Correlates of hepatitis C virus seropositivity in prison inmates: a meta-analysis

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ABSTRACT

Background: The prevalence of infection with hepatitis C virus (HCV) is higher among prison inmates compared with the general population because of the high proportion of injecting drug users (IDU).

Methods: A meta-analysis of studies on HCV infection in the correctional system was performed. The main objective was to analyse risk factors for HCV infection and to assess HCV seroprevalence and incidence in prison.

Results: Thirty studies were included in the meta-analysis on HCV prevalence. IDU were approximately 24 times more likely than non-IDU to be HCV positive. The odds ratio of being HCV positive was three times higher for inmates exposed to tattooing than those not exposed. The odds ratio among women was 1.44 compared with men.

Conclusions: The differences in HCV seroprevalence among studies can largely be explained by differences in the proportion of inmates who are IDU and partly by differences in seroprevalence among IDU in the community. Tattooing and female gender were also associated with HCV positivity. These findings should be taken into account when planning prevention activities in prisons.

The prevalence of infection with hepatitis C virus (HCV) among prison inmates is usually higher than that among the general population,[1–3] mainly because of the high proportion of injecting drug users (IDU),[4] who are known to be at high risk of infection. Some studies have suggested that as many as one third of prison entrants are IDU[5] and that inmates tend to engage in a variety of high-risk behaviours, such as the sharing of drug injection equipment.[6] Other risk factors that may contribute to the high prevalence of HCV infection among inmates include marginal social status, low socioeconomic position and the inconsistency of prison health services.[7] Moreover, given the average length of stay in jail (less than three months) and in prison (two to three years), there is concern over the potential for correctional facilities to serve as reservoirs of HCV infection, in that once released inmates could become a source of infection for the general population.[7–9] For this reason, interventions for preventing infection in prisons could benefit the community outside prison.[10]

To address the often hidden phenomenon of HCV infection in prisons, it is important to identify and quantify correlates of infection among inmates, yet to the best of our knowledge no comprehensive analyses of the available data have been published. We performed a systematic review and meta-analysis of the literature to identify correlates of infection among prison inmates.

MATERIALS AND METHODS

Search strategy

We used the Medline and Embase databases to identify all studies published before June 2005 on the incidence and seroprevalence of HCV infection in prisons, using extended terms for hepatitis and prison. Of the 365 articles identified, 43 were potentially relevant and were reviewed in full.[2 5 10–50] We then manually searched the reference lists for articles that fulfilled the inclusion criteria.

Inclusion and exclusion criteria

Inclusion and exclusion criteria were established before reviewing the abstracts and articles. The inclusion criteria were: studies involving adult prison inmates; and HCV tests performed on serum samples. The exclusion criteria were: studies involving adolescent prison inmates; persons not incarcerated or inmates who were allowed to work outside of the prison; and HCV tests performed on saliva samples, given that oral fluid assays for HCV have an 80% sensitivity and their use could thus result in the true HCV seroprevalence or incidence being underestimated.[12] On the basis of these criteria, nine studies were excluded: two involved adolescent inmates,[37 48] one involved inmates with a semi-free status[39] and six performed HCV testing on saliva samples.[12 21 27 32 45 47] Another study was excluded because only hospitalised inmates were enrolled.[42] Still another study was excluded because we were not able to contact the author for a copy of the full article.[50]

Hypotheses and data extraction

To summarise the incidence and seroprevalence of HCV infection in prisons, two of the investigators (RM and BL) independently extracted the following information from each study: country in which the study was performed; year of performance; whether the survey was performed among already incarcerated inmates or among inmates entering prison; number of participating inmates; participation rate; type of sampling; HCV incidence among IDU and non-IDU; HCV seroprevalence; HCV seroprevalence among IDU and non-IDU; mean and/or median age; proportion of men; proportion of IDU; number of IDU and non-IDU who were HCV positive and HCV negative; number of inmates with tattoos or without tattoos who were HCV positive and HCV negative; number of men and women who were HCV positive and HCV negative; and number of inmates aged under 40 or 40 or more years who were HCV positive and HCV negative. Moreover, because HCV seroprevalence in prisons reflects the seroprevalence in the local general population, we also collected information

Table 1 Characteristics of studies on HCV seroprevalence upon entering prison

Study	Year performed	Study design	Country	Participation rate (%)	Type of sampling	Studied population	Men (%)	IDU (%)	HCV-S (%) (prison)	HCV-S (%) among IDU (prison)	HCV-S (%) among non-IDU (prison)	HCV-S (%) (general population)	HCV-S (%) among IDU (general population)
Arrada *et al*[14]	1998	L	France	73	VP	656	100	–	9	–	–	1.1	42
Baillargeon *et al*[16]	1998	C-S	USA	85	RS*	3712	84	–	29	–	–	1.8	66
Burattini *et al*[17]	1993	C-S	Brazil	94	SS	631	100	–	34	–	–	2.6	70
Butler and colleagues[18 19 49]	1994	C-S	Australia	28	RS	408	100	52	37	66	7	0.3	65
Crofts *et al*[6]	1991	L	Australia	99	VP	3627	94	45	39	65	16	0.3	65
Fox *et al*[25]	2005	C-S	USA	77	NS	467	72	43	34	66	–	1.8	66
Hedouin and Gosset[29]	1995	C-S	France	62	CS	806	91	55	30	80	4	1.1	42
Holsen *et al*[31]	1991	C-S	Norway	69	VP	70	28	57	46	91	10	0.1	68
Macalino *et al*[10]	1998	L	USA	97	RS	4269	100	12	23	83	15	1.8	66
Ruiz and colleagues[3 40]	1994	C-S	USA	97	SS	4513	87	97	41	–	–	1.8	66
Solomon *et al*[44]	2002	C-S	USA	100	RS	3914	85	22	30	–	–	1.8	66
Vlahov *et al*[2]	1985	L	USA	100	RS	266	100	–	38	–	–	1.8	66

C-S, Cross-sectional; CS, convenience sample; HCV-S, hepatitis C seroprevalence; IDU, intravenous drug user; L, longitudinal; NS, not specified; RS, routine screening; SS, selection performed through the calculation of the sample size; VP, voluntary participation.
*The excluded subsample did not exhibit any statistically significant differences from the sample used.

on seroprevalence in the community and among local IDU for each country involved in the studies.[11 51–57] Finally, because harm-reduction programmes in prison could alter the results, we determined whether any programmes had been implemented in the prisons.

Statistical analyses

HCV seroprevalence rates were tabulated, but we did not perform a meta-analysis of seroprevalence because of the great heterogeneity among studies. The sources of heterogeneity were, however, thoroughly investigated. I^2 statistics were calculated as a measure of the degree of heterogeneity, which was not dependent on the number of studies.[58] Selected study characteristics (ie, year in which the study was conducted, proportion of IDU among inmates, proportion of male inmates, proportion of inmates with tattoos, and the mean or median age of the inmates) were investigated using meta-regression techniques, to assess their impact on between-study variation. The HCV seroprevalence rates in the local general population and among local IDU were included as independent variables in meta-regression analyses, so as to assess their association with HCV seroprevalence at the study level.

Meta-analyses of the association between HCV seroprevalence and intravenous drug use, tattooing, and gender were carried out. The odds ratio (OR) was used as a measure of effect. For those studies that did not report OR, we calculated the OR based on the reported HCV seroprevalence in different exposure groups. Random effect (Der Simonian and Laird) and fixed effect (inverse variance) meta-analyses were used, and the results were compared. Stratified analyses and meta-regressions were carried out to investigate the impact of selected study characteristics on heterogeneity (eg, proportion of IDU). To take the different proportions of IDU into account, a meta-analysis of IDU-adjusted OR for tattoos and gender was carried out. To evaluate whether being incarcerated represents a potential risk factor for HCV infection, we considered whether HCV testing was performed among already incarcerated inmates or upon incarceration; we also examined HCV incidence rates. The presence of small-study effects was visually assessed by funnel plots and formally tested by the Egger's regression and rank correlation tests.[59] All statistical analyses were performed using Stata version 9.0 (Stata Corp, College Station, Texas, USA).

RESULTS

HCV seroprevalence

Thirty studies (involving 31 358 inmates) satisfied the inclusion criteria and were included in the meta-analysis of HCV seroprevalence (tables 1 and 2). Of these, 16 enrolled more than 500 inmates;[5 10 13–17 19 28–30 33 34 40 41 44] 12 enrolled between 500 and 100 inmates;[2 11 18 22–26 35 38 43 46] and two enrolled fewer than 100 inmates.[20 31] Of the 30 studies, 24 were cross-sectional in design, and six were longitudinal.[2 5 10 13 14 22] Seventeen studies assessed HCV seroprevalence among already detained inmates, and 12 assessed seroprevalence upon incarceration. The study by Gates *et al*[26] was not included because HCV testing was offered only to recently incarcerated inmates who had no documented positive test result for HCV or an indeterminate result. Only Christensen *et al*[22] specified whether or not harm-reduction programmes had been implemented; none of them were syringe-exchange programmes.

Given that 85% of the total variability in HCV seroprevalence was attributed to between-study heterogeneity, we decided not

to compute an overall estimate. Subgroup and meta-regression analyses were carried out to investigate whether or not heterogeneity may have been related to differences in study design. The results showed that HCV seroprevalence was approximately 11% higher when tested among already detained inmates, as opposed to inmates entering prison. There was, however, still evidence of heterogeneity within the two subgroups of studies (the between-study variance of HCV seroprevalence was 0.0086 upon incarceration and 0.0214 during incarceration, and the proportion of the variation attributable to between-study heterogeneity (I^2 values) was, respectively, 89% and 93%). The main source of heterogeneity was represented by the proportion of IDU (HCV seroprevalence increased by 35% per unit increase in the proportion of IDU among inmates in a meta-regression analysis). The contribution of other variables, such as the national-level HCV seroprevalence among IDU, the year in which the study was conducted, the proportion of inmates with tattoos, and the proportion of men enrolled in the study, was of a somewhat smaller magnitude. No other sources of heterogeneity (eg, age) were observed. For studies that specified the mean or median age, the multivariate analyses revealed no evidence of an association between age and HCV seroprevalence. Other variables, such as duration of imprisonment, ethnicity, sexual behaviour, and number of previous imprisonments, were not studied because data were lacking. We thus carried out separate meta-analyses to investigate the association between HCV seroprevalence and intravenous drug use, tattooing and gender.

Association between HCV seroprevalence and intravenous drug use

Intravenous drug use had a clear effect on HCV seroprevalence (OR 24.32; 95% CI 15.74 to 37.58; fig 1). The most influential study was that of Crofts *et al*,[5] and its exclusion yielded a pooled OR of 26.30 (95% CI 17.06 to 40.04). When stratified and meta-regression analyses of HCV seroprevalence for IDU were carried out, the OR of HCV for IDU was approximately 11% higher during incarceration than upon incarceration. Furthermore, the HCV seroprevalence varied to a greater degree for studies in which HCV testing was performed among already detained inmates, compared with those that tested for HCV upon incarceration. The funnel plot was asymmetric, yet there was no evidence of bias (Egger's method $p = 0.870$; and Begg's method $p = 0.598$), even after having excluded the study of Crofts *et al*.[5]

Association between HCV seroprevalence and tattooing

The pooled OR of HCV seroprevalence was three times higher for inmates who had tattoos, compared with those who did not. The graphical assessment and tests for heterogeneity showed that the association between tattooing and HCV seroprevalence varied among studies (between-study variance 0.382; I^2 83%). When comparing studies conducted among already incarcerated inmates with those conducted upon incarceration, the OR did not vary (fig 2). The association between HCV seroprevalence and tattooing was still robust after having adjusted for the proportion of IDU in a meta-regression analysis (for a prison in which 40% of the inmates were IDU, the OR of HCV seroprevalence for tattooing was 2.50). Taking the proportion of IDU into account, the between-study variance decreased from 0.382 to 0.371. The only studies to report OR adjusted for intravenous drug use were those of Hellard *et al*[30] (OR 2.7; 95% CI 1.4 to 5.2), Babudieri *et al*[15] (OR 1.91; 95% CI 1.26 to 2.91), Holsen *et al*[31] (OR 5.44; 95% CI 1.68 to 9.21) and Utzumi *et al*[46] (OR 1.57; 95% CI 0.63 to 3.92). A meta-analysis of these studies yielded a pooled OR of 2.47 (95% CI 1.56 to 3.91) (data not shown). The funnel plot was symmetric, and there was no evidence of bias (Egger's method $p = 0.861$; Begg's method $p = 0.929$).

Association between HCV seroprevalence and gender

Overall, 11 studies provided data separately for men and women. Meta-analyses showed that the pooled OR of HCV seroprevalence was 1.43 (95% CI 1.07 to 1.92) for women, compared with men (fig 3). The greatest source of heterogeneity was between-study differences in the proportion of IDU (when adjusting for intravenous drug use, the between-study variance decreased from 0.2047 to 0.1724). After having adjusted for the proportion of IDU in a meta-regression analysis, however, the association between HCV seroprevalence and gender was still statistically robust. When the analysis was carried out separately by type of enrolment (upon incarceration or during incarceration), the pooled OR were, respectively, 1.11 and 1.78. The only studies to report OR for women adjusted for intravenous drug use were those carried out by Solomon *et al*[44] (OR 1.32; 95% CI 1.04 to 1.67), Babudieri *et al*[15] (OR 0.90; 95% CI 0.29 to 2.00), Butler *et al*[19] (OR 4.7; $p<0.01$) and Hellard *et al*[30] (OR 1.4; 95% CI 0.8 to 2.6). A meta-analysis of adjusted OR yielded a pooled estimate of 1.31 (1.05; 1.62) (data not shown). The funnel plot was asymmetric. Begg's method provided some evidence of bias ($p = 0.073$), whereas the Egger method showed no evidence of bias ($p = 0.412$).

HCV incidence

Six studies reported HCV incidence.[2 5 10 22 36 49] Estimates ranged between 0.4 and 18.3/100 person-years. In the study by Crofts *et al*,[5] HCV testing had been offered only upon incarceration, and the incidence had been calculated only for seronegative inmates who had been re-admitted to prison. In the article by Butler *et al*,[49] there was no information on the time spent outside of prison or on individuals who had been lost to follow-up (ie, those who were not in prison four years after the first examination); the study of O'Sullivan *et al*[36] only included inmates at high risk of HCV infection (ie, those who had shared syringes in the period 5–29 November 2000); and the study by Macalino *et al*[10] excluded inmates with a detention period of less than one year. Three studies reported incidence separately for IDU (range 5.5–38.2/100 person-years) and non-IDU (range 0–5.9/100 person-years).[5 10 22] The incidence of HCV infection was consistently higher among IDU, and a meta-analysis yielded a pooled risk ratio for IDU of 8.31 (95% CI 4.10 to 16.81), which indicates that IDU were eight times more likely to contract HCV while in prison than non-IDU.

DISCUSSION

Overall, the studies included in our meta-analysis showed a high HCV seroprevalence in the inmate population. In most studies, HCV antibodies were found in approximately 30–40% of participants (range 2–58%), although some studies reported a relatively low seroprevalence.[14 20 35 43] In the studies by Singh *et al*[43] and Michault *et al*,[35] the low seroprevalence was presumably caused by the low prevalence of intravenous drug use among inmates (approximately 3%). In the study by Catalan-Soares *et al*[20] (HCV seroprevalence of 6%), information on the mode of drug administration was not available; however, 12% of the participants used cocaine and 10% used multiple substances.

Table 2 Characteristics of studies on HCV seroprevalence during incarceration

Study	Year performed	Study design	Country	Participation rate (%)	Type of sampling	Studied population	Men (%)	IDU (%)	HCV-S (%) (prison)	HCV-S (%) among IDU (prison)	HCV-S (%) among non-IDU (prison)	HCV-S (%) (general population)	HCV-S (%) among IDU (general population)
Alizadeh *et al*[11]	2002	C-S	Iran	100	RS	427	93	35	30	31	29†	0.1	45
Anon *et al*[13]	1991	L	Spain	41	CS	750	100	37	45	90	16	0.7	60
Babudieri *et al*[15]	2001	C-S	Italy	82	CS	973	87	30	38	75	22	0.5	65
Butler and colleagues[18 19 49]	1996	C-S	Australia	90	RS	789	83	32	39	–	12	0.3	65
Catalan-Soares *et al*[20]	1994	C-S	Brazil			63	100	–	6	–	8	0.6	70
Christensen *et al*[22]	1996	L	Denmark	79	VP*	325	100	43	43	87	10	0.2	75
Ford *et al*[23 24]	1995	C-S	Canada	68	VP	350	100	37	33	73	9	0.1	53
Ford *et al*[23 24]	1995	C-S	Canada	87	VP	113	0	–	40	–	–	0.1	53
Guimaraes *et al*[28]	1993	C-S	Brazil	100	SS	756	100	17	41	82	–	2.6	70
Hellard *et al*[30]	2001	C-S	Australia	20	VP*	630	53	69	57	–	11	0.3	65
Malliori *et al*[33]	1994	C-S	Greece	98	VP	533	91	69	58	81	9†	1.5	50
Massad *et al*[34]	1993	C-S	Brazil	95	SS	631	100	23	34	–	–	2.6	70
Michault *et al*[35]	1997	C-S	La Réunion	50–71	VP	100	100	3	2	0	2	0.8	–
Pearson *et al*[38]	1995	C-S	USA	69	VP	408	100	–	28	–	–	1.8	66
Saiz de la Hoya *et al*[41]	2001	C-S	Spain	91	VP	730	99	72	38	93	8	0.7	60
Singh *et al*[43]	1998	C-S	India	25	VP	240	–	3	5	–	–	1.8	92
Utsumi *et al*[46]	1993	C-S	Japan	100	VP	201	100	34	50	–	13	2.3	74

C-S, Cross-sectional; CS, convenience sample; HCV-S, hepatitis C seroprevalence; IDU, intravenous drug user; L, longitudinal; NS, not specified; RS, routine screening; SS, selection performed through the calculation of the sample size; VP, voluntary participation.
*The excluded subsample did not exhibit any statistically significant differences from the sample used.
†The HCV seroprevalence was calculated among non-IDU.

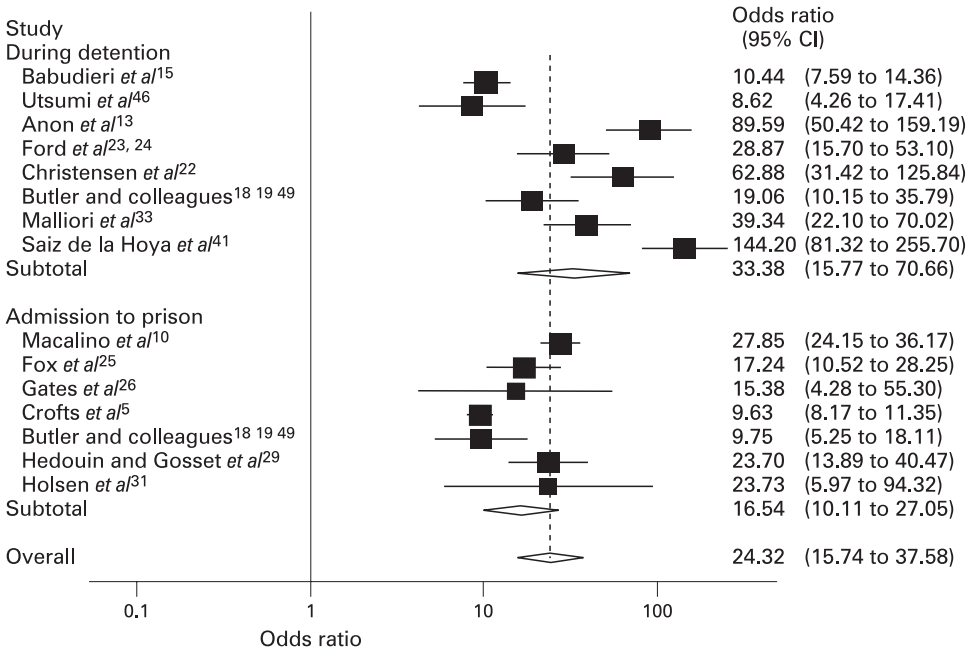

Figure 1 Odd ratios of hepatitis C virus seroprevalence for incarcerated intravenous drug users, by study design (ie, samples collected upon entering prison or during incarceration). Summary estimates were obtained using a random effect model. Squares are proportional to the amount of information contributed. 95% CI are represented by the horizontal line. Overall results are represented by diamonds.

Information on intravenous drug use was also lacking in the study by Arrada *et al*,[14] who reported a 9% seroprevalence, although another study conducted in the same country (France) reported a seroprevalence of 30%.

The most important source of the extreme heterogeneity among studies was the diverse proportion of IDU, which ranged from 3% to 69%. In our meta-analysis, the pooled OR of HCV was 24 times higher among inmates who were current or former IDU, compared with inmates who were not IDU. The difficulty in obtaining injecting apparatus in prison may favour syringe sharing and thus increase the risk of HCV transmission.[22] As mentioned, the most influential study was that of Crofts *et al*,[5] which was carried out in Australia on a sample of 3627 inmates, of whom 46% were IDU, who had a mean age of 26 years and an HCV seroprevalence of 65%.[5] A large study carried out in the United States by Macalino *et al*[10] reported an HCV seroprevalence of 83% among IDU, whereas the study of Butler *et al*,[18] also performed in Australia, found seroprevalence rates similar to those reported by Crofts *et al*,[5] although only 20% of the inmates enrolled in the former study were IDU. It is not possible to establish whether or not the IDU enrolled in those studies were older than those enrolled in the study of Crofts *et*

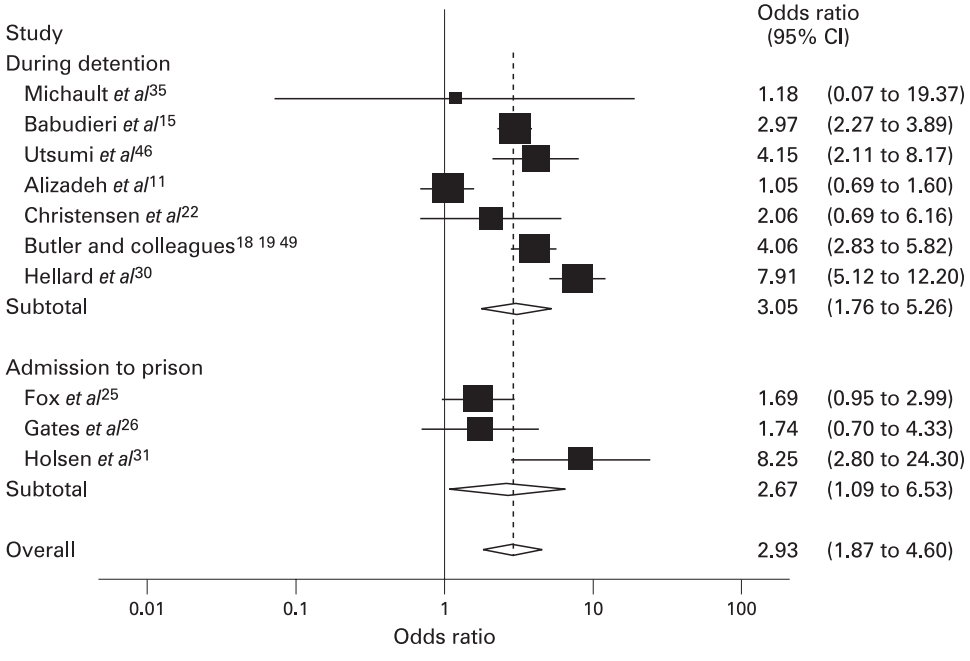

Figure 2 The effects of tattooing on hepatitis C virus seroprevalence, by study design (ie, samples collected upon entering prison or during incarceration). Summary estimates were obtained with a random effect model.

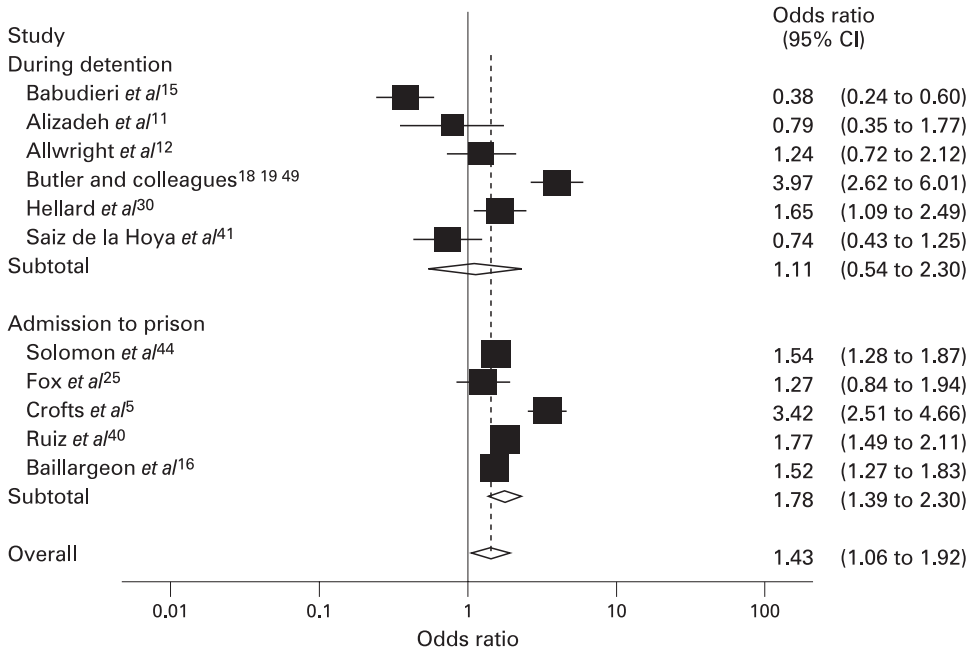

Figure 3 The effects of gender on hepatitis C virus seroprevalence, by study design (ie, samples collected upon entering prison or during incarceration). Summary estimates were obtained with a random effect model.

al,[5] given that age was not reported separately for IDU and non-IDU by Macalino *et al*[10] or by Butler *et al*.[18] The exclusion of the study by Crofts *et al*[5] from the meta-analysis yielded a random effect OR of 26.

The finding that the prevalence of HCV infection upon incarceration was lower than that among already incarcerated inmates could be explained by intra-prison transmission of HCV. This hypothesis is supported by the results of studies that calculated HCV incidence, with an estimate ranging from 0.4 to 18.3/100 person-years. Another possible explanation could be the presence of a selection bias related to the length of the prison sentence. In-prison surveys could oversample prisoners with longer sentences and who are older and have a longer history of drug use, all of which are risk factors for HCV infection. It is also possible that the already incarcerated inmates had acquired infection outside of prison in the periods between detentions. This possibility was not considered in our analysis and may represent a limit of our study.

Our meta-analysis showed that the risk of testing positive for HCV was three times higher for inmates with tattoos, compared with those without tattoos (OR 2.93). Because the practice of tattooing is often associated with that of intravenous drug use, however, we carried out a meta-analysis of the four studies that provided IDU-adjusted OR. This analysis yielded a pooled OR of 2.47, which showed that even after having taken IDU status into account, inmates with tattoos were more likely to be HCV infected than those without tattoos. Some authors have suggested that most tattoos are performed in prison, using equipment shared with other inmates with limited or no access to means of sterilising equipment. Given that the prevalence of HCV infection is high among prison inmates, the use of non-sterilised equipment for tattooing within prison is considered to be a high-risk activity.[60] Furthermore, Samuel *et al*,[61] in a study conducted among street-recruited IDU, observed a significant association between HCV infection and having received tattoos in jail/prison.

Another interesting result of this meta-analysis is the correlation between female gender and HCV infection in prison, which is in contrast to observations among the general population, in which HCV seroprevalence is usually higher among men. Studies conducted in prison have shown inconsistent results, although prevalence tends to be higher among women compared with men. This meta-analysis confirms a slightly higher OR (ie, 1.44) for HCV positivity among women, compared with men, presumably as a result of a higher rate of female incarceration for behaviours associated with an increased risk of HCV, including prostitution, injection drug use and crack/cocaine use.[6 19 62] The meta-analysis carried out on the three studies that provided IDU-adjusted OR showed that women were more likely to be HCV infected than men (OR 1.31). This association may be a spurious result, however, affected by other non-controlled confounders.

The incidence among IDU in prison ranged between 5.5 and 38.2/100 person-years. This extreme variability could be partly due to the different HCV seroprevalence rates among IDU in prison. The incidence in the prison population also depends on the prevalence in the prison, and a relatively low seroincidence could be the result of a saturation of the susceptible population. The incidence among non-IDU in prison ranged between 0 and 5.9/100 person-years. This may indicate that there are other potential sources of infection in prison, apart from injecting drug use. The incidence was consistently higher among IDU, however, and the meta-analysis on HCV rate ratios showed that the risk of seroconversion was approximately eight times higher among IDU than among non-IDU.

All of these considerations stress the need for preventive measures among inmates. Knowledge of the main risk factors for HCV is useful in defining effective measures in the areas of information/education, screening, harm reduction through syringe exchange, and reducing infectivity by treating infected inmates. In prisons, health education is the most readily accepted and commonly used prevention method,[63] whereas there is little agreement with regard to other types of intervention. In 2003, The US Centers for Disease Control and Prevention published guidelines that strongly recommended screening inmates who report risk factors for HCV infection,

primarily a history of intravenous drug use.[64] In a recent study, however, Macalino *et al*[65] found that most infected individuals would not have been tested according to the Centers for Disease Control and Prevention guidelines because the self-reporting of intravenous drug use requires inmates to disclose illegal and stigmatised behaviour. The authors concluded that solutions should include strategies that are responsive to the needs of particular correctional settings, such as routine, mandatory, or voluntary HCV testing upon incarceration.

With regard to harm-reduction measures such as syringe/needle exchange programmes, there have been conflicting results in terms of a reduction in HCV transmission. A review of 19 European prison-based syringe exchange programmes showed no new HCV seroconversions, as well as a reduction in overdose and drug use.[66] Regarding the possibility that inmates could use contaminated syringes as weapons against prison staff or the improper disposal of injection equipment could cause injury, a study performed in a Swiss prison by Nelles *et al*[67] showed that syringe distribution did not encourage drug consumption, that syringes were not used as weapons and that syringe sharing among inmates virtually disappeared. Finally, the treatment of inmates with HCV is an essential requirement for public health. When treatment cannot be completed in correctional facilities, it is necessary to cooperate with community health services to continue treatment after release. Babudieri *et al*[68] demonstrated that an intensive counselling programme that addresses the creation of a relationship between the inmate and the medical team committed to clinical follow-up outside the prison may improve adherence both in prison and in the community after release, at least in countries with a high proportion of IDU among HIV-infected inmates.

Before concluding, some limitations of our meta-analysis need to be mentioned. First, selection bias was a potential problem in some studies, as a result of high non-response rates or flaws in the study design. Second, it is likely that not all IDU in prison are identified, given that admitting injecting drug use may have social implications for the prisoner; thus self-reported data may not be reliable. Information bias would have distorted the results of individual studies if the misclassification of exposure was differential (ie, if the reporting of drug-using behaviour varied among outcome categories) and this may be responsible for the high variability in the OR for IDU (see fig 1). We cannot exclude the possibility that new drug users in particular may tend to hide their status during sampling; thus the prevalence among non-IDU would be overestimated and correlations with other and much weaker risk factors, such as tattooing, would be confounded. The misclassification would also cause the prevalence of infection among IDU to be overestimated, in that there would be a differential bias, with new IDU, who are less likely to be infected, being more likely to be misclassified. Third, confounding could limit the validity of our findings. To investigate whether differences in the distribution of confounding factors biased our results, we thoroughly investigated the sources of heterogeneity and carried out meta-analyses of IDU-adjusted OR. We also examined the association between the size of the effect and potential confounding and performed analyses stratified by relevant variables (eg, the proportion of IDU). Fourth, we did not address the potential role of sexual practices in acquiring HCV infection. It is well known that HCV is generally transmitted through either blood transfusion or the use of contaminated injection equipment, with sexual transmission being a more remote possibility. Although we initially attempted to include homosexual and heterosexual sex among the studied risk factors for HCV infection, few studies provided information on sexual behaviour and the information that was provided differed among studies (eg, sexual risk index, sexual orientation, history of sexual promiscuity, history of sexually transmitted diseases). Finally, there was no evidence of a small-study effect in the meta-analysis of HCV seroprevalence and intravenous drug use or in the meta-analysis of HCV seroprevalence and tattooing, although the possibility of a small-study effect in the meta-analysis of HCV seroprevalence and gender cannot be excluded.

In conclusion, the heterogeneity in HCV seroprevalence across studies was largely explained by differences in the composition of the study population (ie, the proportion of IDU in prison) and, to a lesser extent, by differences in HCV seroprevalence among IDU at the national level. Tattoos were also associated with a higher prevalence of HCV positivity and might be taken into account when planning prevention activities within the correctional system. Regarding the correlation between female gender and HCV, additional studies will be necessary to explore this finding in more depth.

What is already known on this subject

- The prevalence of HCV infection among prison inmates is higher than that among the general population, because of the high proportion of IDU
- Correctional facilities may serve as reservoirs of HCV infection for the general population

What this paper adds

- In most studies, the prevalence of HCV seropositivity was approximately 30–40%. The most important source of the extreme heterogeneity among studies was the diverse proportion of IDU
- The risk of testing positive for HCV was three times higher for inmates with tattoos, compared with those without tattoos
- Female gender was associated with a higher prevalence of HCV positivity. This finding is in contrast to observations among the general population, in which HCV seroprevalence is usually higher among men. Effective strategies for prevention should vary according to the needs of different correctional settings

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