International Journal of Infectious Diseases (2009) 13, 201—208

http://intl.elsevierhealth.com/journals/ijid

Hepatitis C virus infection in South Australian prisoners: seroprevalence, seroconversion, and risk factors

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Received 5 February 2008; received in revised form 4 June 2008; accepted 11 June 2008
Corresponding Editor: Mark Holodniy, California, USA

KEYWORDS
Hepatitis C;
Prisons;
Seroepidemiologic;
Risk factors

Summary
Objectives: To determine entry antibody seroprevalence and seroconversion to hepatitis C virus (HCV) and associated risk factors in newly incarcerated prisoners.
Methods: Males and females entering South Australian prisons completed risk factor surveys and were offered HCV-antibody testing. Participants completed additional surveys and, if HCV-negative at last test, underwent further antibody tests at 3-monthly intervals for up to 15 months. Data were analyzed using univariate and multivariate techniques.
Results: HCV seroprevalence among 662 prison entrants was estimated at 42%. Previous injecting history was highly prevalent at entry (64%) and both community and prison injecting independently predicted entry HCV status. Tattooing was not an important risk factor. While community exposure could not be ruled out, three seroconversions were noted in 148 initially HCV-seronegative individuals occurring in a median 121 days — 4.6 per 100 person-years. Prison injecting was infrequently reported, but HCV-seropositive participants were significantly more likely to commence IDU in prison than seronegative participants ($p = 0.035$).
Conclusions: Entry HCV seroprevalence in South Australian prisoners is extremely high and may have contributed to a 'ceiling effect', minimizing the observable seroconversion rate. Greater frequency of injecting among those already infected with HCV represents a significant threat to other prisoners and prison staff.

Introduction

Hepatitis C virus (HCV) infection has an estimated Australian prevalence of approximately 1.5%.[1] In Australian prison populations, however, prevalence estimates range from around 35% to 50% overall and up to 67% in female prisoners.[2—5] High prevalences have also been estimated for prison populations around the world.[6—10] Prison history has been

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1201-9712/$36.00
doi:10.1016/j.ijid.2008.06.011

identified as an independent risk factor for HCV infection,[11,12] and it seems reasonable to assume some of this risk is attributable to exposures occurring during incarceration. Nonetheless, there have been relatively few published studies of HCV seroconversion in prison and these have struggled to fully characterize disease acquisition in this specific setting. Observed HCV seroconversion rates in prison populations in Europe and the USA have ranged between one and ten per 100 person-years.[13–15] Case studies from Australian prisons (in Victoria and New South Wales) have provided evidence of HCV seroconversions associated with injecting drug use, fighting, and tattooing,[16,17] and a seroconversion rate of 7.1 per 100 person-years has been estimated in continuously detained prisoners (in New South Wales).[18] Injecting drug use (IDU) is thought to be the most common HCV risk in prisoners,[2,6,19] but prison-applied tattoos have also been associated with infection.[5] Sexual contact is not considered an important mode of HCV transmission in Australian prisoners.[12] Reported seroconversion rates in prison populations are relatively low compared to those observed in community dwelling injecting drug users,[20–23] but may highlight the difficulty of undertaking cohort studies in highly mobile populations in which losses to follow-up are common.

We have recently reported HCV antibody prevalence estimates that were derived from a population-wide prison health record audit,[24] however there have been no other published studies on HCV infection (prevalence or transmission) in South Australian (SA) prisons. Here we report the findings of a cohort study that was aimed at estimating entry HCV seroprevalence and seroconversion as well as associated risk factors in SA prisoners.

Methods

Between October 2004 and August 2005, weekly recruitment sessions were conducted in the reception areas of both of SA's metropolitan prisons for male prisoners. Recruitment sessions were also held at the State's only prison for females between January and October 2005, where the shorter recruitment period resulted from difficulties associated with earlier recruitment strategies. Participation was offered to all eligible prisoners remaining in prison on the day of the session. Eligibility required participants be 18 years or older and have the mental capacity to understand the purpose of the study and provide a valid, signed consent. One of the male prisons exclusively accommodated unsentenced prisoners, while the other prisons accommodated both sentenced and unsentenced prisoners. The three prisons received approximately 80% of all prison entrants to the jurisdiction's eight publicly operated prisons during the study period. Participant follow-up occurred in all eight of the State's publicly operated prisons.

At recruitment, all participants completed a brief risk factor survey about their pre-entry injecting and tattooing history and were offered HCV-antibody testing. Where participants had undergone testing within the prison system within the previous three months (i.e., during previous periods of incarceration) and results were available, additional testing was not required. Testing was also not required from participants with recent evidence of repeat positive serology, particularly in the case of poor vein health. Laboratory serology reports filed within the participants' prison health records were considered evidence of HCV serostatus. HIV status was not recorded in this cohort.

Participants completed risk factor surveys and, if remaining seronegative, were offered additional HCV-antibody tests at three-monthly intervals for up to 15 months or until release. Seroconversion was accepted as evidence of newly acquired infection and additional biochemical and virological testing was not performed. Brief follow-up surveys (focusing on injecting and tattooing behaviors since prison entry) were completed only in the presence of the researcher or nursing staff, who provided assistance where literacy was an issue. All surveys were placed immediately in a sealed box before being stored outside of the correctional system.

Correctional system assigned prisoner identification numbers were utilized to monitor prisoner movements within the prison system and to link survey responses to health record information. These identifiers were removed at the time of analysis. Specimens were obtained by prison health staff, and laboratory serology was performed by the Institute for Medical and Veterinary Science in Adelaide, SA (by Abbott third generation serologic assay). Quantitative data were analyzed using Stata (release 8, Stata Corporation, College Station, TX, USA). Kaplan–Meier survival estimates and log binomial models also formed part of the analysis. Risk ratios and seroconversion rates were generated and other statistical methods were utilized as appropriate. All statistical tests were performed at the 0.05 alpha level.

Formal approvals for the study were obtained from the SA Aboriginal Health Research Ethics Committee, the SA Department for Correctional Services Research Management Committee, the SA Department of Health Human Research Ethics Committee, the Royal Adelaide Hospital Research Ethics Committee, and the University of Adelaide Human Research Ethics Committee.

Results

There were 1118 potentially eligible people remaining incarcerated at the weekly recruitment sessions, 126 of whom were incarcerated more than once over the study period. It was not possible to interview or assess the eligibility of 16% (180/1118) of these individuals, with prolonged absences due to court attendances being the main reason, followed by prison-imposed time restrictions. Based on our recruitment experience, 140 of these non-accessed individuals (approximately 80%) might have ultimately had their eligibility confirmed. Of the remaining 938 prisoners, 662 (71%) participated in the study – representing 61% of the 1078 eligible entrants. These rates are comparable to other prison studies involving no participant incentives.[8,14] Reluctance to undergo a blood test was the most commonly expressed reason for declining. Demographic information about decliners was limited, however the sex distribution of this group did not differ significantly from participants ($p = 0.351$). The Mann–Whitney statistic associated with the distribution of ranked prison ID numbers (serially allocated at time of first imprisonment) was also not significant ($p = 0.745$), suggesting little difference in previous incarceration history between the two groups.

Ten percent (66/662) of participants were female and 17% (115/662) were Indigenous Australians (Aboriginal and/or Torres Strait Islanders). Median age was 31.3 years and the median time that participants were incarcerated during the study period was 9.3 weeks, ranging from periods of 1 day to 70 weeks. These data were similar to available Australian figures during the same period.[25,26]

Per incarcerated episode (55 participants were incarcerated and recruited more than once, and three were recruited a third time), discharge prior to 3 months occurred in 56% (405/720) of cases; 76% (549/720) of discharges occurred within 6 months of entry and 4% (30/720) were incarcerated for twelve months or longer during the study period. Only two participants were observed for as long as 15 months.

Sixty-four percent (423/662) of participants reported a history of IDU in the community, and 27% (140/514) of those who had been previously incarcerated reported having injected while in prison. Nearly 60% (394/662) of prison entrants had tattoos that were applied in the community and 23% (117/514) of those with a previous prison history had tattoos applied while incarcerated. Almost 78% (514/662) of participants had been previously imprisoned when they were first enrolled in the study.

Entry HCV serostatus and risk factors

While antibody testing was offered at recruitment, 138 participants did not provide a specimen — most commonly due their being released before a test could be arranged.

For some early release participants, entry HCV status (particularly seronegativity) could be confirmed if they were subsequently re-imprisoned during the study. Risk behaviors reported at prison entry did not differ significantly between those participants providing specimens and those not. Overall entry HCV seroprevalence among 524 of the participants was 41.8% (95% CI 37.6—46.0%). Significant univariate

Table 1 Selected factors associated with HCV-antibody status among prison entrants[a] in South Australia; univariate analysis (N = 524[b])

	Anti-HCV % (95% CI)	Prevalence ratio (95% CI)	p-Value (Chi-square)
Sex			
Female	59.3 (46.4—72.2)	1.50 (1.18—1.90)	0.004
Male	39.6 (35.1—44.0)		
Median age[c]			
>31 years	51.8 (42.6—57.4)	1.69 (1.36—2.10)	<0.001
18—31 years	30.6 (21.4—34.4)		
Indigenous status			
Indigenous	60.2 (50.1—70.3)	1.61 (1.31—1.97)	<0.001
Non-indigenous	37.5 (32.9—42.1)		
Imprisonment history			
Prison history	49.8 (44.9—54.6)	4.84 (2.74—8.54)	<0.001
No prison history	10.3 (4.4—16.1)		
Community injecting			
Injected	58.3 (53.1—63.6)	6.12 (3.85—9.68)	<0.001
Never injected	9.6 (5.1—13.9)		
Prison injecting			
Injected	84.9 (78.3—91.4)	2.38 (2.01—2.83)	<0.001
Never injected	35.6 (30.1—41.1)		
Community tattooing			
Tattoos	49.7 (44.1—55.2)	1.69 (1.33—2.14)	<0.001
No tattoos	29.5 (23.2—35.7)		
Prison tattooing			
Tattoos	76.0 (67.3—84.74)	1.81 (1.42—2.14)	<0.001
No tattoos	42.1 (36.6—47.6)		

HCV, hepatitis C virus; CI, confidence interval.
[a] At time of first enrolment (55 individuals re-enrolled on subsequent admissions).
[b] Excludes 138 individuals for whom entry HCV status could not be confirmed.
[c] Age at prison entry.

Table 2 Demographic and risk factors and HCV-antibody status in prison entrants[a] in South Australia; multivariate analysis (N = 404[b])

	Risk ratio (95% CI[c])	Risk difference (95% CI[c])	p-Value
Indigenous	1.24 (1.241—1.242)	0.13 (0.132—0.133)	<0.001
Above median age (31 years)	1.29 (1.287—1.288)	0.12 (0.119—0.120)	<0.001
Female	1.39 (1.313—1.482)	0.18 (0.125—0.241)	<0.001
Prison IDU	1.61 (1.401—1.860)	0.37 (0.276—0.443)	<0.001
Community IDU	4.10 (2.252—7.476)	0.29 (0.199—0.381)	<0.001

HCV, hepatitis C virus; CI, confidence interval; IDU, injection drug use.
[a] At time of first enrolment (55 individuals re-enrolled on subsequent admissions).
[b] Excludes those for whom entry HCV-status could not be confirmed and those with no previous prison history.
[c] Three decimal places presented due to the narrowness of some confidence intervals.

associations with HCV seroprevalence were found for females, those aged above median age, Indigenous prison entrants, and those with a history of previous imprisonment (see Table 1). History of community injecting was associated with the largest risk ratio (6.12) when compared to those with no IDU history, and the risk ratio for community-applied tattoos versus no tattoos was also significant. Among those who had been previously imprisoned, prison injecting and prison tattooing were both associated with significantly higher risk than for those not reporting these behaviors.

Despite the significant univariate associations observed, neither community nor prison applied tattoos were significant predictors of HCV serostatus at prison entry after adjustment for community and prison IDU. Both of the latter practices remained highly predictive of HCV entry seroprevalence after adjustment for tattooing in the same log binomial model (data not shown). The adjusted risk ratio for prison IDU was 1.66 (95% CI 1.39—1.98, $p < 0.001$) and for community IDU was 3.65 (95% CI 2.25—5.93, $p < 0.001$).

In a model including prison history and community risk factors, adjusted ratios for community tattooing continued to be non-significant but community IDU was significantly associated with HCV antibody status (risk ratio = 4.77, 95% CI 3.01—7.56, $p < 0.001$). Prison history was independently associated with HCV serostatus at entry to prison after adjusting for the other community risk factors (risk ratio = 2.97, 95% CI 1.71—5.15, $p < 0.001$). A final model including Indigenous status, age, sex, and community and prison IDU demonstrated that each factor was an independent predictor of HCV seropositivity (see Table 2), with community IDU associated with the greatest risk (adjusted risk ratio = 4.10).

Risk behaviors while incarcerated

Among the 191 participants remaining in prison beyond 3 months from recruitment, 423 follow-up contacts occurred. Of these, 52% (221/423) occurred at the 3-month point. Some participants either refused the questionnaire or the test (where offered), but 85% (361/423) of follow-ups overall resulted in a completed questionnaire.

IDU and tattooing behaviors reported by prisoners at follow-up are summarized in Table 3. Injecting in prison was relatively infrequently reported by participants overall, but frequency increased with duration of imprisonment. Disregarding multiply admitted prisoners, only 8% of participants incarcerated for 3 months reported having injected in prison, while 26% of those remaining at 12 months had done so (risk ratio = 2.98, 95% CI 1.23—7.22, $p = 0.018$). Overall,

Table 3 HCV risk behavior reported at each 3-monthly follow-up (N = 181[a])

	Time of follow-up (months)			
	3	6	9	12
IDU since entry, n (%)				
No injecting	165 (91.2)	94 (86.2)	43 (86)	14 (73.7)
IDU	16 (8.8)	15 (13.8)	7 (14)	5 (26.3)
Sharing needle, n (%) (prison IDU only)				
No sharing	5 (31.3)	2 (13.3)	0 (00.0)	3 (60)
Shared	11 (68.8)	13 (86.7)	7 (100.0)	2 (40)
Tattoos applied since entry, n (%)				
No tattoos	171 (94.5)	102 (92.7)	45 (88.2)	17 (89.5)
Applied tattoos	10 (5.5)	8 (7.3)	6 (11.8)	2 (10.5)
Sharing tattoo equipment, n (%) (prison tattoos only)				
No sharing	7 (70)	8 (100)	3 (50)	1 (50)
Shared	3 (30)	0 (0)	3 (50)	1 (50)

HCV, hepatitis C virus; IDU, injection drug use.
[a] Includes individuals multiply enrolled in the study (164 individuals followed up at least once).

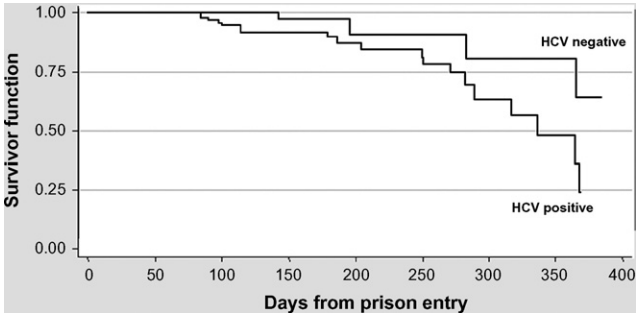

Figure 1 Time to commencing injection drug use (IDU) in prison according to hepatitis C virus status at prison entry; Kaplan—Meier estimates.

82% (23/28) of the individuals reporting injecting reported having shared needles in prison.

Among those whose HCV serostatus was known, 15% (24/160) reported IDU at some stage while incarcerated during the study, and seroprevalence in this group was 79% (19/24). HCV seroprevalence was 59% (80/136) in those reporting no prison IDU. Those testing positive at entry appeared more likely to report prison IDU than HCV-antibody negative participants, albeit not significantly (risk ratio = 2.34, 2-sided Fisher's exact test $p = 0.069$). All prisoners reporting any injecting in prison during the first 3 months of incarceration had tested HCV-antibody positive at entry.

Using the Kaplan—Meier method, survival functions for incarceration time until the first report of IDU in prison differed according to HCV status at entry. As can be seen in Figure 1, those testing HCV-antibody positive at prison entry were more likely to commence prison IDU and continued to be at greater risk of IDU over time. The log-rank test for equality of survivor functions was statistically significant (Chi-square = 4.43, $p = 0.035$).

Three individuals (all males) were apparently initiated into injecting while in prison, having reported no previous community or prison IDU history. One reported injecting within 6 months of prison entry, and the other two within 12 months. Two of these IDU initiates (aged 31 and 43 years) had previous prison histories — one HCV seropositive and one negative at prison entry. The other individual (aged 20 years) was seronegative at entry with no history of previous imprisonment.

Tattooing in prison was also infrequently reported by the participants (Table 3) with 11% of participants incarcerated for 12 months reporting having applied tattoos in prison. This was a greater proportion of tattooers relative to participants followed up at three months, but the difference was not statistically significant (risk ratio = 1.91, 2-sided Fisher's exact test $p = 0.318$). Only 16 individuals reported tattooing during the study overall, of whom eight (50%) reported sharing equipment.

Among those with confirmed serostatus, 8% (13/158) reported tattooing at some stage during the follow-up period. HCV serostatus among these prison tattooers was 69% (9/13), and was 61% (88/145) in those reporting no prison tattooing. On univariate analysis, those testing positive at entry were not more likely to report prison tattooing than seronegative participants (risk ratio = 1.14, 2-sided Fisher's exact test $p = 0.768$).

HCV seroconversion

One hundred and forty-eight of the participants testing HCV-antibody negative at prison entry were available for follow-up during a single or consecutive periods of incarceration (median 121 days, range 2 to 419 days). Three seroconversions were noted during this time — a seroconversion rate of 4.7 per 100 person-years (95% CI 3.4—6.1 per 100 person years). Two seroconversions were noted at 3-month follow up, in non-Indigenous males, aged 34 and 26 years at prison entry. Both had spent approximately 106 days in prison since testing negative at entry, but community exposure could not be ruled out. Both reported no tattooing history and community IDU, but not prison IDU. The third seroconversion was observed in a non-Indigenous male, aged 38 years, who was HCV seronegative when first enrolled but seropositive when enrolled a second time after having spent 34 days in the community between admissions. Given the long seroconversion period for HCV infection, it is feasible that his exposure occurred prior to his first release to the community (following 80 days of incarceration), however the possibility of earlier seroconversion cannot be excluded. This individual reported a history of community and prison tattooing and community IDU and reported having injected in prison for the first time during his first enrolment in the study.

Discussion

This is the first study to investigate entry HCV seroprevalence, seroconversion, and risk factors in SA prisons and is one of very few published studies on these issues in Australia and around the world. High rates of population turnover and difficulty controlling for prisoners leaving and re-entering prison during follow-up have presented perhaps insurmountable difficulties for transmission studies in this specific setting. There is evidence that even more rapid population turnover may occur in injecting drug users (those at greatest HCV risk), who tend to be incarcerated more frequently, but for the shorter periods associated with drug-related offences.[27] The use of prisoner identification numbers in this study may have minimized some losses to follow-up among prisoners readmitted during the observation period.

HCV seroprevalence at prison entry

Similar to other Australian studies,[2—5,28] this study estimated an HCV seroprevalence in prison entrants of 42%. In high prevalence populations, such as prisoners, the presence of HCV-antibody is known to be highly correlated with viremia.[29] Our finding of increased HCV risk with age is consistent with the literature,[11,15,30] and is likely to be related to greater duration of exposure. Much of the literature also supports our finding of increased risk for female prisoners,[2,4,5,9,31] and the greater proportion of female prisoners charged with drug-related offences relative to males[32—34] is commonly proposed to explain the sex differential. Our study, however, found sex was independently associated with entry HCV serostatus after adjusting for IDU history and other factors. Other authors have also identified excess HCV cases in female prisoners after controlling for other factors[2] as well as little evidence that HCV seroprevalence

among females differs according to the nature of the offence.[35] It is possible that there are factors, behavioral or other, that increase the HCV risk associated with injecting in females.

In contrast to other Australian studies,[2,3,28] we found significantly increased risk for Indigenous prisoners. Our previous report also noted increased HCV risk in Indigenous prisoners originating from metropolitan areas but reduced risk for Indigenous prisoners from remote areas in SA.[24] The present study, in metropolitan prisons, further supports the proposal of geographical differences in the risk profile of Indigenous communities.

We have found that any IDU history, in the community or during previous imprisonments, independently predicted entry HCV serostatus. Consistent with the Canadian experience,[8] we found that community IDU, rather than prison IDU, was associated with the greatest risk after adjusting for age, sex, and Indigenous status. While tattoos were common among SA prison entrants, neither community nor prison applied tattoos were predictive of entry HCV serostatus after adjustment for IDU.

In this study, SA prisoners modified their risk behavior during their incarceration. If true of prison populations elsewhere, reduced frequency of risk behaviors may partially explain why transmission studies have tended to observe low seroconversion rates in prisoners relative to those observed in community-dwelling injecting drug users.[20–23] Prison injecting was infrequently reported overall but was more frequently reported in participants identified as HCV seropositive at entry, and this group was significantly more likely to commence injecting over time. Given that sharing needles in prison was reported by the vast majority of prison injectors, and syringes and needles tend to be used and reused by a large number of prisoners,[36,37] there appear to be some safety implications for prisoners and prison officers. While few in number, prison IDU was also reported by HCV seronegative individuals and three participants in this study reported prison injecting for the first time. The HCV risk associated with susceptible individuals sharing contaminated needles in prison cannot be overstated.

Tattooing behaviors, not associated with HCV serostatus in this population, were also apparently modified by incarceration. Sixty percent of prison entrants reported having community applied tattoos but only 9% reported tattooing during the study, the majority of whom reported not sharing tattooing equipment. Boredom has been suggested as a principal motivation for prison tattooing.[17] SA prisoners spend many hours confined to their cells and some might use this time engaging in solitary tattooing — minimizing the opportunity for sharing equipment. Tattoo application method may further reduce the HCV risk associated with tattooing. It has been reported that sewing needles are commonly used for prison tattooing,[11] yet it is possible that solid needles may not efficiently transmit HCV.[38]

Supporting findings elsewhere,[9,11,39,40] we found that previous imprisonment independently predicts HCV seropositivity at entry. It is not clear what the precise mechanism for HCV acquisition might be, but it is possibly related to high background HCV prevalence. This would result in greater exposure risks associated with blood prone activities, such as physical altercations.[16]

HCV seroconversion in SA prisoners

A relatively low HCV seroconversion rate was observed in this study with uncertainty surrounding the location of exposure in all three of the seroconversions noted. Nonetheless, the calculated rate of 4.6 per 100 person-years was comparable to the published literature in this area.[13,14,18,41] It is possible that the low rate observed is due to a 'ceiling effect,' given the high background HCV seroprevalence in this population. At entry, up to 42% of prison entrants were positive for HCV-antibody and up to 64% reported having a pre-entry IDU history. As suggested in one US study,[30] low HCV incidence rates in prisoners may be due to a 'saturation' of the population — with those likely to inject in prison already having seroconverted prior to entry. Relatively low frequency of prison injecting was also a characteristic of this study population.

Nonetheless, prison exposure cannot be ruled out as a major contributor to HCV seroprevalence in this at risk group. This is because non-returning participants were lost to follow-up once they were released to the community. Since drug-related offences are associated with relatively short incarceration periods, losses to follow-up were greater in the group with, potentially, the greatest risk for HCV.

Limitations of this study

Due to the high frequency of illiteracy, it was not always possible for participants to respond to the questionnaire without assistance. While all participants were advised that information provided by them would not be passed on to correctional staff, self-reporting clandestine activity is known to be difficult for some participants.[42]

As a result of high entry HCV seroprevalence, the number of susceptible individuals in this study may have been too few to detect prison-exposed HCV seroconversions. Combined with a long seroconversion window and rapid population turnover (resulting in relatively short periods of follow-up), this 'ceiling effect' may represent an almost insurmountable problem for studying transmission in this particular population. Compounding this difficulty was the relatively small size of the SA incarcerated population — reported to number approximately 1500 on any given day during the time of the study.[25] Nonetheless, three seroconversions were identified and the HCV serostatus of a number of returning participants was confirmed. The latter was made possible by the study design, which allowed for the detection of participants if they came back into prison. This design might be effectively employed in larger prison populations on this or other issues of public health importance.

Conclusions

This study estimated high HCV seroprevalence in the SA prisoners, especially in women, indigenous persons, and injection drug users. The seroconversion rate for HCV-negative entrants was low. Of most concern was that HCV seropositive prison entrants were significantly more likely to commence injecting while incarcerated and that needle sharing was common in this group. This suggests that each needle currently in circulation within the SA prison system

will almost certainly be contaminated with HCV, which has serious implications for prison staff and also for susceptible prisoners.

Acknowledgements

The authors would like to thank the prisoners involved in the study and to acknowledge the efforts of the South Australian Prison Health Service. We also thank the South Australian Department for Correctional Services for the access they have provided and the support they and the South Australian Department of Health maintained for the project.

Conflict of interest: No conflict of interest to declare.

Funding sources: None to declare.

Ethical approvals: Formal approvals for the study were obtained from the SA Aboriginal Health Research Ethics Committee, the SA Department for Correctional Services Research Management Committee, the SA Department of Health Human Research Ethics Committee, the Royal Adelaide Hospital Research Ethics Committee and the University of Adelaide Human Research Ethics Committee.

References

1. Farrell GC. *Hepatitis C, other liver disorders, and liver health*. NSW, Australia: MacLennan and Petty; 2002.
2. Butler T, Spencer J, Cui J, Vickery K, Zou J, Kaldor J. Seroprevalence of markers for hepatitis B, C and G in male and female prisoners—NSW, 1996. *Aust N Z J Public Health* 1999;**23**:377—84.
3. Butler TG, Dolan KA, Ferson MJ, McGuinness LM, Brown PR, Robertson PW. Hepatitis B and C in New South Wales prisons: prevalence and risk factors. *Med J Aust* 1997;**166**:127—30.
4. Crofts N, Stewart T, Hearne P, Ping XY, Breshkin AM, Locarnini SA. Spread of bloodborne viruses among Australian prison entrants. *Br Med J* 1995;**310**:285—8.
5. Hellard ME, Hocking JS, Crofts N. The prevalence and the risk behaviours associated with the transmission of hepatitis C virus in Australian correctional facilities. *Epidemiol Infect* 2004;**132**:409—15.
6. Allwright S, Bradley F, Long J, Barry J, Thornton L, Parry JV. Prevalence of antibodies to hepatitis B, hepatitis C, and HIV and risk factors in Irish prisoners: results of a national cross sectional survey. *Br Med J* 2000;**321**:78—82.
7. Babudieri S, Longo B, Sarmati L, Starnini G, Dori L, Suligoi B, et al. Correlates of HIV, HBV, and HCV infections in a prison inmate population: results from a multicentre study in Italy. *J Med Virol* 2005;**76**:311—7.
8. Ford PM, Pearson M, Sankar-Mistry P, Stevenson T, Bell D, Austin J. HIV, hepatitis C and risk behaviour in a Canadian medium-security federal penitentiary. Queen's University HIV Prison Study Group. *Q J Med* 2000;**93**:113—9.
9. Fox RK, Currie SL, Evans J, Wright TL, Tobler L, Phelps B, et al. Hepatitis C virus infection among prisoners in the California state correctional system. *Clin Infect Dis* 2005;**41**:177—86.
10. Malliori M, Sypsa V, Psichogiou M, Touloumi G, Skoutelis A, Tassopoulos N, et al. A survey of bloodborne viruses and associated risk behaviours in Greek prisons. *Addiction* 1998;**93**:243—51.
11. Crofts N, Thompson S, Wale E, Hernberger F. Risk behaviours for blood-borne viruses in a Victorian prison. *Aust N Z J Criminol* 1996;**29**:20—8.
12. Dolan K. Surveillance and prevention of hepatitis C infection in Australian prisons. A discussion paper. NDARC Technical Report No. 95. Sydney, Australia: National Drug and Alcohol Research Centre, University of New South Wales; 2000.
13. Champion JK, Taylor A, Hutchinson S, Cameron S, McMenamin J, Mitchell A, et al. Incidence of hepatitis C virus infection and associated risk factors among prison inmates: a cohort study. *Am J Epidemiol* 2004;**159**:514—9.
14. Christensen PB, Krarup HB, Niesters HG, Norder H, Georgsen J. Prevalence and incidence of bloodborne viral infections among Danish prisoners. *Eur J Epidemiol* 2000;**16**:1043—9.
15. Macalino GE, Hou JC, Kumar MS, Taylor LE, Sumantera IG, Rich JD. Hepatitis C infection and incarcerated populations. *Int J Drug Policy* 2004;**15**:103—14.
16. Haber PS, Parsons SJ, Harper SE, White PA, Rawlinson WD, Lloyd AR. Transmission of hepatitis C within Australian prisons. *Med J Aust* 1999;**171**:31—3.
17. Post JJ, Dolan KA, Whybin LR, Carter IW, Haber PS, Lloyd AR. Acute hepatitis C virus infection in an Australian prison inmate: tattooing as a possible transmission route. *Med J Aust* 2001;**174**:183—4.
18. Butler T, Kariminia A, Levy M, Kaldor J. Prisoners are at risk for hepatitis C transmission. *Eur J Epidemiol* 2004;**19**:1119—22.
19. Long J, Allwright S, Barry J, Reynolds SR, Thornton L, Bradley F, et al. Prevalence of antibodies to hepatitis B, hepatitis C, and HIV and risk factors in entrants to Irish prisons: a national cross sectional survey. *Br Med J* 2001;**323**:1209—13.
20. Garfein RS, Doherty MC, Monterroso ER, Thomas DL, Nelson KE, Vlahov D. Prevalence and incidence of hepatitis C virus infection among young adult injection drug users. *J Acquir Immune Defic Syndr* 1998;**18**(Suppl 1):S11—9.
21. Lucidarme D, Bruandet A, Ilef D, Harbonnier J, Jacob C, Decoster A, et al. Incidence and risk factors of HCV and HIV infections in a cohort of intravenous drug users in the North and East of France. *Epidemiol Infect* 2004;**132**:699—708.
22. Patrick DM, Tyndall MW, Cornelisse PG, Li K, Sherlock CH, Rekart ML, et al. Incidence of hepatitis C virus infection among injection drug users during an outbreak of HIV infection. *Can Med Assoc J* 2001;**165**:889—95.
23. van Beek I, Dwyer R, Dore GJ, Luo K, Kaldor JM. Infection with HIV and hepatitis C virus among injecting drug users in a prevention setting: retrospective cohort study. *Br Med J* 1998;**317**:433—7.
24. Miller ER, Bi P, Ryan P. The prevalence of HCV antibody in South Australian prisoners. *J Infect* 2006;**53**:125—35.
25. Australian Bureau of Statistics. Prisoners in Australia. Canberra: ABS (no. 4512.0).
26. Department for Correctional Services. Annual Report 2004—2005. Adelaide: DCS, Government of South Australia.
27. Dolan K. Why is there conflicting evidence of hepatitis transmission in prison? Proceedings of the First Australasian Conference on Hepatitis C, Sydney, March 16—18, 1997.
28. Butler T, Boonwaat L, Hailstone S. National prison entrants' bloodborne virus survey, 2004. Sydney: Centre for Health Research in Criminal Justice & National Centre in HIV Epidemiology and Clinical Research; 2005. Available at: http://www.justicehealth.nsw.gov.au/pubs/bbv_survey.pdf (accessed August 2008).
29. Erensoy S. Diagnosis of hepatitis C virus (HCV) infection and laboratory monitoring of its therapy. *J Clin Virol* 2001;**21**:271—81.
30. Vlahov D, Nelson KE, Quinn TC, Kendig N. Prevalence and incidence of hepatitis C virus infection among male prison inmates in Maryland. *Eur J Epidemiol* 1993;**9**:566—9.
31. Jurgens R. Canada: CBC "releases" CSC report on infectious diseases prevention and control. *Can HIV AIDS Policy Law Rev* 2003;**8**:49—50.
32. Boutwell AE, Allen SA, Rich JD. Opportunities to address the hepatitis C epidemic in the correctional setting. *Clin Infect Dis* 2005;**40**(Suppl 5):S367—72.

33. Ehrmann T. Community-based organizations and HIV prevention for incarcerated populations: three HIV prevention program models. *AIDS Educ Prev* 2002;**14**(5 Suppl B):75—84.
34. Richie BE, Freudenberg N, Page J. Reintegrating women leaving jail into urban communities: a description of a model program. *J Urban Health* 2001;**78**:290—303.
35. Solomon L, Flynn C, Muck K, Vertefeuille J. Prevalence of HIV, syphilis, hepatitis B, and hepatitis C among entrants to Maryland correctional facilities. *J Urban Health* 2004;**81**: 25—37.
36. Hagan H. Hepatitis C transmission dynamics in injection drug users. *Subst Use Misuse* 1998;**33**:1197—212.
37. Seamark R, Gaughwin M. Jabs in the dark: injecting equipment found in prisons, and the risks of viral transmission. *Aust J Public Health* 1994;**18**:113—6.
38. Thompson SC, Gouday RE, Breschkin AM, Carnie J, Catton M. Exposure to hepatitis B and C of tattooists in Victoria in 1984. *J Viral Hepat* 1997;**4**:135—8.
39. Dolan K. Surveillance and prevention of hepatitis C in Australian prisons. *Can HIV AIDS Policy Law Rev* 2000;**5**:68—9.
40. Stark K, Bienzle U, Vonk R, Guggenmoos-Holzmann I. History of syringe sharing in prison and risk of hepatitis B virus, hepatitis C virus, and human immunodeficiency virus infection among injecting drug users in Berlin. *Int J Epidemiol* 1997;**26**:1359—66.
41. Macalino G, Vlahov D, Sanford-Colby S, Patel S, Sabin K, Salas C, et al. Prevalence and incidence of HIV, hepatitis B virus, and hepatitis C virus infections among males in Rhode Island prisons. *Am J Public Health* 2004;**94**:1218—23.
42. Macalino GE, Dhawan D, Rich JD. A missed opportunity: hepatitis C screening of prisoners. *Am J Public Health* 2005;**95**:1739—40.