Do needle exchange programmes increase the spread of HIV among injection drug users?: an investigation of the Vancouver outbreak

Martin T. Schechter*†, Steffanie A. Strathdee*†, Peter G.A. Cornelisse*, Sue Currie*, David M. Patrick‡§, Michael L. Rekart‡§ and Michael V. O'Shaughnessy*||¶

Objective: An association between needle exchange attendance and higher HIV prevalence rates among injecting drug users (IDU) in Vancouver has been interpreted by some to suggest that needle exchange programmes (NEP) may exacerbate HIV spread. We investigated this observed association to determine whether needle exchange was causally associated with the spread of HIV.

Design and method: Prospective cohort study of 694 IDU recruited in the downtown eastside of Vancouver. Subjects were HIV-negative at the time of recruitment and had injected illicit drugs within the previous month.

Results: Of 694 subjects, the 15-month cumulative HIV incidence was significantly elevated in frequent NEP attendees (11.8 ± 1.7 versus 6.2 ± 1.5%; log-rank $P = 0.012$). Frequent attendees (one or more visits per week) were younger and were more likely to report: unstable housing and hotel living, the downtown eastside as their primary injecting site, frequent cocaine injection, sex trade involvement, injecting in 'shooting galleries', and incarceration within the previous 6 months. The Cox regression model predicted 48 seroconversions among frequent attendees; 47 were observed. Although significant proportions of subjects reported obtaining needles, swabs, water and bleach from the NEP, only five (0.7%) reported meeting new friends or people there. When asked where subjects had met their new sharing partners, only one out of 498 respondents cited the needle exchange. Paired analysis of risk variables at baseline and the first follow-up visit did not reveal any increase in risk behaviours among frequent attendees, regardless of whether they had initiated drug injection after establishment of the NEP.

Conclusions: We found no evidence that this NEP is causally associated with HIV transmission. The observed association should not be cited as evidence that NEP may promote the spread of HIV. By attracting higher risk users, NEP may furnish a valuable opportunity to provide additional preventive/support services to these difficult-to-reach individuals.

AIDS 1999, **13**:F45–F51

Keywords: HIV, injecting drug use, needle exchange programme

From the *British Columbia Centre for Excellence in HIV/AIDS, St. Paul's Hospital, the †Department of Health Care and Epidemiology, University of British Columbia, the ‡British Columbia Centre for Disease Control, the §Department of Medicine, University of British Columbia, ||St. Paul's Hospital and the ¶Department of Pathology, University of British Columbia, Vancouver, British Columbia, Canada

Sponsorship: BC Ministry of Health, National Health Research and Development Programme of Health Canada (Scientist Award – MTS), National Institutes of Health (NIH 1 R01 DA11591-01).

Requests for reprints to: M. Schechter, British Columbia Centre for Excellence in HIV/AIDS, 611-1081 Burrard Street, Vancouver, British Columbia, Canada V6Z 1Y6.

Date of receipt: 30 November 1998; revised: 22 January 1999; accepted: 1 February 1999.

Introduction

The downtown eastside of Vancouver has long been the centre of the city's injecting drug users (IDU) community. In 1989, a fixed-site needle exchange programme (NEP) was established in the downtown eastside community [1], with mobile vans added 2 years later. This programme has grown to be one of the largest in North America, having exchanged over two million needles in 1997. However, in 1996, we reported that among more than 1000 IDU entering into a cohort study, those who had ever attended Vancouver's needle exchange had significantly higher prevalence rates of HIV infection than those who had never attended [2]. This has received considerable attention, particularly in the USA where consensus about the value of NEP has yet to emerge [3,4]. Members of the USA Congress [5,6] interpreted this as evidence that NEP may promote the spread of HIV. A similar interpretation appeared in a report of the Office of National Drug Control Policy [7]. In April 1998, based in part on this report, the USA Administration continued its ban on the use of federal funds to support NEP.

The purpose of the present study was to investigate the observed association between NEP attendance and HIV infection. We proposed three *a priori* hypotheses. The first was that the NEP was causally associated with HIV transmission by facilitating the formation of new needle sharing partnerships. The second was that the NEP was causally associated with HIV transmission by leading to higher risk behaviours among its frequent attendees. The final hypothesis was that the NEP *per se* was not causally associated with HIV transmission, and that the apparent excess risk was due to the fact that the programme attracted participants who were at higher risk because of their risk behaviours.

Methods

Study sample

Beginning in May 1996, persons who had injected illicit drugs in the previous month and resided in the Greater Vancouver region were recruited into the Vancouver Injection Drug User Study. The study established a storefront office in the downtown eastside. Most participants (82%) came forward to the study office, having learned of the study through recruitment materials or other participants. The remaining subjects were referred by the NEP (5%), other storefront agencies (10%), and clinics (3%). Evidence of recent injecting drug use was required by inspection of needle tracks. Eligible subjects provided written informed consent. At the baseline visit and semi-annually thereafter, subjects provided blood samples for HIV and hepatitis C virus antibodies, and completed an interviewer-administered questionnaire. Subjects were reimbursed $20 Canadian for each study visit, at which time referrals were provided for universal medical care, HIV/AIDS care, available drug and alcohol treatment, and counselling.

Study instrument

Trained interviewers, who were blind to the current HIV status of participants, administered questionnaires. Detailed information included demographics, injecting and non-injecting drug use, needle borrowing and lending, re-use of own needles, source of needles, attendance at NEP, location of injection, housing, drug treatment, methadone maintenance and other drug/alcohol programmes. Sexual behaviours and condom use were assessed for regular, casual and sex trade partners of the same and opposite sex. As in our previous study [2], unstable housing was defined as living primarily in a hotel, boarding room, hostel, transition house, jail, or on the street during the previous 6 months.

With regard to the issue of network formation, the questionnaire included the following exact question: "In the last 6 months (or since your last visit) what did you get from the needle exchange?" For each respondent, interviewers read out the following list of responses, and probed for each item: condoms, alcohol swabs, vitamins, water, AIDS education, bleach, warning sheets, counselling or referrals, stickers to mark syringes, and meeting new people or friends.

To study network formation, a series of questions was added to the most recent follow-up questionnaire in December 1997. Respondents who indicated that they had shared (borrowed or lent) injecting equipment with other people since their last visit were asked the following exact question: "How many of these people were new (i.e. persons you had never injected with before)?" Respondents with new sharing partners were then probed to determine if they had met these new partners through any of the following sources: other users, on the street, through family, 'shooting galleries', methadone clinics, jails, needle exchange, hospitals, aboriginal reserves, or home town.

Statistical analysis

Kaplan–Meier methods were used to estimate HIV incidence. Such analyses were restricted to those participants who were HIV-negative at study entry and who completed at least one additional follow-up visit. Time of seroconversion was estimated as the midpoint between the last negative and first positive test. Persistently seronegative subjects were censored at their last follow-up visit.

Consistent with our previous study [2], frequent NEP attendees were defined *a priori* as those who reported

visiting the exchange at least once weekly at baseline. Unless otherwise indicated, all risk information was obtained from the baseline questionnaire. To test the association of NEP with subsequent HIV incidence, Kaplan–Meier curves for frequent and infrequent NEP attendees were compared using the log-rank test.

To assess whether the infection rate in frequent attendees was elevated, observed seroconversions were compared with predicted seroconversions. First, a Cox proportional hazard model was fitted by using variables which were associated with seroconversion in univariate analyses ($P < 0.05$), but excluding frequent NEP attendance. Predicted probability of seroconversion at 15 months was calculated for each individual using the following method: the Cox model with covariates fixed at zero was used to compute the value of the baseline survival function; this value and the value of each participant's risk set multiplied by the coefficient matrix were used to compute the predicted survival for each participant, and by subtraction, the predicted probability of infection; predicted probabilities were then summed separately for frequent and infrequent attendees to derive the predicted number of seroconversions in each group.

To study the association of NEP with changes in HIV risk behaviour, paired questionnaire responses to key risk items in the baseline and first follow-up visits were compared using McNemar's test. Because effects may have possibly differed according to when drug injection was initiated, the sample was stratified into those who initiated their drug injection before and after the establishment of the NEP in 1989; for convenience, these groups are referred to as pre-NEP initiates and post-NEP initiates, respectively.

Results

Incidence and NEP attendance

As of April 1998, 934 IDU had completed baseline interviews and were seronegative at baseline. Of these, 64 completed their baseline visit within the 6 months prior to April 1998 and were not yet eligible for follow-up. Of 870 eligible subjects (496 frequent attendees; 374 infrequent attendees), 694 (80%) completed at least one follow-up visit. The follow-up rates were similar in frequent attendees (405 out of 496; 81%) and infrequent attendees (289 out of 374; 77%) ($P = 0.11$).

The 694 subjects were predominantly male (68%) and had a median age of 36 years (interquartile range, 29–41 years). Their ethnic status was as follows: 65% white, 25% aboriginal, 10% other. Their median age at first injection was 19 years (interquartile range, 15–25 years), 26% had ever been enrolled in methadone maintenance, and 59% reported their residence as the downtown eastside.

Of the 694 subjects, 64 seroconverted: 39 were documented at the first follow-up, 17 at the second follow-up, and eight at the third follow-up. Based on the estimated date, 25 seroconversions occurred during the period July 1996 to December 1996, 25 during the period January 1997 to June 1997, and 14 during the remainder of 1997. Based on 768.3 person years of observation, these 64 infections gave rise to an estimated HIV incidence density of 8.3 per 100 person-years [95% confidence interval (CI), 6.3–10.4]. The Kaplan–Meier estimate for the cumulative HIV incidence rate at 15 months following the baseline visit was 9.8% (95% CI, 7.5–12.2).

Table 1 presents univariate comparisons of baseline risk variables in those who did and did not subsequently seroconvert. Those who subsequently seroconverted were more likely at baseline to have had unstable housing, lived in a hotel, injected more than four times daily, injected cocaine at least once per day, identified the downtown eastside as their main fixing location, reported needing help injecting, and been a frequent NEP attendee.

There were 47 seroconversions observed in the 405 frequent attendees and 17 in the 289 infrequent attendees. Fig. 1 shows the 15-month cumulative HIV incidence stratified by NEP attendance. The elevation in the HIV infection rate among the frequent attendees was significant ($11.8 \pm 1.7\%$ versus $6.2 \pm 1.5\%$; log-rank, $P = 0.012$).

Table 2 presents a comparison of the frequent and infrequent attendees with regard to several key risk variables at baseline. There was a clear pattern of greater baseline risk among frequent attendees. These subjects, when compared to infrequent attendees, were younger and were more likely to report unstable housing and hotel living, the downtown eastside as their main injection site, frequent injection and frequent injection of cocaine, involvement in the sex trade, injecting in 'shooting galleries', and incarceration

Table 1. Comparison of seroconverters and non-seroconverters with respect to baseline risk factors.

Variable	Non-converter (n = 630)	Converter (n = 64)	*P*
Unstable housing	478 (76%)	56 (88%)	0.035
Living in a hotel	370 (59%)	46 (73%)	0.031
Inject four or more times per day	182 (29%)	31 (48%)	≤ 0.001
Inject cocaine at least once per day	265 (42%)	46 (73%)	≤ 0.001
DTES as main injecting location	438 (70%)	56 (88%)	0.002
Needed help injecting	248 (39%)	36 (56%)	0.009
Frequent NEP attendee	358 (57%)	47 (73%)	0.010

DTES, Downtown eastside; NEP, needle exchange programme.

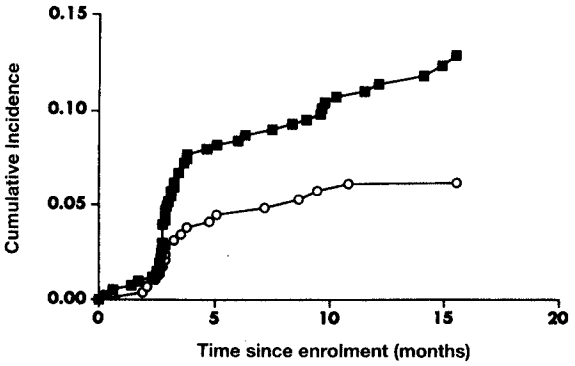

Fig. 1. Kaplan–Meier HIV incidence curves from enrolment to 15 months for frequent attendees (closed squares) and infrequent NEP attendees (open circles).

within the prior 6 months. They were also more likely to report other illegal income. They were less likely to report current enrolment in a methadone programme, and far less likely to report pharmacies as their primary needle source. The distribution of follow-up in calendar time was similar between the frequent and infrequent attendees.

Predicted numbers of seroconversions were based on a multivariate Cox regression model containing the variables: unstable housing, hotel living, injecting four or more times per day, cocaine injection at least once per day, downtown eastside as main injecting site, and needing assistance injecting. The numbers of seroconversions predicted by this Cox model (48 and 18) were very similar to the numbers observed (47 and 17) for frequent and infrequent attendees respectively. Alternatively, the NEP attendance variable did not enter into the model when fitted in addition to the covariate set used for prediction (risk ratio, 1.2; 95% CI, 0.6–2.2; likelihood ratio χ^2, 0.29; $P = 0.99$). To see if the modelling was sensitive to the choice of Cox regression, this analysis was also conducted using logistic regression; this yielded predicted seroconversions in the frequent and infrequent attendees of 45 and 19 respectively. In addition, Cox model analysis was performed separately for pre-NEP and post-NEP initiates; in this case a similar pattern of results was obtained in which observed numbers were similar to those predicted. Finally, a separate analysis was carried out in which the predictive model was derived in a random 66% subsample of the population; observed events were then compared with predicted events in the remaining subjects and were found to be similar.

Network formation

In response to the question, "In the last six months, what did you get from the needle exchange?", most respondents reported getting needles (86%), and significant proportions reported receiving alcohol swabs (50%), water (55%) and bleach (39%). A total of only five (0.7%) reported meeting new people or friends at the needle exchange.

As of April 1988, 498 participants completed the questionnaire, which had been amended in December 1997. A total of 100 of these subjects reported sharing (borrowing and/or lending) injecting equipment since the previous questionnaire, and 36 indicated that they had new sharing partners since the previous visit. The breakdown of where these subjects reported meeting their new sharing partners, was as follows: through other users (16), on the street (14), jail (five), 'shooting gallery' (two), family member (one), methadone clinic (one), and NEP (one).

Behaviour change

Table 3 presents paired comparisons of risk behaviours among frequent attendees at the baseline and first

Table 2. Comparison of frequent versus infrequent attendees at the Vancouver needle exchange programme with respect to risk behaviour profile at the baseline visit and follow-up duration.

Variable	Infrequent attendee (n = 289)	Frequent attendee (n = 405)	P
Median age (years)	37	35	0.029*
Unstable housing	188 (65%)	346 (85%)	≤ 0.001
Living in a hotel	144 (50%)	272 (68%)	≤ 0.001
DTES as main injecting site	183 (63%)	311 (77%)	≤ 0.001
Inject four or more times per day	42 (14%)	171 (42%)	≤ 0.001
Inject heroin at least once per day	69 (24%)	205 (51%)	≤ 0.001
Inject cocaine at least once per day	62 (22%)	249 (62%)	≤ 0.001
Injecting in 'shooting galleries'	66 (23%)	170 (42%)	≤ 0.001
Incarceration in past 6 months	67 (23%)	154 (38%)	≤ 0.001
Involved in the sex trade	47 (16%)	109 (27%)	≤ 0.001
Any illegal income (excluding sex trade)	83 (29%)	176 (44%)	≤ 0.001
Currently enrolled in methadone treatment	47 (16%)	34 (8%)	≤ 0.001
Pharmacy as primary needle source	50 (17%)	6 (1%)	≤ 0.001
Person-semesters of follow-up			
Prior to December 1996	149 (23%)	224 (25%)	0.645
January 1997–June 1997	241 (38%)	345 (38%)	
After July 1997	248 (39%)	330 (37%)	

*Wilcoxon's rank sum test. DTES, Downtown eastside.

Table 3. Trends in risk behaviour between the baseline and first follow-up visits among all frequent attendees and restricted to post-needle exchange programme (NEP) initiates.

	All		Post-NEP initiates	
Variable	Odds ratio*	(95% CI)	Odds ratio*	(95% CI)
Unstable Housing	0.61	(0.35, 1.09)	0.38	0.14, 1.08)
Hotel living	0.78	(0.51, 1.21)	0.55	(0.25, 1.15)
Inject four or more times per day	1.28	(0.87, 1.87)	1.43	(0.72, 2.38)
Cocaine at least once per day	0.54	(0.35, 0.84)	0.75	(0.35, 1.58)
DTES as main injecting site	0.95	(0.61, 1.95)	0.52	(0.28, 1.38)
Needed help injecting	0.21	(0.12, 0.39)	0.04	(0.01, 0.31)

*McNemar's test. DTES, Downtown eastside.

follow-up visits. Odds ratios which are elevated above 1.0 indicate a trend toward riskier behaviour. None of the odds ratios for frequent attendees was significantly different from 1.0 with the exception of needing help injecting and daily cocaine injection which were reduced by the follow-up visit. A similar pattern was present when the analysis was restricted to frequent attendees who were post-NEP initiates.

Discussion

Two recent Canadian studies have fuelled debate regarding the effectiveness of NEP. Results from our cohort [2] and from Montreal [8] showed higher prevalence and incidence rates of HIV infection among frequent NEP attendees relative to infrequent attendees. These data have led some to suggest that NEP could have a deleterious effect on HIV transmission rates, rather than a protective effect [5–7]. It has been proposed, for example, that NEP could facilitate the formation of high risk social networks [9] which themselves are important risk factors for HIV infection [10,11].

Do NEP contribute to harm production rather than harm reduction, as has been claimed? Our analysis confirms that, at least in our setting, the role of NEP in the formation of new needle sharing networks is minimal. Further, we demonstrated that the number of new HIV infections observed among frequent NEP attendees is close to that expected based on their higher risk profile at baseline. Even so, NEP could still be culpable if it were found that NEP was causally related to higher risk behaviours among its attendees. However, we could find no evidence of changes toward riskier practices among frequent attendees during the initial period of observation. Some may focus on the one variable which showed a trend towards riskier behaviour; however, it must be stressed that this was not statistically significant and should be viewed in the light of reductions in risk behaviour in the remaining five variables, two of which were statistically significant. It could still be argued that NEP may have contributed to promoting high risk behaviour among frequent attendees in the past, prior to the study, but not during the study itself. For this, one would have to postulate an interaction of the effects of NEP on risk behaviour depending on the duration of the injection career. For this reason, analysis of behaviour change was stratified according to whether onset of injection preceded or followed the establishment of the NEP; no differences were found. Based on these findings, we believe the most likely hypothesis is that the association between NEP attendance and higher risk behaviour is due to selection rather than causation. This is further corroborated in this setting by comparisons that show that NEP attendees who choose to use mobile vans as their primary exchange site report higher risk behaviours than attendees who primarily use the fixed site [12]. Several other studies have reported an association between NEP attendance and higher risk injection activities [8,13,14]. Of particular interest, Hahn *et al.* found that HIV incidence rates measured prior to NEP attendance were higher in those who later chose to attend NEP compared to those who did not, clearly suggesting a selection effect [15].

Although we found no evidence that the NEP facilitated the formation of small sharing networks, the programme might still have had an indirect causal effect by attracting IDU to the downtown eastside. In this way, NEP might be held accountable for the geographic compression of such people in this neighbourhood and this could have facilitated indirectly network formation. However, this area has been a haven for IDU long before needle exchange. Indeed, a national inquiry into drug use in Canada estimated that the downtown eastside was home to as many as 60% of the country's heroin addicts as far back as the 1960s [16]. Thus, it would not appear that the IDU are attracted to this area because the needle exchange is there; rather, the needle exchange was placed in this area because the IDU were already there.

Since the first NEP was introduced in Amsterdam in 1984, other studies have shown NEP to be associated with reduced incidence of HIV infection [17–21], hepatitis B and C [22] and associated injection behaviours [13,23] but not increased drug use [19,24]. In a global survey of 81 cities with available data on IDU

Hurley *et al.* estimated that HIV prevalence decreased by an average of 5.8% per year in 29 cities with established NEP, but increased by an average of 5.9% per year in 51 cities without such programmes [25].

Several caveats should be considered in the interpretation of our findings. First, like many investigations of IDU, our study relied on self-reported data and thus the validity and reliability of responses require careful scrutiny. However, we used a comprehensive questionnaire covering a number of illicit activities and have no reason to suspect that self-reported NEP attendance would vary systematically across other exposure categories. Other researchers have found self-reported risk behaviours of IDU to be reliable [26] and not significantly affected by socially desirable responding [27]. Another limitation is that the Vancouver NEP opened several years prior to the initiation of our study. Although we found no evidence that NEP promoted network formation or increased risk behaviours, we cannot rule out the possibility that NEP may have contributed to adverse behavioural changes soon after its inception. However, we did not see any differences when we stratified analyses on whether subjects had initiated drug injection before or after the opening of the exchange.

There remains the observation that Vancouver has recently experienced an explosive HIV outbreak among IDU, with observed rates reaching as high as 18 per 100 person-years [2]. Rapid onset epidemics of HIV infection in IDU communities have been documented in cities around the world including Edinburgh, New York City, Rio de Janeiro, Milan and Geneva among others. Clearly, there are etiologic forces such as primary infection [28] and concurrent networks [29], which can generate explosive outbreaks in IDU.

How, critics ask, could this have occurred unless the NEP was ineffective, or even harmful? Part of the answer, in our view, is that NEP is only one component of what should have been an integrated approach to HIV prevention in Vancouver. Although NEP was introduced in 1989, access to drug and alcohol treatment, methadone maintenance and counselling services has been woefully inadequate in the downtown eastside and has diminished even further since 1995.

Furthermore, there are a number of other local factors, which should be taken into account in understanding this epidemic. The loss of low-income and social housing units has led to the emergence of single room occupancy hotel rooms in the downtown eastside. Many of these charge residents to re-enter the building at night; this encourages drug users to remain within the hotels which thus function as *de facto* 'shooting galleries'; this probably accounts for the unusually high rate of reported injection in 'shooting galleries' in this study. These observations prompted frontline [illegible] workers to begin exchanging syringes in local hot[illegible]n 1995, but the programme remains far from complete.

A second critical factor was the shift from injected heroin to injected cocaine as the primary drug of choice around 1994. Cocaine use has been associated with more frequent injection, 'shooting gallery' attendance and the sex trade [2,30]. Based on the increased injection frequency, we have previously estimated that as many as five to ten million needles would have had to have been exchanged in Vancouver annually to have met the goal of a clean needle for each injection [2]. Currently, the Vancouver NEP exchanges approximately two million needles per year and only recently have limits been removed on the number of needles that one can exchange. Needle exchange limits earlier in the epidemic, imposed by funding constraints, may have impeded secondary exchange and lessened overall needle accessibility.

It is difficult to know what size and shape this outbreak might have assumed in the absence of any NEP. Nevertheless, in our view, it appears that the effectiveness of this particular NEP was compromised by a number of environmental and programmatic factors. However, this observation about one particular needle exchange should not lead to the conclusion that all needle exchanges are ineffective.

In summary, we found little evidence to support the hypothesis that this particular NEP was causally associated with higher risk of HIV infection. The number of infections observed was similar to that which would be expected based on the underlying risk profiles of frequent attendees. There was no evidence to suggest that the NEP played a role in the formation of new needle sharing partnerships, and little support for the hypothesis that frequent attendance was causally associated with a shift to higher risk behaviour. Although the interpretation of the Montreal data remains unclear [8,9,31], opponents of needle exchange should desist from citing the association in Vancouver as evidence that needle exchange may exacerbate the spread of HIV. Rather, they should understand that NEP attract higher risk IDU, and thus provide a window of opportunity to access these difficult-to-reach individuals. If there is a lesson to be learned from the Vancouver outbreak, it is not that NEP cause harm; it is that they must be designed to serve the needs of their local community.

Acknowledgements

The authors gratefully acknowledge the contributions of the Vancouver Injection Drug User Study (VIDUS) staff for data collection and preparation (M. Pitchford,

C. Johnson, R. Brooks, J. Atwood, S. Lipscombe, G. Fernandez and T. Yip) and assistance from the VIDUS Community Advisory Board.

References

1. Bardsley J, Turvey J, Blatherwick J: **Vancouver's needle exchange program.** *Can J Public Health* 1990, **81**:39–45.
2. Strathdee SA, Patrick DM, Currie SL, *et al.*: **Needle exchange is not enough: lessons from the Vancouver Injecting drug use study.** *AIDS* 1997, **11**:F59–F65.
3. Lurie P, Drucker E: **An opportunity lost: HIV infections associated with lack of a national needle-exchange programme in the USA.** *Lancet* 1997, **349**:604–608.
4. Anonymous. **Needle-exchange programmes in the USA: time to act now.** *Lancet* 1998, **351**:75.
5. Departments of Labor, Health and Human Services, and Education, and Related Agencies Appropriations Act, 1998 (House of Representatives – September 11, 1997); Congressional Record 1997; p. H7218.
6. The Needle Exchange Programs Prohibition Act of 1998 – Statements on Introduced Bills and Joint Resolutions (Senate – April 21, 1998); Congressional Record 1998; p. S3356.
7. Task Force Report on a Site Visit to Vancouver. Office of National Drug Control Policy, Executive Office of the President, Washington, DC; April 1998.
8. Bruneau J, Lamothe F, Franco E, *et al.*: **High rates of HIV infection among injection drug users participating in needle exchange programs in Montréal: results of a cohort study.** *Am J Epidemiol* 1997, **146**:994–1002.
9. Bruneau J, Franco E, Lamothe F: **Assessing harm reduction strategies: the dilemma of observational studies.** *Am J Epidemiol* 1997, **146**:1004–1008.
10. Friedman SR, Neaigus A, Jose B, *et al.*: **Sociometric risk networks and HIV risk.** *Am J Pub Health* 1997, **87**:1289–1296.
11. Latkin C, Mandell W, Vlahov D, Oziemkowska M, Celentano D: **People and places: Behavioural settings and personal network characteristics as correlates of needle sharing.** *J Acquir Immune Defic Syndr* 1996, **13**:273–280.
12. Currie S, Strathdee SA, O'Shaughnessy MV, Patrick DM, Rekart ML, Schechter MT: **Maximizing needle exchange coverage among injection drug users (IDUs): Do mobile vans attract those at highest risk?** *XII World AIDS Conference.* Geneva, June 1998 [abstract: 33196].
13. Vlahov D, Junge B, Brookmeyer R, *et al.*: **Reductions in high-risk drug use behaviours among participants in the Baltimore needle exchange program.** *J Acquir Immune Defic Syndr Hum Retrovirol* 1997, **16**:400–406.
14. van Ameijden EJC, van den Hoek JAR, van Haastrecht HJA, Coutinho RA: **The harm reduction approach and risk factors for human immunodeficiency virus seroconversion in injecting drug users, Amsterdam.** *Am J Epidemiol* 1992, **136**:236–243.
15. Hahn JA, Vranizan KM, Moss AR: **Who uses needle exchange? A study of injection drug users in Treatment in San Francisco, 1989–1990.** *J Acquir Immune Defic Syndr Hum Retrovirol* 1997, **15**:157–164.
16. Le Dain G, Lehmann HE, Bertrand MA, Campbell IL, Stein JP: *Commission of Inquiry into the Non-Medical Use of Drugs: Final Report.* Ottawa: Government of Canada; 1973: 604.
17. van Ameijden EJC, van den Hoek JAR, Coutinho RA: **Injecting risk behaviour among drug users in Amsterdam, 1986–1992, and its relationship to AIDS prevention programs.** *Am J Public Health* 1994, **84**:275–281.
18. Des Jarlais DC, Marmor M, Paone D, *et al.*: **HIV incidence among injecting drug users in New York City syringe-exchange programmes.** *Lancet* 1996, **348**:987–991.
19. Lurie P, Reingold A, Bower B, *et al.*: *The Public Health Impact of Needle Exchange Programs in the United States and Abroad, Vol. 1.* Atlanta: Centers for Disease Control and Prevention; 1993.
20. Watters JK, Estilo MJ, Clark GL, Lorvick J: **Syringe and needle exchange as HIV/AIDS prevention for injection drug users.** *JAMA* 1994; **271**:115–120.
21. Des Jarlais DC, Friedmann P, Hagan H, Friedman SR: **The protective effect of AIDS related behavioural change among injection drug users: a cross-national study.** *Am J Public Health* 1996; **12**:1780–1785.
22. Hagan H, Des Jarlais DC, Friedman SR, *et al.*: **Reduced risk of hepatitis B and hepatitis C among injection drug users in the Tacoma Syringe Exchange Program.** *Am J Pubic Health* 1995; **85**:1531–1537.
23. Kipke MD, Unger JB, Palmer R, Edgington R: **Drug-injecting street youth: a comparison of HIV-risk injection behaviours between needle exchange users and nonusers.** *AIDS Behav* 1997; **1**:225–232.
24. Normand J, Vlahov D, Moses LE, eds: *Preventing HIV Transmission: The Role of Sterile Needles and Bleach.* Edited by Washington, DC: National Academy Press; 1995.
25. Hurley S, Jolley D, Kaldor J: **Effectiveness of needle-exchange programmes for prevention of HIV infection.** *Lancet* 1997, **349**:1797–1800.
26. De Irala J, Bigelow C, McCusker J, Hindin R, Zheng L: **Reliability of self-reported human immunodeficiency virus risk behaviors in a residential drug treatment population.** *Am J Epidemiol* 1996, **143**:725–731.
27. Latkin C, Vlahov D, Anthony JC: **Socially desirable responding and self-reported HIV infection risk behaviors among intravenous drug users.** *Addiction* 1993, **88**:517–526.
28. Koopman JS, Jacquez JA, Welch GW, *et al.*: **The role of early HIV infection in the spread of HIV through populations.** *J Acquir Immune Defic Syndr Hum Retrovirol* 1997, **14**:249–258.
29. Morris M, Kretzschmar M: **Concurrent partnerships and the spread of HIV.** *AIDS* 1997, **11**:641–648.
30. Chaisson RE, Bacchetti P, Osmond D, *et al.*: **Cocaine use and HIV infection in intravenous drug users in San Francisco.** *JAMA* 1989, **261**:561–565.
31. Lurie P: **Invited Commentary: le mystère de Montréal.** *Am J Epidemiol* 1997, **146**:1003–1006.