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# Transmission of Hepatitis C Virus Infection Through Tattooing and Piercing: A Critical Review

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## Abstract

Tattoos and piercings are increasing, especially among youths, but the risk of hepatitis C virus (HCV) infection from these practices has not been adequately assessed and there are conflicting findings in the literature. We evaluated the risk of HCV infection from tattooing and piercing using the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines. Studies that specified the venue of tattooing and/or piercing showed no definitive evidence for an increased risk of HCV infection when tattoos and piercings were received in professional parlors. However, the risk of HCV infection is significant, especially among high-risk groups (adjusted odds ratio, 2.0–3.6), when tattoos are applied in prison settings or by friends. Prevention interventions are needed to avoid the transmission of hepatitis C from tattooing and piercing in prisons, homes, and other potentially nonsterile settings. Youths also should be educated on the need to have tattoos and piercings performed under sterile conditions to avoid HCV infection.

Hepatitis C Virus (HCV) infection, which is primarily transmitted through percutaneous exposure to contaminated blood, affects approximately 3 million Americans and is the leading cause of liver cancer in the United States [1]. In 2009, an estimated 16 000 new HCV infections occurred in the United States [2]. Although injection drug use (IDU) was the main mode of transmission among patients with available risk factor information, approximately 20% of patients denied exposure to traditional risk factors, such as IDU or other parenteral exposure [2]. From 1994 through 2006, recent tattooing and piercing were reported by 6% and 5% of respondents, respectively, with acute HCV infection in the Sentinel County Surveillance System [3]. However, more than two-thirds of these patients also reported exposure to other risk factors, including IDU, which prevented drawing sound conclusions about the actual mode of transmission in those cases [3].

Although the practice of tattooing and piercing has been present for thousands of years, the numbers of tattoos and piercings have been increasing during the past decade, particularly among youths [4–7]. A 2004 survey among persons aged 18–50 years in the United States found that 24% of respondents had at least 1 tattoo and 14% had ever had body piercings

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[4]. Because of conflicting findings reported in the literature regarding the risk of transmission of hepatitis C through tattooing and piercing, the Centers for Disease Control and Prevention receives multiple inquiries by health professionals and laypersons for information on that matter.

Because of the increase in the practice of tattooing and piercing and the interest of health professionals and the public, we conducted a review of the literature to present the best available data on the risk of HCV transmission through these 2 modes. The review is intended to inform recommendations to prevent and reduce the risk of HCV transmission.

## METHODS

### Study Identification

Articles addressing the transmission of HCV through tattooing and piercing were identified through a literature search using PubMed and Medline. The search was limited to articles published from 1994 through July 2011 in all languages. A combination of the Medical Subject Headings terms “hepatitis C,” “HCV,” “tattooing,” “tattoo,” and “piercing” was used to identify potentially relevant abstracts and articles. Relevant references cited in identified studies were also assessed for inclusion. Articles published in languages other than English and French were evaluated on the basis of information included in the English abstract only. Unpublished, non-peer-reviewed studies were not retrieved because of the questionable reliability of such reports. The first author (R. T.) performed the search and retrieved the articles. Both authors (R. T. and S. H.) evaluated the validity of inclusion of each article and agreed on the strength of evidence in each based on preset ratings (Table 1).

The literature search resulted in the retrieval of 293 published articles or abstracts on HCV infection that included information about tattooing and/or piercing exposure. However, 231 studies were excluded because they were review papers (n = 47), did not measure the risk of HCV infection through tattooing or piercing (ie, relied on descriptive statistics and did not include measures of association, such as odds ratios (ORs) and relative risk; n = 163), did not control for any HCV infection risk factor (eg, drug use, transfusion before 1992, hemodialysis, contact with blood from HCV-infected person, and number of sex partners) when assessing the risk (n = 14), were duplicate studies (n = 4), were editorials or author responses (n = 2), or relied on self-reported HCV infection (n = 1). Therefore, a total of 62 articles were eligible for inclusion.

### Study Rating

We used the Meta-analysis of Observational Studies in Epidemiology and the Grades of Recommendation, Assessment, Development, and Evaluation guidelines to evaluate the quality of evidence [8, 9]. Table 1 summarizes the criteria used to evaluate and rate the strength of the evidence in each study. Final rating consisted of adding the rates in each category. Reports were evaluated on the basis of the study design, representativeness of the study population, adjustment for other HCV infection risk factors, and use of adequate laboratory testing methods for ascertainment of HCV infection. Cohort and case-control studies were given the highest rates, followed by cross-sectional studies. Case reports or

case series were rated lowest, because the sample size from these types of studies is typically insufficient to quantify risk of HCV transmission. Studies that included incident cases of HCV infection; a sample size including at least 100 cases for case-control studies and 2000 individuals for cross-sectional studies (calculated considering a power of 80%, an $\alpha$ of 0.05, and an estimated OR of 2 and taking into account the variability in HCV infection and tattoo prevalence rates in different study populations); controlled for other hepatitis C risk factors, including mainly IDU and transfusion of blood or blood products; and confirmed HCV infection with recombinant immunoblot assay or nucleic acid testing were given additional rating.

### Analysis

The magnitudes of the risk of HCV transmission through tattooing and piercing were presented as adjusted ORs (AORs) obtained by compiling AORs from studies that controlled for the most common routes of HCV transmission, particularly IDU. Because of the wide variability in the characteristics of study populations, we separately evaluated the risk of HCV infection from tattooing in the general population, blood donors, high-risk groups (ie, drug users, homeless persons, sex workers, and patients in sexually transmitted disease clinics), prisoners, and veterans. High-risk groups, prisoners, and veterans have been shown to have higher prevalence rates of IDU and HCV infection than the general population [1, 10–12], which could jeopardize analyses and conclusions if they are aggregated with low-risk groups. In addition, when information was available in the study, we separately assessed the risk of transmission of HCV infection from tattooing and piercing performed in professional parlors (ie, commercial venues that are licensed and regulated by health authorities), compared with those performed in nonprofessional settings under potentially nonsterile conditions (eg, by friends, at home, or in prison).

## RESULTS

### Association Between HCV Infection and Tattooing in the General Population

Table 2 summarizes findings from studies in the general population. Of 10 case-control studies, 6 reported no increased risk of HCV infection from tattooing when they controlled for IDU and other risk behaviors [15, 16, 18, 20–22], and 2 studies reported a 2–3 times higher risk for HCV infection when the tattoo was received in nonprofessional settings [14, 17]. One hospital-based case-control study including 64 patients and 128 control subjects did not find a significant association between tattooing and HCV infection in univariate analysis and, thus, excluded tattooing from the multivariate model [32]. Of the few reports showing an association between tattooing and HCV infection, 1 study compared 598 patients with acute HCV infection with 7221 control subjects with acute hepatitis A virus infection [13]. Patients with acute hepatitis A virus infection were younger and lived in other geographic areas, compared with those with acute HCV infection, which might affect the validity of the findings. Another study recruited 58 patients and 58 control subjects from a gastroenterology clinic, which limited generalizability of its findings [19]. More important, 29% of the originally enrolled study population admitted IDU when requestioned, and control subjects were not tested to confirm that they were not HCV infected. Moreover,

tattooing was frequently performed by family members or friends using unhygienic techniques [19].

A cross-sectional study including >5000 college students in the United States revealed no risk of HCV infection when the tattoo was performed in a professional setting (AOR, 0.8; 95% confidence interval [CI], 0.4–1.7), whereas the risk was significant for tattoos performed in nonprofessional settings (AOR, 3.5; 95% CI, 1.4–8.8) [23]. Other large cross-sectional studies indicated an association between tattooing and HCV infection but did not specify venue of tattooing [25, 26, 29]. A cross-sectional hospital-based survey in Brazil showed an increased risk of HCV infection among persons having a tattoo; however, more than half of individuals received their tattoos in nonprofessional settings using nonsterile instruments [27]. Moreover, 26% of those who had a tattoo reported IDU, compared with 0% of those who did not have a tattoo [33].

Only one early (1991–1992) cross-sectional study conducted among a selected US population (minority, indigent, and orthopedic patients) indicated a potential risk of HCV transmission by tattooing in commercial parlors [24]. One case report suggested potential hepatitis C transmission by tattooing in commercial parlors from reuse of nondisposable tattooing needles that are not appropriately sterilized [34].

### Association Between HCV Infection and Tattooing Among Blood Donors

Persons with certain high-risk behaviors are excluded from blood donation, and several countries require persons who have recently had a tattoo or body piercing to defer from blood donation for at least 6 months, leading to lower rates of risk behaviors in this population. All studies conducted among blood donors did not inquire about the venue of tattooing. As shown in Table 3, almost all studies of these low-risk individuals that controlled for major HCV infection risk factors have not reported an increased risk for HCV infection from tattooing [37–39, 42–44, 47]. Case-control studies conducted in large samples of blood donors in the United States did not show an increased risk of HCV transmission from tattooing, but did report significant associations between tattooing and IDU [43, 44].

Some studies suggest that tattoos received before 1995 increased the risk of HCV infection, whereas those received after 2005 did not [35, 36, 40, 41, 45, 46]. However, none of the studies recruited patients with incident cases, limiting the ability to draw temporal causality. One study involving blood donors in Canada found that the odds of HCV infection from tattooing were much lower among blood donors in 2005 (AOR, 2.9; 95% CI, 1.2–7.0) than among blood donors in 1993 (AOR, 8.3; 95% CI, 2.8–24.5) [32]. However, the venue of tattooing was not specified.

### Association Between HCV Infection and Tattooing Among High-Risk Groups

Table 4 summarizes the findings of studies that assessed the risk of HCV infection from tattooing in high-risk groups. Two cohort studies conducted among prisoners in Australia reported discrepant findings. The study that recruited a larger sample (n = 488) showed a significant association between tattooing and HCV infection [48]; the other study, which did not find such an association, recruited 181 prisoners, a smaller number, which might have

limited the power to demonstrate statistical significance [49]. Although cohort studies followed up with prisoners over >4 years, the presence of tattooing was assessed during their lifetime and not necessarily during their time in prison; this hinders temporal linkage between tattooing and HCV infection [48, 49].

Results from cross-sectional studies involving incarcerated individuals have been inconsistent. Two studies conducted in the United States among incarcerated youths reported no increased risk of HCV infection among those who were tattooed, even if the tattoo was applied in a nonprofessional setting [56, 58]. However, several studies from other countries found a 2–3 times higher likelihood of HCV infection among prisoners who had a tattoo [51–55, 57]. Of note, approximately 90% of prisoners received tattoos in nonprofessional settings [57]. Case reports of acute HCV infection from tattooing in prison suggest that tattooing could be the source of infection [67–69]. One case report documented seroconversion in a prisoner after a negative hepatitis C test result, and tattooing in prison was the only risk factor during the incubation period [67].

Findings from cross-sectional studies involving injection drug users varied by country, duration of injection, and incarceration [59–61]. Although the risk of HCV infection increased by 3 times among injection drug users who had tattoos applied in prison or jail, the risk was not statistically significant if the tattoos were received outside prison or jail [61]. Current noninjecting heroin users who reported never injecting drugs did not have a significantly increased risk of HCV infection from tattooing, whereas former injectors who had a tattoo had 3 times higher risk of HCV infection [63]. Other studies involving noninjection drug users reported a 2–3 times higher risk of HCV infection among those who had a tattoo [62, 64], and 1 study specified that the tattoos were applied by friends or relatives [64].

Studies involving street youths and homeless persons did not find an association between HCV infection and tattoos [65, 70], with 57% of homeless persons reporting IDU and 41% of them having shared needles with others [70].

Tattoos are highly prevalent among soldiers. Almost 36% of soldiers in the US Army had at least 1 tattoo, and 76% experienced bleeding after the procedure, which might promote transmission of blood-borne infections [71]. Studies that recruited >1000 veterans found almost 3 times higher risk of HCV infection among veterans with a tattoo, compared with those who did not have a tattoo (Table 4) [11, 12, 66]. However, in all studies, the researchers did not inquire about the venue of tattooing.

### Association Between HCV Infection and Piercing

Table 5 summarizes findings of studies that assessed the risk of HCV infection among those who reported having a body or ear piercing. The majority of studies did not distinguish between piercings received in professional settings from those received in nonprofessional settings. Only 5 of 23 studies reported an increased risk of HCV infection among persons with a piercing (AOR, 2.0–7.3) [13, 22, 43, 44, 73]. Of the 5, 2 were conducted among blood donors in the United States during the early 1990s [43, 44], with 1 study showing a

significant association between ear piercing and HCV infection only among men and no association among women [44].

Moreover, a number of cohort, case-control, and cross-sectional studies involving high-risk groups did not find significant associations between body piercing and HCV infection in univariate analysis and, thus, did not include this variable in the multivariable model [32, 48, 62, 64]. A cross-sectional study including >5000 college students in the United States did not reveal an increased risk of HCV infection among those with a body piercing [23]. Acute HCV infection occurred after ear piercing with a gun at a jeweler in an older French woman with no other identified risk factor [74]. Swapping body piercing jewelry was also reported as a potential source of HCV infection in another case report [75].

## DISCUSSION

This article critically reviewed the literature for the risk of transmission of HCV infection through tattooing and piercing by distinguishing among different study populations and careful examination of potential study limitations. To date, there is no definitive evidence that such infections occur when sterile equipment is used. Of note, no outbreaks of HCV infection have been detected in the United States that originate from professional tattoo or piercing parlors. In addition, recent cohort and case-control studies including samples from the general population or blood donors in developed countries did not show an increased risk of HCV infection with body or ear piercing.

Although commercial parlors have not been implicated in HCV transmission, such transmission could occur at different stages of tattooing and piercing, from the reuse of nondisposable needles, inappropriate sterilization of equipment, or reuse of ink contaminated with blood from an infected person. Although data on survival of hepatitis C in tattooing or piercing equipment are not available, survival of HCV ranges from a few days on inanimate surfaces to almost 1 month in propofol solutions [76–79]. Because of the potential risk of transmission of blood-borne pathogens through tattooing and piercing, the US Occupational Safety and Health Administration includes these practices in their blood-borne safety standards [80]. In addition, several countries and more than two-thirds of state health jurisdictions in the United States have additional regulations for tattoo and piercing parlors [81].

Although the majority of reviewed studies failed to report the venue of tattoo and/or piercing, studies that specified the location in the general population showed a significant increase in risk of HCV infection when the tattoo was done in nonprofessional settings [14, 17, 19, 23, 27]. In addition, the risk of HCV infection is significant among high-risk groups when nonsterile tattooing equipment is used, especially in unregulated settings, such as homes or prison (AOR, 2.0–3.6) [48, 57, 61, 64]. Although location of tattooing was not specified in all studies including prisoners, this population seems to be at increased risk of HCV infection from tattooing, according to the available data [48, 51–56]. Tattooing in prison is of particular concern because of the high prevalence of tattooing among incarcerated persons, reaching up to 40% in some studies [57, 82]. Tattooing in this setting typically is performed using nonsterile equipment, such as guitar strings, paper clips, or

sewing needles, which are usually cleaned by heating or use of boiling water [82]. The strong association between tattoos received in prison and HCV infection may in part be confounded by other high-risk behaviors, such as IDU, or may be a consequence of an association between history of imprisonment and dangerous lifestyles. Prisoners with a history of IDU were 5 times more likely to have a tattoo and were significantly more likely to have acquired the tattoo in prison [57]. Qualitative studies might be helpful to identify successful techniques to prevent blood-borne viruses in prison environments and among high-risk groups [61].

A major limitation, common to all studies, was the reliance on self-reports for the ascertainment of IDU. Tattoos and drugs often coexist, and the risk of HCV infection among tattooed individuals consistently has been shown to be related to drug use [57, 59, 63, 65]. Of note, in one study, 67% of the participants who initially denied drug use at study entry subsequently admitted IDU or intranasal cocaine use [18]. In addition, almost all cohort and case-control studies did not recruit patients with incident cases of HCV infection and asked about ever having a tattoo or piercing, which hinders drawing temporal causal relationships between HCV infection and tattooing or piercing. Finally, most studies did not inquire about the venue of receipt of the tattoo or piercing. Therefore, future studies that inquire about tattooing and piercing need to specify the venue where they were received to draw more scientifically sound conclusions about the association between HCV infection and those exposures.

Although our original objective was to conduct a meta-analysis, several of the studies that found no association between HCV infection and tattooing or piercing in the univariate analysis either did not include those exposures in the multivariable analysis or did not report the AOR. Therefore, pooling the results of studies with available ORs would be inappropriate and would lead to inaccurate and false conclusions. It is recommended that upcoming studies report AORs even if they are not significant to facilitate the conduct of meta-analyses in the future.

Despite these limitations, we could evaluate the quality of the evidence in each study. The findings emphasize the need to prevent hepatitis C transmission from use of unsterile tattooing and piercing equipment, especially in prisons. Because of the increasing prevalence of tattooing and piercings, particularly among youths, awareness campaigns should highlight the danger of such procedures in unregulated and potentially unsterile environments, such as homes and prisons. In addition, tattoo and piercing parlors need to be educated about and monitored for use of proper infection control procedures to avoid isolated cases of HCV infection and other infections.

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## Table 1

Rating Criteria Used to Assess the Strength of the Evidence for Hepatitis C Virus Transmission Through Tattooing and Piercing

| Characteristic | Description of Study (Rating[a]) |
|---|---|
| Study design | Case series/report (1), cross-sectional (2), case-control (3), cohort (4) |
| Study population[b] | Hospital or clinic based (1), general population/surveillance (2) |
| Comparison population | Not representative (1), representative (2) |
| Outcome data | Prevalence (1), incidence (2) |
| Sample size | <100 cases for case-control or <2000 for cross-sectional studies (1), |
| | ≥100 cases for case-control or ≥2000 for cross-sectional studies (2) |
| Included and adjusted for confounders | Excluded IDU and transfusion (1), adjusted for IDU and transfusion (2) |
| Assessment of HCV infection | Serology only (1), serology and confirmatory RIBA or HCV RNA (2) |
| Specified venue of tattoo/piercing | No (1), yes (2) |

Abbreviations: HCV, hepatitis C virus; IDU, injection drug use; RIBA, recombinant immunoblot assay.

[a] Higher number indicates increased strength of evidence.

[b] For studies not including blood donors or high-risk groups.

**Table 2**

Studies Assessing the Transmission of Hepatitis C Virus Through Tattooing in the General Population, by Study Design and Year of Study

| Author(s) | Country (Years of Study) | Study Population | Sample Size | HCV Prevalence (%) | No. Tattooed (% HCV Infected) | Tattooing Reported as a Risk Factor; Adjusted OR (95% CI) | Location Where Tattoo Was Done |
|---|---|---|---|---|---|---|---|
| Case-control studies | | | | | | | |
| Mariano et al 2004 [13] | Italy (1997–2002) | Surveillance data | 598 acute HCV cases; 7221 acute HAV controls | … | 38 cases; 101 controls | Yes; OR = 5.6 (2.8–11) | … |
| Hand & Vasquez 2005 [14] | US (2000–02) | Hospital sample | 320 cases;307 controls[a] | … | 182 cases; 67 controls | Yes; OR = 2.9 (1.9–4.6) | Friends, relatives, prisons |
| Delarocque-Astagneau et al 2007[b] [15] | France (1998–2001) | Hepatology clinics; blood donors | 64 cases; 227 controls | … | 8 cases; 8 controls | No; OR = 2.8 (.7–10.7) | … |
| Karmochkine et al 2006 [16] | France (1997–2001) | Cases from clinics; controls from telephone survey | 450 cases; 757 controls | … | … | No | … |
| Lasher et al 2005 [17] | Hawaii (1998–99) | Cases from surveillance; controls from telephone directory | 222 cases; 699 controls | … | Professional: 67 cases vs 62 controls; nonprofessional: 32 cases vs 13 controls | Yes; OR = 2.0 (1.1–3.7) | Risk for HCV infection was double if tattoo was done in nonprofessional compared with professional settings |
| Silverman et al 2000 [18] | US (n/a) | Hospital sample | 106 cases; 106 controls | 9.4% | 106 (6.6%) | No | … |
| Balasekaran et al 1999 [19] | US (1995–96) | Clinics | 58 cases; 58 controls | … | 25 cases; 9 controls | Yes; OR = 5.9 (1.1–30.7) | Mainly by family/friends |
| Dubois et al 1997 [20] | France (1994) | Population-based | 72 cases; 144 controls | 1.05% | … | No | … |
| Sun et al 1999 [21] | Taiwan (1991–92) | Community-based | 272 cases; 282 controls | … | 7 cases; 3 controls | No; OR = 3.1 (.7–13.3) | … |
| Mele et al 1995 [22] | Italy (1985–93) | Acute surveillance | 363 cases; 4879 HAV controls | … | 6 cases; 16 controls | No; OR = 2.5 (.8–7.8) | … |
| Cross-sectional studies | | | | | | | |
| Hwang et al 2006 [23] | US (2000–01) | College students | 5282 | 0.9% | 1327 (1%) | Professional: OR = 0.8 (.4–1.7); nonprofessional: OR = 3.5 (1.4–8.8) | Yes |

| Author(s) | Country (Years of Study) | Study Population | Sample Size | HCV Prevalence (%) | No. Tattooed (% HCV Infected) | Tattooing Reported as a Risk Factor; Adjusted OR (95% CI) | Location Where Tattoo Was Done |
|---|---|---|---|---|---|---|---|
| Haley and Fisher 2001 [24] | US (1991–92) | Patients in spinal clinic | 626 | 6.9% | 113 (22.1%) | Yes; OR = 6.5 (2.9–14.8) | Commercial parlors |
| King et al 2009 [25] | France (2004) | National health insurance system | 14 416 | 0.8% | 1053 (5.3%) | Yes; OR = 2.4 (1.4–4.2) | … |
| Perez et al 2005 [26] | Puerto Rico (2001–02) | Community-based study | 970 | 6.3% | 120 (34.2%) | Yes; OR = 8.9 (1.7–44.7) | … |
| Nishioka et al 2002 [27] | Brazil (1998–2000) | Hospital-based | 345 | 9.9% | 182 (17.6%) | Yes; OR = 6.4 (1.3–31.8) | Mainly nonprofessional settings |
| La Torre et al 2006 [28] | Italy (1995–2000) | Household contacts of HCV patients | 259 | 8.9% | 8 (25%) | No; OR = 7.7 (1.0–60.2) | … |
| Dominguez et al 2001 [29] | Spain (1996) | Community-based | 2142 | 2.5% | 1258 (2.3%) | Yes; OR = 6.2 (1.9–20.9) | … |
| Brusaferro et al 1999 [30] | Italy (1994–95) | Household contacts of HCV-infected persons | 514 | 10.3% | 20 (80%) | Yes; OR = 2.5 (1.1–5.6) | … |
| Campello et al 2002 [31] | Italy (1994–95) | Community-based | 2776 | 3.3% | … | Males: OR = 3.2 (.7–13.8); Females: OR = 2.6 (.2–29.3); Total: OR = 4.2 (1.5–15.2) | … |

Abbreviations: CI, confidence interval; HAV, hepatitis A virus; HCV, hepatitis C virus; OR, odds ratio.

[a] Confirmatory HCV testing done for 40 cases only.

[B] Combined tattooing and piercing in 1 question.

**Table 3**

Studies Assessing the Transmission of Hepatitis C Virus Through Tattooing Among Blood Donors, by Study Design and Year of Study

| Author(s) | Country (Years of Study) | Sample Size | HCV Prevalence (%) | No. Tattooed (% HCV Infected) | Tattooing Reported as a Risk Factor; Adjusted OR (95% CI) |
|---|---|---|---|---|---|
| Case-control studies | | | | | |
| Goldman et al 2009 [35] | Canada (2005–06) | 88 cases; 349 controls | … | 20 cases; 38 controls | Tattoo >10 years ago: OR = 5.43 (1.82–16.2); tattoo past decade: OR = 2.35 (.77–7.22) |
| O'Brien et al 2008 [36] | Canada (1993–94; 2005–06) | 1993: 107 cases; 428 controls | | 1993: 32 cases; 21 controls | Overall OR = 3.8 (2.0–7.3); 1993: OR = 8.3 (2.8–24.5); 2005: OR = 2.9 (1.2–7.0) |
| | | 2005: 77 cases; 308 controls | | 2005: 16 cases; 34 controls | |
| Kerzman et al 2007 [37] | Israel (2001–02) | 50 cases; 128 controls | … | 13 cases; 10 controls | No; OR = 1.1 (.1–9.2) |
| Thaikruea et al 2004 [38] | Thailand (2001–02) | 166 cases; 329 controls | … | … | No |
| Tanwandee et al 2006 [39] | Thailand (n/a) | 435 cases; 894 controls | … | … | No |
| Delage et al 1999 [40] | Canada (1993–94) | 267 cases; 1068 controls | … | 97 cases; 60 controls | Yes; OR = 5.7 (2.5–13.0) |
| Brandao & Fuchs 2002 [41] | Brazil (1995–96) | 178 cases; 356 controls | 1.10% | 27 cases; 15 controls | Yes; OR = 4.4 (1.6–11.9) |
| Alavian et al 2002 [42] | Iran (1996–98) | 193 cases; 196 controls | … | 22 cases; 4 controls | No |
| Murphy et al 2000 [43] | US (1994–95) | 758 cases; 1039 controls | … | 205 cases; 52 controls | No |
| Conry-Cantilena et al 1996 [44] | US (1991–94) | 248 cases; 131 controls | … | 52 cases; 5 controls | No |
| Neal et al 1994 [45] | UK (1991–92) | 35 cases; 150 controls | … | 6 cases; 11 controls | Yes; OR = 3.3 (1.2–8.7) |
| Shev et al 1995 [46] | Sweden (1990–92) | 51 cases; 51 controls | … | 19 cases; 3 controls | Yes |
| Cross-sectional studies | | | | | |
| Khin et al 2010 [47] | Myanmar (2005–07) | 65 240 | 0.95% | 408 (0.98%) | No |

All studies adjusted for injection drug use and other risks for HCV acquisition.

Abbreviations: CI, confidence interval; HCV, hepatitis C virus; OR, odds ratio.

**Table 4**

Studies Assessing the Transmission of Hepatitis C Virus Through Tattooing in Prisoners, High-Risk Groups, and Veterans, by Study Design and Year of Study

| Author(s) | Country (Year of Study) | Study Sample | Sample Size | HCV Prevalence (%) | No. Tattooed (% HCV Infected) | Tattooing Reported as a Risk Factor; Adjusted OR (95% CI) | Location Where Tattoo Was Done |
|---|---|---|---|---|---|---|---|
| Cohort studies | | | | | | | |
| Teutsch et al 2010 [48] | Australia (2005–09) | Prison | 488 | 19% incidence rate: 31.6 per 100 person-years | 354 (21.5%) | Yes; OR = 2.01 (1.01–4.01) | … |
| Butler et al 2004 [49] | Australia (1996–2001) | Prison | 181 | 18% incidence rate: 7.1 per 100 person-years | 52 (26.9%) | No | Mainly prison |
| Case-control studies | | | | | | | |
| Russell et al 2009 [50] | US (2001–04) | STD clinics | 170 cases; 345 controls | 3.4% | 10% cases; 2.6% controls | No; OR = 1.87 (. 62–5.65) | Nonprofessional settings |
| Cross-sectional studies | | | | | | | |
| Kheirandish et al 2009 [51] | Iran (2006) | Male IDUs in detention | 454 | 80% | 125 (89%) | Yes; OR = 2.33 (1.05–5.17) | … |
| Coelho et al 2009 [52] | Brazil (2003) | Prison | 333 | 8.7% | 120 (19.2%) | Yes; OR = 3.2 (1.05–10.0) | … |
| Lai et al 2007 [53] | Taiwan (2004–05) | Amphetamine abusers in prison | 285 | 22.5% | 178 (28.7%) | Yes; OR = 2.97 (1.37–6.43) | … |
| Liao et al 2006 [54] | Taiwan (2004–05) | Non-drug abuse Prisoners | 297 | 10.1% | 117 (14.5%) | Yes; OR = 2.24 (1.03–4.88) | … |
| Babudieri et al 2005 [55] | Italy (2001–02) | Prison inmates | 973 | 38.0% | 463 (51.2%) | Yes; OR = 1.91 (1.26–2.91) | … |
| Bair et al 2005 [56] | US (2000–01) | Detention center | 1002 | 2.0% | 506 (3.6%) | No; OR = 1.90 (. 33–1.79) | … |
| Hellard et al 2007 [57] | Australia (2001) | Prisons | 642 | 57.5% | 449 (65.5%) | Yes; OR = 2.7 (1.4–5.2) | Prison |
| Murray et al 2003 [58] | US (1999–2001) | Incarcerated youths | 305 | 2.0% | 101 (2%) | No | Nonprofessional settings |
| Miller et al 2009 [59] | Australia (2005–07) | IDU | 355 | 68.9% | 201 (68%) | No | Multiple locations |
| Mehta et al 2010[a] [60] | India (2005–06) | IDU | 1158 | 55% | … | Yes; PR 5 1.26 (1.14–1.41) | … |

| Author(s) | Country (Year of Study) | Study Sample | Sample Size | HCV Prevalence (%) | No. Tattooed (% HCV Infected) | Tattooing Reported as a Risk Factor; Adjusted OR (95% CI) | Location Where Tattoo Was Done |
|---|---|---|---|---|---|---|---|
| Samuel et al 2001[a] [61] | US (1995–97) | IDU | 945 | 82.2% | 577 (84.8%) | Not in prison/jail: OR = 1.7 (0.9–2.9); in prison/jail: OR = 3.4 (1.6–7.5) | Prisons, friends, relatives |
| Nurutdinova et al 2011[a] [62] | US (1998–2004) | African American women who abuse substances | 782 | 21.2% | 210 (26.7%) | Yes; OR = 2.05 (1.15–3.66) | … |
| Gyarmathy et al 2002[a] [63] | US (1996–2001) | Noninjection heroin users | 483 | 26% | 99 (18.2%) | Never injectors: OR = 2.2 (1.0–4.7); former injectors: OR = 3.5 (1.3–9.6) | … |
| Howe et al 2005 [64] | US (2000) | Noninjection drug users | 722 | 3.9% | 265 (4.5%) | Yes; OR = 3.6 (1.2–11.3) | Friends, relatives |
| Roy et al 2001 [65] | Montreal, Canada (1995–96) | Street youths | 437 | 12.6% | 247 (18.2%) | No; OR = 1.8 (.9–3.6) | … |
| Zuniga et al 2006[b] [66] | US (2001–03) | Veterans | 2263 | 4.6% | 681 (7.0%) | Yes; OR = 2.12 (1.28–3.49) | … |
| Dominitz et al 2005 [11] | US (1998–2000) | Veterans | 1288 | 4.0% | 247 (11.3%) | Yes; OR = 2.9 (1.4–5.8) | … |
| Briggs et al 2001 [12] | US (1998–99) | Veterans | 1032 | 17.7% | 256 (34.7%) | Yes; OR = 2.93 (1.70–5.08) | … |

Abbreviations: CI, confidence interval; HCV, hepatitis C virus; IDU, injection drug user; OR, odds ratio; PR, prevalence ratio; STD, sexually transmitted disease.

[a] Confirmatory HCV testing was not done.

[b] Combined both tattoo and body piercing.

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**Table 5**

Studies Assessing the Transmission of Hepatitis C Virus Through Piercing Among Different Study Populations

| Author(s) | Country (Year of Study) | Study Sample | Sample Size | HCV Prevalence (%) | No. Pierced (% HCV Infected) | Piercing Reported as a Risk Factor; Adjusted OR (95% CI) | Location Where Piercing Was Done |
|---|---|---|---|---|---|---|---|
| Cohort study | | | | | | | |
| Bruneau et al 2010 [72] | Canada (2004–08) | IDU | 145 | 28% | 17 (35%) | No; HR 5 0.96 (.3–2.7) | … |
| Case Control studies | | | | | | | |
| Mariano et al 2004 [13] | Italy (1997–2002) | Surveillance data | 598 acute HCV cases; 7221 acute HAV controls | … | 42 cases; 224 controls | Yes; OR = 2.4 (1.2–4.8) | … |
| Karmochkine et al 2006 [16] | France (1997–2001) | Cases from clinics; controls from telephone survey | 450 cases; 757 controls | … | … | No | … |
| Lasher et al 2005 [17] | US (1998–99) | Cases from surveillance; controls from telephone directory | 222 cases; 699 controls | … | 13 cases; 14 controls | No; OR = 1.5 (.4–1.6) | … |
| Balasekaran et al 1999[a] [19] | US (1995–96) | Clinics | 58 cases; 58 controls | … | Men: 7 cases; 5 controls. Women: 34 cases; 36 controls | No; Men: OR = 1.7 (.4–7.0); Women: OR = 0.3 (.03–3.2) | … |
| Mele et al 1995[a] [22] | Italy (1985–93) | Acute surveillance | 363 cases; 4879 HAV controls | … | 12 cases; 74 controls | Yes; OR = 2.8 (1.3–5.8) | … |
| He et al 2011[a] [73] | China (2006–07) | Blood donors | 305 cases; 610 controls | 0.53% | 98 cases; 62 controls | Yes; OR = 7.3 (3.3–16.3) | … |
| Goldman et al 2009 [35] | Canada (2005–06) | Blood donors | 88 cases; 349 controls | … | … | No | … |
| Kerzman et al 2007 [37] | Israel (2001–02) | Blood donors | 50 cases; 128 controls | … | 11 cases; 37 controls | No; OR = 0.8 (.4–1.8) | … |
| Thaikruea et al 2004 [38] | Thailand (2001–02) | Blood donors | 166 cases; 329 controls | … | 49 cases; 35 controls | No | … |
| Tanwandee et al 2006 [39] | Thailand (n/a) | Blood donors | 435 cases; 894 controls | … | … | No | … |
| Murphy et al 2000 [43] | US (1994–95) | Blood donors | 758 cases; 1039 controls | … | 425 cases; 416 controls | Yes; OR = 2.0 (1.1–3.7) | … |

| Author(s) | Country (Year of Study) | Study Sample | Sample Size | HCV Prevalence (%) | No. Pierced (% HCV Infected) | Piercing Reported as a Risk Factor; Adjusted OR (95% CI) | Location Where Piercing Was Done |
|---|---|---|---|---|---|---|---|
| Conry-Cantilena et al 1996[a] [44] | US (1991–94) | Blood donors | 248 cases; 131 controls | … | 42 cases; 0 controls | Yes (men): OR = N; No (women) | … |
| Neal et al 1994 [45] | UK (1991–92) | Blood donors | 35 cases; 150 controls | … | 23 cases; 71 controls (ear) | No; OR = 1.4 (.7–2.9) | … |
| Cross-sectional studies | | | | | | | |
| Hwang et al 2006 [23] | US (2000–01) | College students | 5282 | 0.9% | 1108 (0.7%) | No; OR = 0.76 (.36–1.62) | … |
| King et al 2009 [25] | France (2004) | National seroprevalence survey | 14 416 | 0.8% | 5398 (1.8%) | No | … |
| Perez et al 2005 [26] | Puerto Rico (2001–02) | Community-based study | 970 | 6.3% | 247 (4.4%) | No | … |
| Khin et al 2010 [47] | Myanmar (2005–07) | Blood donors | 65 240 | 0.95% | 638 (0.31%) | No | … |
| Bair et al 2005 [56] | US (2000–01) | Detention center | 1002 | 2.0% | 506 (3.6%) | No | … |
| Murray et al 2003 [58] | US (1999–2001) | Newly incarcerated youths | 305 | 2.0% | 163 (3.10%) | No | Nonprofessional settings |
| Miller et al 2009 [59] | Australia (2005–07) | IDU | 355 | 68.9% | 117 (58.1%) | No | Multiple locations assessed |
| Roy et al 2001 [65] | Canada (1995–96) | Street youths | 437 | 12.6% | 342 (13.4%) | No | … |
| Dominitz et al 2005 [11] | US (1998–2000) | Veterans | 1288 | 4.0% | 178 (12.9%) | No; OR = 2.2 (.7–6.8)[b] | … |

Abbreviations: CI, confidence interval; HAV, hepatitis A virus; HCV, hepatitis C virus; IDU, injection drug user; OR, odds ratio.

[a] Ear piercing.

[b] OR adjusted for IDU only.