2.64 (1.27, 5.46)
No	94 (87.5)	78.5	Ref.	371 (89.1)	12.1	Ref.
Mental health						
Major depression, lifetime[d]						
Yes	44 (42.9)	70.8	0.76 (0.48, 1.19)	126 (29.1)	15.9	1.28 (0.71. 2.31)
No	64 (57.1)	81.0	Ref.	292 (70.9)	12.9	Ref.
Schizophrenia, lifetime[d]						
Yes	8 (9.5)	80.5	1.23 (0.24, 6.23)	30 (6.5)	7.5	0.49 (0.12, 2.11)
No	101 (90.6)	76.5	Ref.	389 (93.5)	14.2	Ref.

Table 2 (continued). HCV seroprevalence among urban homeless adults, by risk factor, stratified by drug injection: downtown Los Angeles, California, 2003–2004

Variable	Injector group			Non-injector group		
	N (percent)	HCV Percent	OR (95% CI)	N (percent)	HCV Percent	OR (95% CI)
Drugs						
Drug dependence, lifetime						
Yes	63 (57.5)	76.6	0.90 (0.36, 2.24)	117 (27.0)	17.5	1.51 (0.83, 2.72)
No	46 (42.5)	78.4	Ref.	302 (73.0)	12.4	Ref.
Cocaine dependence, lifetime[d]						
Yes	54 (47.4)	72.9	0.61 (0.25, 1.51)	110 (25.4)	15.8	1.25 (0.68, 2.31)
No	55 (52.6)	81.4	Ref.	308 (74.6)	13.1	Ref.
Amphetamine dependence, lifetime[d]						
Yes	17 (14.5)	68.6	0.58 (0.19, 1.76)	16 (3.3)	31.5	3.05 (0.95, 9.75)
No	92 (83.6)	79.1	Ref.	403 (96.7)	13.1	Ref.
Opiate dependence, lifetime[d]						
Yes	22 (21.8)	91.4	3.83 (0.85, 17.30)	4 (1.2)	37.2	3.81 (0.63, 23.02)
No	87 (78.2)	73.5	Ref.	415 (98.8)	13.5	Ref.
Injection drug use, past 12 months						
Yes	79 (71.2)	79.6	1.14 (0.29, 4.45)	NA	NA	NA
No	32 (28.8)	77.4	Ref.	NA	NA	NA
Injection drug use ≥20 years		[b]				
Yes	69 (63.3)	87.6	4.65 (1.78, 12.10)	NA	NA	NA
No	42 (36.7)	60.4	Ref.	NA	NA	NA
Drug smoker (crack or other drug), lifetime						
Yes	101 (89.9)	79.1	2.06 (0.55. 7.67)	260 (62.2)	14.7	1.28 (0.71, 2.31)
No	10 (10.1)	64.8	Ref.	163 (37.8)	11.8	Ref.
Intranasal cocaine use, lifetime						
Yes	79 (72.6)	74.1	0.43 (0.13, 1.37)	128 (30.9)	13.0	0.92 (0.50, 1.69)
No	32 (27.4)	87.1	Ref.	295 (69.2)	13.9	Ref.
Drug use, lifetime[e]					[c]	
No drug use	NA	NA	NA	80 (17.9)	12.6	Ref.
Non-injection drug use, including marijuana[f]	NA	NA	NA	29 (71.8)	11.1	0.97 (0.46, 2.04)
Non-injection drug use, excluding marijuana[g]	NA	NA	NA	46 (10.4)	33.1	3.06 (1.23, 7.63)
Single-drug injection[h]	35 (32.1)	67.6	Ref.	NA	NA	NA
Multiple-drug injection[i]	76 (67.9)	82.4	2.25 (0.90, 5.64)	NA	NA	NA
Mixed-drug injection, lifetime[j]						
Yes	53 (48.3)	84.8	2.29 (0.89, 5.91)	NA	NA	NA
No	58 (51.7)	70.9	Ref.	NA	NA	NA
Alcohol						
Alcohol dependence, lifetime[a]						
Yes	45 (39.7)	70.0	0.50 (0.20, 1.24)	110 (27.2)	17.9	1.57 (0.87, 2.83)
No	64 (60.3)	82.2	Ref.	309 (72.8)	12.2	Ref.
Binge drinking, past 12 months						
Yes	65 (59.3)	74.5	0.63 (0.24, 1.61)	156 (37.7)	15.9	1.35 (0.77, 2.38)
No	46 (40.7)	82.3	Ref.	267 (62.3)	12.2	Ref.

starkly with the 1.6%–2.0% HCV prevalence estimated for the U.S. general population (in part, the high contrast is exaggerated by the younger age range of the NHANES comparison group [those aged 6 years and older], which includes very low-risk young people).[2–5]

HCV risk factors

Injection drug use. Consistent with the literature on HCV among general[1,37,38] and homeless[6] populations,[8,10] the strongest independent predictor of HCV infection in this sample was lifetime injection drug use. Similar to the general population,[1] other independent predictors

Table 2 (continued). HCV seroprevalence among urban homeless adults, by risk factor, stratified by drug injection: downtown Los Angeles, California, 2003–2004

Variable	Injector group			Non-injector group		
	N (percent)	HCV Percent	OR (95% CI)	N (percent)	HCV Percent	OR (95% CI)
Sexual behavior						
MSM, lifetime (among males reporting: 102 injectors, 322 non-injectors)						
Yes	33 (33.4)	63.6	0.30 (0.11, 0.79)	46 (13.0)	20.6	1.65 (0.72, 3.75)
No	69 (66.6)	85.4	Ref.	276 (87.0)	13.6	Ref.
Sex for cash, lifetime						
Yes	41 (38.7)	78.9	1.13 (0.45, 2.84)	74 (17.0)	17.5	1.46 (0.74, 2.90)
No	70 (61.4)	76.9	Ref.	348 (83.0)	12.7	Ref.
Sex for drugs, lifetime						
Yes	30 (25.2)	70.1	0.58 (0.22, 1.54)	54 (12.0)	10.2	0.70 (0.27, 1.82)
No	81 (74.8)	80.2	Ref.	368 (88.0)	13.9	Ref.
Syphilis, lifetime						
Yes	15 (14.4)	93.2	4.59 (0.62, 34.11)	33 (6.9)	16.4	1.27 (0.46, 3.53)
No	96 (85.6)	75.0	Ref.	390 (93.1)	13.4	Ref.
Gonorrhea, lifetime						
Yes	41 (37.6)	83.9	1.84 (0.69, 4.92)	67 (14.3)	9.6	0.63 (0.26, 1.57)
No	70 (42.4)	73.9	Ref.	356 (85.7)	14.3	Ref.
Chlamydia, lifetime						
Yes	12 (9.8)	64.2	0.48 (0.13, 1.83)	21 (5.1)	11.3	0.81 (0.21, 3.15)
No	98 (90.2)	78.4	Ref.	400 (94.9)	13.6	Ref.
≥5 sex partners, past 12 months						
Yes	31 (29.6)	72.4	0.66 (0.26, 1.70)	73 (16.3)	6.5	0.39 (0.14, 1.07)
No	80 (70.4)	79.8	Ref.	349 (83.7)	15.0	Ref.

Note: Percentages are weighted; sample sizes are unweighted. Percentages may sum to >100% due to rounding.

[a]p<0.001

[b]p<0.01

[c]p<0.05

[d]Based on the Diagnostic Interview Schedule, Version IV

[e]Categories are mutually exclusive, with participants assigned to their most severe drug-use category.

[f]Non-injection drug use including marijuana: those who reported lifetime marijuana use and use of other non-injection drugs

[g]Non-injection drug use excluding marijuana: those who reported no lifetime marijuana use but use of other non-injection drugs

[h]Single-drug injector

[i]Multiple-drug injector indicates someone who injected more than one drug, at the same time or at different times.

[j]Mixed injection drug use indicates someone who combined two or more drugs during the same injection.

HCV = hepatitis C virus

OR = odds ratio

CI = confidence interval

Ref. = reference group

NA = not applicable

MSM = men who have sex with men

of HCV among injectors included older age and prison history. Injectors had a much higher HCV prevalence (77.6%) compared with reported non-injectors in this sample (13.6%), and compared with injectors of similar age in the U.S. general population (58%).[2] The rates of injection drug use and HCV among injectors in the sample were similar to those for a general homeless sample.[11] However, the rate of injection drug use in this study was lower compared with previous studies of high-risk homeless subsamples.[6–10,12,13]

Patterns of injection drug use associated with HCV infection. Among the total sample, participants with a lifetime drug-use pattern that included injection of multiple

Table 3. Results of logistic regression analysis for HCV infection among urban homeless adults in downtown Los Angeles, California, 2003–2004

Characteristic	Total sample (n=526) OR (95% CI)	Injectors (n=110) OR (95% CI)	Non-injectors (n=412) OR (95% CI)
Age ≥40 years	4.34 (2.12, 8.88)[a]	3.64 (1.02, 12.95)[b]	4.69 (1.97, 11.18)[c]
Higher education (≥10 years)	0.86 (0.75, 0.98)[b]	NA	0.87 (0.76, 1.00)[b]
Prison history	1.92 (1.10, 3.34)[b]	4.55 (1.23, 16.85)[b]	
≥3 tattoos, lifetime	NA	NA	2.75 (1.13, 6.69)[b]
Drug-use pattern, lifetime (vs. no drug use)[d]			
Non-injection drug use, including marijuana[e]	0.76 (0.33, 1.74)	NA	0.87 (0.38, 2.01)
Non-injection drug use, excluding marijuana[f]	2.87 (1.02, 8.07)[b]	NA	3.08 (1.11, 8.54)[b]
Single-drug injection[g]	12.54 (4.00, 39.28)[a]	NA	NA
Multiple-drug injection[h]	27.10 (9.48, 77.46)[a]	NA	NA
Intranasal cocaine use, lifetime	NA	0.26 (0.08, 0.87)[b]	NA

Note: Percentages are weighted; sample sizes are not weighted. Sample sizes are reduced due to list-wise deletion of missing values.

[a]$p<0.001$

[b]$p<0.05$

[c]$p<0.01$

[d]Categories are mutually exclusive, with participants assigned to their most severe drug-use category.

[e]Those who reported lifetime marijuana use and/or use of other non-injection drugs, but no injection drug use

[f]Those who did not report lifetime marijuana use but reported use of other non-injection drugs

[g]Single-drug injectors only injected one drug during their lifetime.

[h]Multiple drug injectors injected more than one drug during their lifetime, during the same injection or at different times.

HCV = hepatitis C virus

OR = odds ratio

CI = confidence interval

NA = not applicable

drugs (whether injected singly or in combination) had twice the odds of having HCV compared with single-drug injectors.[37] Higher HCV rates among multiple-drug injectors have been reported elsewhere.[39] Increased odds of HCV infection among multiple-drug injectors may be due to more high-risk injection practices (e.g., sharing injection paraphernalia), as reported in the current study.

Non-injection drug use independently associated with HCV infection. Use of non-injection drugs has been found to be associated with HCV infection among the general population.[1,40] For the overall homeless sample and for the non-injector subgroup, HCV infection was independently associated with a lifetime pattern of drug use that excluded injection drugs and marijuana.

Contrary to expectation, however, this finding was apparently not due to smoking (e.g., crack) or "snorting" (inhaling) drugs. In bivariate analysis of non-injectors, HCV was not significantly higher among those who reported these suspected risk behaviors.

The relatively high prevalence of HCV infection among the non-injector subgroup may represent under-reported injection drug use, which led to misclassification of injectors as non-injectors and subsequent artifi-

cial inflation of HCV infection in the group reporting a lifetime pattern of drug use that excluded injection drugs and marijuana. No findings in this study offer an alternative explanation.

However, in this sample, not all non-injection drug use was associated with HCV. For example, the lifetime pattern of drug use that excluded injection drugs but included marijuana included participants who reported marijuana as their only drug use. This second group of non-injectors was not independently associated with HCV infection.

Prison history associated with higher HCV rates

Prison history was an independent predictor of HCV infection among the total sample and among injectors. Increased testing and counseling about HCV and substance use upon prison entry and release into the community are needed as part of HCV reduction efforts.[14]

Tattoos associated with HCV among non-injection drug users

HCV infection was 13.6% among non-injection drug users. Controlling for important covariates, non-injection drug participants who reported three or more

tattoos had greater odds of HCV infection than those with fewer or no tattoos. Numerous studies suggest that people with tattoos are at increased risk for HCV,[41–45] although there is controversy about the role of tattoos in HCV transmission.[33,46–48]

"Hidden" hepatitis C and unmet need for treatment
This study documented a high rate of hidden HCV infection among homeless adults. That is, nearly half of homeless adults with HCV infection were unaware of their HCV status. Only half of those with HCV infection had ever been tested for HCV.

The lack of awareness of HCV infection can have serious consequences. First, if individuals do not know their HCV infected status, they can inadvertently infect others. Furthermore, most people exposed to HCV in the U.S. general population develop chronic HCV (85%–95%) and never clear the virus from their systems.[49] If unaware of their infections, they will not seek out primary or specialty health care to monitor and treat their HCV, which can lead to long-term risk for serious medical problems (e.g., cirrhosis, end-stage liver disease, liver transplantation, or hepatocellular carcinoma) and even death.[5] Because most HCV-infected injectors in this study first used injection drugs 20 or more years ago, the majority may soon need costly medical care.[14] Studies are needed to identify barriers to testing and treatment of homeless people and to determine the degree to which early screening and appropriate treatment of HCV infection might reduce serious long-term health problems and costs associated with chronic HCV infection.

Only one-quarter of the sample had ever received any counseling or education about the prevention, consequences, and transmission of HCV. Even among those who correctly knew that they were infected, few had received any HCV-related medical care. These findings demonstrate a clear unmet need for prevention, screening, and treatment interventions among this high-risk population.[50,51]

Our findings reinforce the recommendation that clinicians screen (i.e., test) homeless adults for HCV, particularly those reporting a history of injection drug use, a prison stay, unspecified hepatitis, or HIV.[2] Using the CDC-recommended method for HCV screening,[27] only 13% of homeless adults who tested HCV-positive on initial screening with ELISA required the more costly RIBA test for confirmation. Thus, voluntary testing for all homeless adults, especially those at high risk for HCV, should be feasible, even with fiscal constraints.

Limitations
This study was subject to several limitations. While HCV, HIV, and ALT status were assessed with blood tests, most measures were based on self-report, which can be subject to recall bias and other measurement errors (e.g., injection drug use may have been underreported due to stigma, possibly inflating the rate of HCV infection among reported non-injectors). Also, sampling error may have resulted from a strategy that targeted only meal and shelter programs; however, previous studies[21,52] suggest that similar sampling frames have captured the great majority (85%–94%) of homeless adults in U.S. urban areas. Additionally, findings may not generalize beyond the population and geographic area studied; however, our sample demographics parallel other rigorous studies of homeless adults in U.S. urban areas.[18,19,53,54] Furthermore, cost constraints prevented blood testing of HCV-positive cases for current HCV infectiousness and the prevalence of chronic HCV. Finally, given the study's cross-sectional design, causal inferences cannot be made about the associations between HCV infection and independent risk factors (e.g., multiple-drug injection, non-injection drug use, prison, or tattoos).

Despite these limitations, as far as we know, this is the first estimate of HCV infection rates among urban homeless adults in the U.S. reported for a population-based probability sample. Previous studies have been largely based on convenience, clinical, or subgroup samples, which have problems with their generalizability to the larger urban homeless population.[13]

CONCLUSIONS

This and previous studies suggest that U.S. urban homeless adults are at high risk for HCV infection. Findings further suggest that as many as half of those infected with HCV may be unaware of their infection. Homeless adults need interventions that include HCV education, counseling, voluntary testing, and treatment services. HCV prevention and treatment programs could be modeled after successful HIV/AIDS interventions developed for shelters, meal programs, health clinics, substance abuse treatment programs, outreach, and other service programs. If resources are limited, findings suggest that interventions prioritize urban homeless subgroups that are at the highest risk for HCV infection; that is, those with a history of injection drug use, time spent in prison, and multiple tattoos.

REFERENCES

1. Alter MJ, Kruszon-Moran D, Nainan OV, McQuillan GM, Gao F, Moyer LA, et al. The prevalence of hepatitis C virus infection in the United States, 1988 through 1994. N Engl J Med 1999;341:556-62.
2. Armstrong GL, Wasley A, Simard EP, McQuillan GM, Kuhnert WL, Alter MJ. The prevalence of hepatitis C virus infection in the United States, 1999 through 2002. Ann Intern Med 2006;144:705-14.
3. Gish RG. Treating hepatitis C: the state of the art. Gastroenterol Clin North Am 2004;33(1 Suppl 1):S1-9.
4. Chak E, Talal AH, Sherman KE, Schiff ER, Saab S. Hepatitis C virus infection in USA: an estimate of true prevalence. Liver Int 2011;31:1090-101.
5. Institute of Medicine. Hepatitis and liver cancer: a national strategy for prevention and control of hepatitis B and C. Washington: National Academies Press; 2010.
6. Klinkenberg WD, Caslyn RJ, Morse GA, Yonker RD, McCudden S, Ketema F, et al. Prevalence of human immunodeficiency virus, hepatitis B, and hepatitis C among homeless persons with co-occurring severe mental illness and substance use disorders. Compr Psychiatry 2003;44:293-302.
7. Schwarz KB, Garrett B, Alter MJ, Thompson D, Strathdee SA. Seroprevalence of HCV infection in homeless Baltimore families. J Health Care Poor Underserved 2008;19:580-7.
8. Cheung RC, Hanson AK, Maganti K, Keeffe EB, Matsui SM. Viral hepatitis and other infectious diseases in a homeless population. J Clin Gastroenterol 2002;34:476-80.
9. Desai RA, Rosenheck RA, Agnello V. Prevalence of hepatitis C virus infection in a sample of homeless Veterans. Soc Psychiatry Psychiatr Epidemiol 2003;38:396-401.
10. Stein JA, Nyamathi A. Correlates of hepatitis C virus infection in homeless men: a latent variable approach. Drug Alcohol Depend 2004;75:89-95.
11. Nyamathi AM, Dixon EL, Robbins W, Smith C, Wiley D, Leake B, et al. Risk factors for hepatitis C virus infection among homeless adults. J Gen Intern Med 2002;17:134-43.
12. Hall CS, Charlebois ED, Hahn JA, Moss AR, Bangsberg DR. Hepatitis C virus infection in San Francisco's HIV-infected urban poor. High prevalence but low treatment rates. J Gen Intern Med 2004;19:357-65.
13. Strehlow AJ, Robertson MJ, Zerger S, Rongey C, Arangua L, Farrell E, et al. Hepatitis C among clients of health care for the homeless primary care clinics. J Health Care Poor Underserved 2012. In press.
14. Gish RG, Afdhal NH, Dieterich DT, Reddy KR. Management of hepatitis C virus in special populations: patient and treatment considerations. Clin Gastroenterol Hepatol 2005;3:311-8.
15. McKinney-Vento Homeless Assistance Act. Public Law 100-77 (1987).
16. Manly JJ, Bell-McGinty S, Tang MX, Schupf N, Stern Y, Mayeux R. Implementing diagnostic criteria and estimating frequency of mild cognitive impairment in an urban community. Arch Neurol 2005;62:1739-46.
17. Koegel P, Burnam MA, Farr RK. The prevalence of specific psychiatric disorders among homeless individuals in the inner city of Los Angeles. Arch Gen Psychiatry 1988;45:1085-92.
18. Robertson MJ, Clark RA, Charlebois ED, Tulskey J, Long HL, Bangsberg DR, et al. HIV seroprevalence among homeless and marginally housed adults in San Francisco. Am J Public Health 2004;94:1207-17.
19. Robertson MJ, Zlotnick C, Westerfelt A. Drug use disorders and treatment contact among homeless adults in Alameda County, California. Am J Public Health 1997;87:221-8.
20. Smith EM, North CS, Spitznagel EL. Are hard-to-interview street dwellers needed in assessing psychiatric disorders in homeless men? Int J Methods Psychiatr Res 1991;1:69-78.
21. Burnam MA, Koegel P. Methodology for obtaining a representative sample of homeless persons. The Los Angeles Skid Row Study. Eval Rev 1988;12:117-52.
22. Vernez G, Burnam MA, McGlynn EA, Trude S, Mattman BS. Review of California's program for the homeless mentally disabled [R-3631-CDMH]. Santa Monica (CA): The RAND Corp.; 1988.
23. RAND Survey Research Group. Downtown health project hepatitis study summary report. Santa Monica (CA): RAND Corp.; 2004.
24. Robins L, Cottler L, Bucholz K, Compton W. C-DIS-IV: computerized diagnostic interview schedule, version IV. St. Louis: Washington University in St. Louis Department of Psychiatry; 2000.
25. Kral AH, Bluthenthal RN, Booth RE, Watters JK. HIV seroprevalence among street-recruited injection drug and crack cocaine users in 16 US municipalities. Am J Public Health 1998;88:108-13.
26. Des Jarlais DC, Hagen H, Arasteh K, McKnight C, Semaan S, Perlman DC. Can intranasal drug use reduce HCV infection among injecting drug users? Drug Alcohol Depend 2011;119:201-6.
27. Alter MJ, Kuhnert WL, Finelli L. Guidelines for laboratory testing and result reporting of antibody to hepatitis C virus. MMWR Recomm Rep 2003;52(RR-3):1-13, 15.
28. SAS Institute, Inc. SAS®: Version 6.12. Cary (NC): SAS Institute, Inc.; 1999.
29. Stata Corp. Stata®: Release 5. College Station (TX): Stata Corp.; 1993.
30. Choo QL, Kuo G, Weiner AJ, Overby LR, Bradley DW, Houghton M. Isolation of a cDNA clone derived from a blood-borne non-A, non-B viral hepatitis genome. Science 1989;244:359-62.
31. Krawczynski K, Alter MJ, Robertson BH, Lu L, Spelbring JE, McCaustland KA. Environmental stability of hepatitis C virus (HCV): viability of dried/stored HCV in chimpanzee infectivity studies. Program and Abstracts of the 54th Annual Meeting of the American Society for the Study of Liver Disease. Philadelphia: W.B. Saunders; 2003.
32. Centers for Disease Control and Prevention (US). HIV/AIDS basics: how well does HIV survive outside the body? [cited 2009 Oct 22]. Available from: URL: http://www.cdc.gov/hiv/resources/qa/qa35.htm
33. Alter MJ. Epidemiology of hepatitis C virus infection. World J Gastroenterol 2007;13:2436-441.
34. Centers for Disease Control and Prevention (US). The ABCs of hepatitis (publication no. 21-1076) [cited 2011 Dec 9]. Available from: URL: http://www.cdc.gov/hepatitis/Resources/Professionals/PDFs/ABCTable.pdf
35. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. The Lancet 2005;5:558-67.
36. Rosenblum A, Nuttbrock L, McQuistion HL, Magura S, Joseph H. Hepatitis C and substance use in a sample of homeless people in New York City. J Addict Dis 2001;20:15-25.
37. Williams IT, Boaz K, Openo K, Avent K, Bedell M, Gill J, et al. Incidence and risk factors for hepatitis C in the USA, 1982–2004: the role of injection drug use. J Clin Virol 2006;36:S44.
38. Centers for Disease Control and Prevention (US). Hepatitis surveillance report #61. Department of Health and Human Services, Public Health Service (US); 2006.
39. Cook PA, McVeigh J, Syed Q, Mutton K, Bellis MA. Predictors of hepatitis B and C infection in injecting drug users both in and out of drug treatment. Addiction 2001;96:1787-97.
40. Scheinmann R, Hagan H, Lelutiu-Weinberger C, Stern R, Des Jarlais DC, Flom PL, et al. Non-injection drug use and hepatitis C virus: a systematic review. Drug Alcohol Depend 2007;89:1-12.

41. Ko YC, Ho Ms, Chiang TA, Chang SJ, Chang PY. Tattooing as a risk of hepatitis C virus infection. J Med Virol 1992;38:288-91.

42. Haley RW, Fischer RP. Commercial tattooing as a potentially important source of hepatitis C infection. Clinical epidemiology of 626 consecutive patients unaware of their hepatitis C serologic status. Medicine (Baltimore) 2001;80:134-51.

43. Haley RW, Fischer RP. The tattooing paradox. Arch Intern Med 2003;163:1095-8.

44. Nishioka SA, Gyorkos TW, Joseph L, Collet JP, MacLean JD. Tattooing and risk for transfusion-transmitted diseases: the role of the type, number and design of the tattoos, and the conditions in which they were performed. Epidemiol Infect 2002;128:63-71.

45. Nishioka SA, Gyorkos TW, Joseph L, Collet JP, MacLean J. Tattooing and transfusion-transmitted diseases in Brazil: a hospital-based cross-sectional matched study. Eur J Epidemiol 2003;18:441-9.

46. Centers for Disease Control and Prevention (US). Viral hepatitis [cited 2006 Aug 9]. Available from: URL: http://www.cdc.gov/ncidod/diseases/hepatitis/c/fact.htm

47. Silverman AL, Sekhon JS, Saginaw SJ, Wiedbrauk D, Balasubramaniam M, Gordon SC. Tattoo application is not associated with an increased risk for chronic viral hepatitis. Am J Gastroenterol 2000;95:1312-5.

48. Alter MJ. Epidemiology of hepatitis C. Hepatology 1997;26(3 Suppl 1):62S-65S.

49. Dienstag JL. Acute viral hepatitis. In: Longo DL, Fauci AS, Kasper DL, Hauser SL, Jameson JL, Loscalzo J. Harrison's principles of internal medicine. Volumes 1 and 2. 18th ed. New York: McGraw-Hill; 2011. p. 2537-57.

50. Thompson VV, Ragland KE, Hall CS, Morgan M, Bangsberg DR. Provider assessment of eligibility for hepatitis C treatment in HIV-infected homeless and marginally housed persons. AIDS 2005;19 Suppl 3:S208-14.

51. Neale J. Homelessness, drug use and hepatitis C: a complex problem explored within the context of social exclusion. Int J Drug Policy 2008;19:429-35.

52. Dennis ML. Changing the conventional rules: surveying homeless people in nonconventional locations. Housing Policy Debates 1991;2:701-32.

53. Burt MR, Aron LY, Douglas T, Valente J, Lee E, Iwen B. Homelessness: programs and the people they serve—summary report. Washington: Urban Institute; 1999.

54. Breakey WR, Fischer PJ, Kramer M, Nestadt G, Romanoski AJ, Ross A, et al. Health and mental health problems of homeless men and women in Baltimore. JAMA 1989;262:1352-7.