Spread of bloodborne viruses among Australian prison entrants

Nick Crofts, Tony Stewart, Peter Hearne, Xin Yi Ping, Alan M Breschkin, Stephen A Locarnini

Abstract

***Objectives*—To assess spread of bloodborne viruses among prison entrants in Victoria, Australia.**

***Design*—Voluntary confidential testing of all prison entrants for markers of exposure to bloodborne viruses with collection of minimal data on demography and risk factors over 12 months.**

***Setting*—Her Majesty's Prisons, Pentridge and Fairlea, Victoria, Australia.**

***Subjects*—3429 male and 198 female prison entrants (>99% of all prison entrants); 344 entered prison and were tested more than once.**

***Main outcome measures*—Prevalence and incidence of antibodies to HIV, hepatitis B, and hepatitis C viruses, and minimal data on risk factors.**

***Results*—1562 (46%) gave a history of use of injected drugs, 1171 (33%) had antibody to hepatitis B core antigen, 1418 (39%) were anti-hepatitis C positive including 914 (64%) of the men who injected drugs, 91 (2·5%) were positive for hepatitis B surface antigen, and 17 (0·47%) were positive for antibody to HIV. Incidence rates for infection with hepatitis B and C virus were 12·6 and 18·3 per 100 person years, respectively; in men who injected drugs and were aged less than 30 years (29% of all prison entrants) these were 21 and 41 per 100 person years. Seroconversion to hepatitis B or C was associated with young age and shorter stay in prison. Only 5% of those who were not immune to hepatitis B reported hepatitis B immunisation.**

***Conclusions*—Hepatitis B and C are spreading rapidly through some populations of injecting drug users in Victoria, particularly among men aged less than 30 years at risk of imprisonment in whom rates of spread are extreme; this group constitutes a sizeable at risk population for spread of HIV. This spread is occurring in a context of integrated harm reduction measures outside prisons for prevention of viral spread but few programmes within or on transition from prisons; it poses an urgent challenge to these programmes.**

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Introduction

A large proportion of prison entrants are in prison because of their need to generate income to buy illegal drugs. Among Australian prison entrants, 37% to 66% have a history of injecting drug use,[1-4] and 33% overall and 50% of male injecting drug users in Australia have a history of imprisonment.[5-7]

The prevalence of HIV infection in prison entrants may be higher than in the non-prison population, depending on the spread of HIV among injecting drug users. In the United States, with high prevalences of HIV among injecting drug users,[8] estimates of HIV among prison entrants in 1990 ranged from 2·1% to 14·7% depending on area[9] compared with 0·03% in first time blood donors.[10] Similarly in Scotland, where HIV spread among injecting drug users in the early 1980s,[11] seroprevalence of HIV was 4·5% among inmates of one prison in 1991.[12] In contrast, in England and Australia, where reported prevalences of HIV among injecting drug users have been low,[13,14] little HIV has been discovered in prison entrants.[5,15] The prevalence of hepatitis B and C in prisoners is also high, both being associated with injecting drug use; hepatitis C is also associated with tattooing.[16,17]

Several risk behaviours for transmission of HIV and hepatitis B and C occur in prison, including the injection of illicit drugs and tattooing with inadequately disinfected equipment as well as unprotected sexual intercourse, including male to male anal intercourse. One Australian study estimated that 36% of prisoners had injected themselves intravenously, and 12% had participated in anal intercourse at least once while in prison.[2]

Together, these factors potentially increase the risk of transmission of these infections in these populations.[18] We tested for these viruses among entrants to the central Victorian prisons, through which most people enter the Victorian prison system, to study the magnitude of these risk in Australian prisons.

Subjects and methods

Her Majesty's Prison, Pentridge, receives more than 98% of all male prison entrants in Victoria, and Fairlea Prison is the only reception prison for women. From 1985 routine screening for hepatitis B and syphilis has been available to all prison entrants; all such testing is voluntary and is carried out by health department (as distinct from correctional services) staff. Since its introduction in 1985 it has achieved greater than 98% compliance. From October 1991 through September 1992 all entrants to these prisons were also offered screening for hepatitis C (except for seven prisoners who were known to be infected with HIV) and on admission they were asked brief questions on demography and risk factors by prison medical support staff. Use of the results of this testing in an anonymous and collated manner was approved by a properly constituted ethics committee. Specimens and data were identified only by a number unique to the prisoner and a name code. When a person entered prison more than once during the study period he or she was tested at each entry and was considered a re-entrant only if prison number, name code, sex, and date of birth all matched exactly.

Presence of hepatitis C antibody was determined by using an enzyme immunoassay based on a synthetic oligopeptide derived from the nucleocapsid region.[19] All samples from those who entered prison more than once during the study period, where sufficient remained, were later retested with a second generation enzyme immunoassay and if equivocal were retested by using a different second generation enzyme immunoassay. First entry prevalences of antibody to hepatitis C were calculated by using the results of the peptide assay; for calculations of incidence only second generation assay results were used. Standard techniques

were used for determination of anti-HIV antibody and hepatitis B core antibody and surface antigen.

Analytical techniques included Pearson's contingency table χ^2 and Fisher's exact test statistics to determine the significance of associations for categorical variables and Student's t test or Kruskal-Wallis χ^2 test for difference in means between continuous variables; 95% confidence intervals were calculated by using exact methods for proportions,[20] the method of Greenland and Robins for relative risks,[21] and an exponential error factor for incidence rates.[22]

Results

DEMOGRAPHY AND RISK FACTORS

Specimens and data were collected from 3627 prisoners (3429 men and 198 women) on 4008 occassions; 344 subjects presented more than once in the study period. Over 99% of all entrants accepted testing; there were no demographical differences between those not accepting testing and those tested. Average (range) age for men was 29·5 (15 to 68) years and for women was 28·7 (17 to 51) years. History of injecting drug use was more common among women, and injecting drug users were significantly younger than non-users (table I). Most injecting drug users reported last injecting within the past three years (93%, 1308/1414). Most entrants (3311, 81·3%) were of non-aboriginal, Australian ethnicity; distribution of prisoners by ethnic origin was similar to that for the Victorian population, except for aboriginal Australians, who were overrepresented (156, 4·3% compared with 0·2% of the Victorian population).

PREVALENCE OF HIV AND HEPATITIS B AND HEPATITIS C VIRUSES

A third (1171) of prisoners had been exposed to hepatitis B virus; the proportion positive for hepatitis B core antibody was greater in women (table II) and in those with a history of injecting (table I). The overall prevalence of hepatitis B surface antigen was 2·5% (91/3627), again associated with injecting (table I). Among those exposed to hepatitis B the prevalence of surface antigen was higher among men (8·5%) than women (3%) (P=0·06) both for injecting drug users (7% *v* 3·5%) and non-users (12% *v* 0%). Exposure to hepatitis B was lower among those with no history of injecting for those of all ethnic backgrounds, but among prisoners from Pacific Island and with southern European backgrounds the carriage rate of hepatitis B was higher for both those with and without a history of injecting than among those of other ethnic origins.

TABLE I—*Bloodborne viral infections in prison entrants in Victoria, Australia, according to use of injected drugs, October 1991 to September 1992*

Detail	Users of injected drugs	No use of injected drugs	Odds ratio (95% confidence interval)
Men:			
No by drug use†	1436	1749	
Mean (SD) age (years)	26·8 (6·8)	31·5 (10·2)***	
No (%) positive for:			
Anti-hepatitis C virus	897/1410 (63·6)	274/1712 (16·0)	9·15 (7·7 to 10·9)***
Anti-hepatitis B core antigen	693/1377 (50·3)	264/1719 (15·4)	5·56 (4·7 to 6·6)***
Hepatitis B surface antigen	48/1370 (3·5)	31/1722 (1·8)	2·00 (1·2 to 3·2)**
Anti-HIV	5/1436 (0·35)	4/1749 (0·23)	1·52 (0·4 to 6·7)
Women:			
No by drug use†	125	54	
Mean (SD) age (years)	26·8 (6·1)	32·7 (10·6)***	
No (%) positive for:			
Anti-hepatitis C virus	100/118 (84·8)	14/53 (26·4)	15·50 (6·5 to 37·5)***
Anti-hepatitis B core antigen	87/122 (71·3)	10/52 (19·2)	10·44 (4·4 to 25·3)***
Hepatitis B surface antigen	3/120 (2·5)	0/53	
Anti-HIV	0/125	0/54	
All men and women:	1561	1803	
Mean (SD) age (years)	26·8 (6·5)	31·6 (10·2)	
No (%) positive for:			
Anti-hepatitis C virus	997/1528 (65·3)	288/1765 (16·3)	9·61 (8·1 to 11·4)***
Anti-hepatitis B core antigen	780/1499 (52·0)	274/1771 (15·5)	5·91 (5·0 to 7·0)***
Hepatitis B surface antigen	51/1490 (3·4)	31/1775 (1·7)	2·01 (1·3 to 3·2)**
Anti-HIV	5/1561 (0·32)	4/1803 (0·22)	1·45 (0·3 to 1·9)

†Drug use not known for 242 men and 18 women. **P<0·01. ***P<0·001.

TABLE II—*Bloodborne viral infections in prison entrants in Victoria, Australia, according to sex, October 1991 to September 1992*

Detail	Men and women	Men	Women	Odds ratio (95% confidence interval)
No of prisoners	3624	3427	197	
Mean (SD) age (years)	29·5 (9·1)	29·5 (9·1)	28·7 (8·2)	
No (%) positive for:				
Anti-hepatitis C virus	1365/3546 (38·5)	1239/3357 (36·9)	126/189 (66·7)	3·41 (2·5 to 4·7)***
Anti-hepatitis B core antigen	1145/3526 (32·5)	1038/3334 (31·1)	107/192 (55·7)	2·78 (2·1 to 3·8)***
Hepatitis B surface antigen	91/3445 (2·6)	88/3250 (2·7)	3/195 (1·5)	0·56 (0·1 to 1·9)
Anti-HIV	10/3624 (0·28)	10/3427 (0·29)	0/197	

***P<0·001.

TABLE III—*Proportion of prison entrants with antibody to HIV by serostatus for hepatitis B and C*

Anti-hepatitis B core antigen	Anti-hepatitis C virus: Positive	Anti-hepatitis C virus: Negative	Total
Positive	0·50% (4/793)	0·0% (0/326)	0·36% (4/1119)
Negative	0·38% (2/523)	0·16% (3/1821)	0·21% (5/2344)
Total	0·46% (6/1316)	0·14% (3/2147)	0·26% (9/3463)

The prevalence of hepatitis C was 39·1% (1418/3269) overall, again higher in women and injecting drug users; the highest seroprevalence was among women with a history of injecting (table I). The proportion seropositive for hepatitis C did not differ with year of last injection, from 61% before 1986 to 66% after 1990. Compared with the second generation assay the sensitivity of the peptide assay was 87·9% (95% confidence interval 84·9 to 91·0%) and its specificity was 95·8% (92·5 to 98·0%). The proportions with past exposure to hepatitis B or C rose with age up to 40 years and then declined, both for those with and those without a history of injecting.

HIV seroprevalence overall was 0·47% (17/3634), but seven prisoners previously known to be positive for HIV were not retested in this study. Of 3620 people tested at least once during the period, 10 (0·28%) had antibodies to HIV; all were men, and there was no difference in the prevalence of HIV between those with a history of injecting and those without (table I). Prisoners infected with HIV who did or did not inject drugs differed with regard to age (mean ages 25·8 *v* 35·4 years) and on rate of exposure to hepatitis C (4/5 *v* 1/4) and to hepatitis B (4/5 *v* 1/4). Those who were infected with HIV did not differ significantly from those who were not with regard to age, history of injecting drug use, or ethnicity. Almost a quarter of those tested for antibody to both hepatitis B and C were positive for both, with 15% positive only for C, 9·5% positive only for B, and half negative for both antibodies. Among injecting drug users there was a gradient in mean age between those positive for both (44%, mean 28·7 years), for B only (8%, 27·4), for C only (21%, 26·1), and for neither (27%, 24·1) (P=<0·001). Of those who were tested for all three viruses, HIV seropositivity was associated with seropositivity for hepatitis C marginally more than with seropositivity for hepatitis B (table III).

INCIDENCE OF HEPATITIS B AND HEPATITIS C VIRUSES

Of the 327 entrants for whom sufficient data were available, 180 (55%) were negative for antibody to hepatitis B core antigen at first entry. Ten of these entrants were considered to have seroconverted at a subsequent entry; and incidence rate of 12·6 per 100 person years (table IV). Hepatitis B converters were all men, significantly younger than their counterparts (mean age 22·9 *v* 25·7 years; P=0·003), and more likely to give a history of injecting (90% *v* 59%; P=0·09). Among men aged less than 30 years who injected drugs

TABLE IV—*Incidence of infection with hepatitis B and C virus among subjects entering prison more than once, October 1991 to September 1992, in Victoria, Australia*

Detail	No initially seronegative	No of seroconverters	Mean (SD) period of observation (days)	Range of observation (days)	Incidence rate per 100 person years (95% confidence interval)
			Hepatitis C		
Drug users	47	8	163 (89)	3-348	38·2 (19·1 to 76·4)
Not drug users	72	2	171 (89)	4-339	5·9 (1·5 to 23·6)
Total	119	10	168 (89)	3-348	18·3 (9·8 to 34·0)
			Hepatitis B		
Drug users	108	9	158 (86)	4-348	19·3 (10·0 to 37·0)
Not drug users	70	1	170 (87)	4-343	3·1 (0·4 to 22·0)
Total	178*	10	163 (87)	4-348	12·6 (6·8 to 23·5)

*Excludes two people who were initially negative for hepatitis B core antibody and positive for hepatitis B surface antigen.

the incidence rate for hepatitis B was 21·2 per 100 person years (10·6 to 42·4).

Sufficient data were available to assess conversion rates to hepatitis C for 312 entrants (90·7% of all multiple entrants) (table IV). Of 193 people who were seropositive at first test, all were positive on second or subsequent tests; 93% of these entrants gave a history of injecting. Of 119 who were seronegative at first test, 10 (8·4%) were subsequently seropositive, an incidence rate of 18·3 per 100 person years. Hepatitis C converters were all men and significantly younger than other men who remained negative (mean age 22·2 *v* 26·2 years). A history of injecting was more common among converters than among those who did not convert (80% *v* 36%, P=0·01). Among men aged less than 30 years who injected drugs, who made up 29% of all prison entries in the study period, the incidence rate for hepatitis C was 41 per 100 person years (20·5 to 82·0).

Of the 10 seroconverters to hepatitis B, eight (80%) were positive for hepatitis C on both occasions; of the 10 seroconverters to hepatitis C, three (30%) were positive for hepatitis B on both occasions (Fisher's two tailed test; P=0·07). No one seroconverted to both hepatitis B and C during the study, and none of those who were tested more than once during the study period was positive for HIV.

There was no difference in time spent in prison between tests among those who became positive for hepatitis B and C and those who did not; this was on average 44 days between entrance and discharge and 153 days between discharge and re-entry for both groups. Conversion to hepatitis C was inversely associated with length of time in prison: in those whose length of stay was one month or less the incidence was 62% a year compared with 26% a year in those whose stay was over one month (P=<0·01). Most (8/10) seroconverters to hepatitis B spent one month or less in prison. All seroconverters to both hepatitis B and C, however, spent more than three months outside prison between tests. Five cases of acute icteric illness in prisoners were observed during the study, all as a result of acute hepatitis B infection.

HEPATITIS B VIRUS IMMUNISATION

Data were available on past immunisation for hepatitis B for 72% (2611/3269) of prisoners; for the rest, status was unknown or unasked. Overall, 5% (180) reported having been immunised, with similar rates for men (126, 5·1%) and women (10, 7·4%). Injecting drug users were no more likely to report having been immunised for hepatitis B (5·5% *v* 4·5%). Only 5% of prisoners who were not immune to hepatitis B reported having been immunised. Injecting drug users who were not immune were somewhat more likely to report having been immunised than other entrants (7% *v* 4·5%, P=0·02). Of men aged less than 30 years who gave a history of injecting, only 26 (7·5%) of those not immune to hepatitis B gave a history of hepatitis B immunisation.

Discussion

Despite Australia's strong commitment to widespread and accessible needle and syringe exchange programmes, accessible low threshold methadone maintenance, and peer education in the community at large[23] there are few such programmes in Australian prisons. Our study documents continuing extremely high rates of transmission of both hepatitis B and C, especially among young men who inject drugs and enter prison. In particular, the high rate of continuing exposure to hepatitis B in male prisoners aged less than 30 years who inject drugs suggests that this is a group in whom spread of HIV must be considered to be simply a matter of time. This continuing spread poses an enormous challenge to our harm reduction programmes.

We have previously documented an incidence rate for hepatitis C of 20% among field recruited injecting drug users in Victoria, over half of whom carry hepatitis C and have argued that with such high rates further spread is inevitable even with substantial and rapid behaviour change.[6] These data illustrate this, with presumably high carriage rates of hepatitis C[24] matched by high incidences of new infection; there is, however, a high incidence of hepatitis B infection here where rates of carriage are low. This implies that there is common reuse of contaminated injecting equipment with many others.

We do not have data to draw conclusions about the timing of transmission of these viruses in this population. There were three possible periods: before first prison entry, during imprisonment, and after initial imprisonment but before the second entry. There is evidence of transmission of these viruses within prisons,[25] and a local study found a prison history to be an independent risk factor for exposure to hepatitis C among male injecting drug users in Victoria.[10] Other evidence suggests that the period immediately after release from prison is the most risky in terms of transmission of bloodborne viruses.[5] The association of seroconversion with shorter stay in prison and longer period outside prison is intriguing but susceptible to conflicting explanations. One is the possibility that the most dangerous time for transmission of these viruses is in the remand yards, where the shorter stay prisoners spend their time and where injecting is reputedly most unsafe. Alternatively, most of this transmission might be occurring on release and is detected only in those who are out of prison for three months or more because of the seroconversion period.

Exposure to hepatitis C in this population precedes exposure to hepatitis B and occurs at a young age; most hepatitis B seroconverters had already been exposed to hepatitis C whereas most hepatitis C seroconverters had not been exposed to hepatitis B, and the average age of those exposed only to hepatitis C (22 years) was less than that of those exposed to both viruses. The low rate of jaundice is not surprising in view of, firstly, the low rate of such illness with acute hepatitis C injection and, secondly, the short stay in prison of seroconverters to hepatitis B. This would be consistent with injection occurring inside prison and illness occurring outside, but this remains speculative.

The rates of injecting drug use among prison entrants and of hepatitis C among prison entrants with a history of injecting documented here are likely to underestimate the true rates for two reasons. The assay used for determination of hepatitis C serostatus was not as accurate as currently available assays, and the seroprevalence results for hepatitis C are an estimate based on comparison of a subset with more recent assays. There was therefore some misclassification of hepatitis C serostatus, more likely to obscure the degree of association with injecting drug use because of a higher proportion of false positive results among

Key messages

- Australia has implemented widespread harm reduction programmes outside prison but few inside or on transition from prison
- These programmes are seen to be effective in controlling the spread of HIV among injecting drug users among whom prevalence of HIV remains low
- There is, however, continued spread at high rates of hepatitis C and B among young injecting drug users entering prisons in Australia
- The highest rates (41% a year for hepatitis C and 21% a year for hepatitis B) are occurring among young male injecting drug users
- There is an urgent need to refocus harm reduction programmes to cope with the challenge of hepatitis C and to ensure prisoners are at no greater risk inside or on transition from prisons than they are outside

those with no history of injecting. Secondly, a history of injecting was obtained only by self report to the prison medical support officer at entry and is therefore likely to be an underestimate of the true rate, again underestimating the contribution of injecting to the prevalence of hepatitis C among prison entrants.

Vaccination rates against hepatitis B among these prison entrants were low despite the high incidence rates, highlighting the failure of Australia's national targeted programme for hepatitis B immunisation.[26] Two thirds of prison entrants were not immune but not vaccinated, including over 90% of those with a history of injecting. Offering hepatitis B vaccination to this at risk and high incidence population (and perhaps to the families and sexual partners of those found to be positive for surface antigen) is a sensible public health strategy.[27,28]

Harm reduction programmes have proved important in the prevention of spread of HIV among injecting drug users in many parts of the world, including Australia. These data show continued spread of both high and low prevalence bloodborne viruses in a considerable population in the context of these programmes. There is need to clarify further exactly where transmission of these viruses is taking place in this population,[29] and this research has led to the institution of incidence studies both inside and on transition from this prison. Sensible harm reduction strategies, however, including reform of sentencing policies, specific education about hepatitis C, hepatitis B vaccination, methadone maintenance, and sterile tattooing equipment, must be urgently introduced into prisons and during transition from prison to the outside without awaiting such final clarification.[30]

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1 Gaughwin MD, Douglas RM, Liew C, Davies L, Mylvaganam A, Treffke H, *et al.* HIV prevalence and risk behaviours for HIV transmission in South Australian Prisons. *AIDS* 1991;5:845-51.
2 Indermauer D, Upton K. Alcohol and drug use patterns of prisoners in Perth. *Australian and New Zealand Journal of Criminology* 1988;3:144-67.
3 Indermauer D. *Substance abuse history of Fremantle prisoners: a survey conducted of prisoners.* Perth: Western Australian Department of Corrective Services, 1990.
4 Dobinson I, Ward P. Heroin and property crime: an Australian perspective. *Journal of Drug Issues* 1986;16:249-62.
5 Wolk J, Wodak A, Morlet A, Guinan JJ, Gold J. HIV-related risk-taking behaviour, knowledge and serostatus of IV drug users in Sydney. *Med J Aust* 1990;152:453.
6 Crofts N, Hopper J, Milner R, Bowden DS, Breschkin AM, Locarnini SA. Hepatitis C virus infection among a cohort of Victorian injecting drug users. *Med J Aust* 1993;159:237-41.
7 Bell J, Fernandes D, Batey R. Heroin users seeking methadone treatment. *Med J Aust* 1990;152:361-4.
8 Hahn RA, Onorato IM, Jones A, Dougherty J. Prevalence of HIV infection among intravenous drug users in the United States. *JAMA* 1989;261: 2677-84.
9 Vlahov D, Brewer TF, Castro KG, Narkunas JP, Salive ME, Ullrich J, *et al.* Prevalence of antibody to HIV-1 among entrants to US correctional facilities. *JAMA* 1991;265:1129-32.
10 Centers for Disease Control. *National HIV seroprevalence surveys—summary of results: data from serosurveillance activities through 1989.* Atlanta: United States Department of Health and Human Services, Public Health Service, Center for Disease Control, 1990.
11 Skidmore CA, Robertson JR, Robertson AA, Elton RA. After the epidemic: follow up study of HIV seroprevalence and changing patterns of drug use. *BMJ* 1990;300:219-23.
12 Bird AG, Gore SM, Jolliffe DW, Burns SM. Anonymous HIV surveillance in Saughton Prison, Edinburgh. *AIDS* 1992;6:725-33.
13 Donoghoe MC, Stimson GV, Dolan KA. Sexual behaviour of injecting drug users and associated risks of HIV infection for non-injecting sexual partners. *AIDS Care* 1989;1:51-8.
14 Kaldor J, Elford J, Wodak A, Crofts N, Kidd S. HIV prevalence among IDUs in Australia: a methodological review. *Drug and Alcohol Review* 1993;12: 175-84.
15 Gaughwin MD, Douglas RM, Liew C, Davies L, Mylvaganam A, Treffke H, *et al.* HIV prevalence and risk behaviours for HIV transmission in South Australia prisons. *AIDS* 1991;5:845-51.
16 Holsen DS, Harthug S, Myrmel H. Prevalence of antibodies to hepatitis C virus and association with intravenous drug abuse and tattooing in a national prison in Norway. *Eur J Clin Microbiol Infect Dis* 1993;12:673-6.
17 Watson PG, Watts JR, Nelson M. The incidence of Australia antigen and antibody in male prisoners of two Sydney penitentiaries. *Med J Aust* 1973;2:421-3.
18 Gaughwin MD. HIV/AIDS: risk behaviours—research findings and their implications for prevention. In: J Fortuin, ed. *Issues in HIV/AIDS in the Australian prison system.* Canberra: Australian Institute of Criminology, 1992.
19 Okamoto H, Munekata E, Tsuda F, Munekata E, Akahane Y, Sugair Y, *et al.* Enzyme-linked immunosorbent assay for antibodies against the capsid protein of hepatitis C virus with a synthetic oligopeptide. *Japan J Exp Med* 1990;60:223-33.
20 Breslow NE, Day NE. *Statistical methods in cancer research.* Lyons: International Agency for Research on Cancer, 1980.
21 Greenland S, Robins JM. Estimation of a common effect parameter from sparse follow-up data. *Biometrics* 1985;41:55-68.
22 Clayton D, Hills M. *Statistical models in epidemiology.* Oxford: Oxford University Press, 1993:81.
23 Australian National Council on AIDS. *National HIV/AIDS strategy, 1993-4 to 1995-6.* Canberra: Australian Government Printing Service, 1993.
24 Sugitani M, Inchauspe G, Shindo M, Prince AM. Sensitivity of serological assays to identify blood donors with hepatitis C viraemia. *Lancet* 1992;339: 1018-9.
25 Christie B. HIV outbreak investigated in Scottish jail. *BMJ* 1993;307:151-2.
26 Thompson SC, Stevenson E, Wilby R, Crofts N. Hepatitis B infection in Victoria 1992: time to review the high risk vaccination strategy (letter). *Med J Aust* 1993;159:562-3.
27 Decker MD, Vaughn WK, Brodie JS, Hutcheson RH, Schaffner W. The incidence of hepatitis B in Tennessee prisoners. *J Infect Dis* 1985;152:214-7.
28 Bayas JM, Bruguera M, Martin V, Vidal J, Rodes J, Salleras LY. Hepatitis B vaccination in prisons: the Catalonian experience. *Vaccine* 1993;11:1441-4.
29 Bird AG, Gore SM. Inside methodology: HIV surveillance in prisons. *AIDS* 1991;8:1345-6.
30 Gore SM, Bird AG. No escape: HIV transmission in jail. *BMJ* 1993;307: 147-8.

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