

A B S T R A C T

Objective: To conduct a cost-effectiveness analysis of the Edmonton Streetworks needle exchange program, in terms of the additional cost per HIV infection averted. The main outcome measures were needle use with and without Streetworks, HIV cases averted, and program costs.

Method: We conducted interviews and HIV saliva tests on a sample of street-involved intravenous drug users (IDU) who are regular Streetworks' clients. Outcomes were used in a cost-effectiveness model.

Results: It is projected that the program has a cost-effectiveness of \$9,500 (Canadian) per HIV infection delayed for one year.

Conclusions: The discounted cost per case averted is less than the cost of a case of AIDS. Continuing the program is a dominant strategy.

A B R É G É

Objectif : effectuer une analyse coût-efficacité du programme d'échange de seringues Edmonton Streetworks pour déterminer le coût supplémentaire pour chaque infection à VIH évitée. Les principales mesures des résultats ont été l'utilisation des seringues avec et sans Streetworks, les cas d'infection par le VIH évités, et les coûts du programme.

Méthode : on a mené des entrevues et réalisé des tests de dépistage du VIH dans la salive auprès d'un échantillon d'usagers de drogues injectables (UDI) de la rue qui sont des clients réguliers de Streetwork. Les résultats ont ensuite servis à un modèle d'analyse coût-efficacité.

Résultats : l'analyse coût-efficacité situe à 9 500 \$ (CAN) le coût par cas d'infection à VIH différée d'un an.

Conclusions : le coût actualisé de chaque cas évité est inférieur au coût global d'un cas de sida. Le maintien du programme constitue une stratégie essentielle.

Cost Effectiveness of Streetworks' Needle Exchange Program of Edmonton

Philip Jacobs, DPhil, CMA,^{1,2} Peter Calder, PhD,³ Marliis Taylor, RN, BScN, NP,⁴ Stanley Houston, MD, FRCPC,⁵ L. Duncan Saunders, MB, PhD,¹ Terry Albert, MHSA⁶

Streetworks is a preventive program run by agencies that serve the inner city street-involved population of Edmonton. It exchanges clean needles, distributes condoms, and delivers a variety of nursing and health-education services. The program serves a community from which HIV/AIDS can be widely transmitted throughout Edmonton, northern, and native communities. At the time of our study, the program was primarily delivered through two fixed sites and an outreach van. Individuals who are intravenous drug users (IDU) and persons who work in the sex trade make up a large portion of the client contacts. In 1997 the program reported serving an estimated 400 discrete users per month, the majority of whom were native and unemployed; 73% of the program users exchanged needles.¹

Intravenous drug users are at considerable risk of becoming HIV positive and being infected with other blood-borne pathogens. The risk of becoming HIV infected arises through the large volume of injections with needles that are sometimes shared. Recent reports indicate that the number of HIV/AIDS cases continues to increase with a shift from male homosexuals to IDUs, women and Aboriginal people.² From 1986 to 1996, in Alberta, the proportion of HIV-positive tested persons

who were IDU increased from 10.6 to 26.4%.³ The discounted cost of treatment over an average survival period of 17 years of someone with HIV/AIDS has been estimated at \$150,000.⁴ There is a potential for considerable cost savings to the health care systems through the reduction in the spread of HIV infection in a high risk IDU population.

We conducted a cost-effectiveness analysis of the impact of the Streetworks program on new needle-induced HIV infections. One of the intentions of the project was to collect primary data from the program and its clients.

LITERATURE SUMMARY

There have been very few economic studies of the exchange of needles for intravenous drug users (IDUs).⁵⁻¹¹ Within this group of studies, there has been a considerable difference in how the investigators approached their analyses. Using a "behavioural" approach, investigators focused on the injecting and sharing behaviour of IDUs and their sharing partners.^{11,12} Alternatively, using a "needle-circulation" approach, investigators focused on the number of needles and risky inter-IDU contacts which these needles generated.⁹ Using a third method of determining effectiveness, investigators⁶ compared HIV incidence rates in two cities, one with a needle exchange program and one without a program. All studies have resorted to "modeling" exercises, using data from a variety of different programs. Whatever the approach, the ratios of cost per HIV case averted have been shown to be very favourable (e.g., \$16,600⁶) – in all cases far less than the cost of treating a case of HIV/AIDS in Canada.

1. Department of Public Health Sciences, University of Alberta
2. Institute of PharmacoEconomics, Edmonton
3. Department of Educational Psychology, University of Alberta
4. Streetworks, Inc., Edmonton, Alberta
5. Department of Medicine, University of Alberta
6. Canadian Policy Research Networks, Inc., Ottawa, Ontario

Correspondence: Philip Jacobs, Institute of Pharmaco-Economics, #710, 10665 Jasper Avenue, Edmonton, AB, T5J 3S9, Tel: 403-448-4881, Fax: 403-448-0018, E-mail: Philip.Jacobs@ualberta.ca

METHODS

In order to collect the information required to carry out a cost-effectiveness analysis of the Streetworks program, the following steps were taken.

Survey of program users

Interview schedules are subject to the same criteria of reliability and validity as other measuring instruments.¹³ The survey which we used was developed and piloted with the assistance of members of the IDU community. An interview protocol related to needle-use practices was developed; it was administered by a psychologist and a social worker, both of whom had experience working with individuals from the inner city. To check on the validity of the responses, numerous questions designed to obtain the same information were phrased in different ways. The questioning was done in a relaxed, non-threatening manner to encourage truthfulness of response and to reduce response bias.¹⁴

In the summer of 1997, Streetworks' clients meeting inclusion criteria were randomly referred for interviews by the person operating the needle exchange. Individuals were approached at each of the two primary stationary sites and the van. Inclusion criteria were that they were able enough to be interviewed and were known users. We interviewed 100 Streetworks clients, each interview lasting approximately 15 minutes. The interviewees were paid \$10.00 for participating in the study. All of the interviews were anonymous. Individuals were told that they didn't have to answer any questions if they chose not to; however, no one exercised that option. Approximately 80% of the individuals who were asked to take the behavioural survey agreed to do so. Those who refused usually cited time constraints.

Questions relating to needle use

The questions were designed to find out the amount of needle sharing that is presently occurring and what would occur if there weren't a needle exchange program. An attempt was also made to assess the degree of effective needle cleaning that was taking place as well as the number of injections. Respondents were asked questions such as, "When was the last time you fixed?"; "Did you use a new needle at that time?"; "How

TABLE I
**Estimating Equation for New HIV Infections Resulting from Needle Sharing:
Needle Use Approach**

Variable	Definition	Measurement	Base Value
I	Proportion of population who are not infected, and hence susceptible to infection	Seropositive test	0.93
N	Total number of circulating needles in 1997	Streetworks data	565,754
s	Proportion of needles which are shared (alternatively, with and without Streetworks)	Interview data	0.08 with program, 0.24 without program
d	Proportion of shared needles which are uncleaned	Interview data	0.5
t	Transmission rate per shared injection	Literature	0.005
q	Rate of infection in population	Seropositive test	0.07
m	Number of sharing partners per shared injection	Interview data	1.38

TABLE II
Demographics of Intravenous Drug User Sample

- 48% of respondents were male, 48% female, and 4% transgender.
- 66% considered themselves to be native - 38 treaty, 28 Metis
- Age: Mean 34.6(SD 9.19), Range 19 to 61 years
- Years injecting: Mean 12.87 (SD 8.0), Range 0.2 to 34 years
- Age started injecting: Mean 21.7 years (SD 8.0)
25th percentile - 15 yrs., 50th percentile - 19 yrs
75th percentile - 26 yrs
- Drugs "usually used": Cocaine (53%), T & R's (49%), Heroin (6%), Speed (5%), Morphine (5%), others (4%)

many people shared that needle?", "How was it cleaned?", "How many times do you fix?", "What percent of the needles that you use are shared?", and "What percentage of needles would you share if there wasn't a needle exchange program?"

Sero-prevalence study

In order to carry out an HIV sero-prevalence study of the Streetworks participants, 100 volunteer subjects (not necessarily the same individuals who were interviewed) were anonymously tested for the presence of HIV. For safety reasons it was decided to test for HIV using saliva samples. The sampling procedures were similar to those used in the behaviour survey, although sampling was carried out about two months later. Subjects were not paid to participate. The results of saliva testing were not linked to those of the behavioural interview. Approximately 50% of subjects who were asked to give a saliva sample did so. Some who refused said they would do so at a later time (and perhaps did) but as the testing was anonymous and was carried out by four different staff members, it is impossible to say if they did. Of note, 8 individuals refused to take the test saying that they already knew that they were HIV positive. It cannot be said for sure that these individuals were HIV positive.

Saliva specimens were collected using the Saliva Sampler (Saliva Diagnostics Systems Inc., Vancouver WA) and transferred to a tube for storage. The samples were transported to the Alberta Provincial Laboratory in Edmonton for assessment. Samples found to be positive were sent to the Ontario Provincial Laboratories for confirmatory analysis.

Program costs

Annual data on the cost of running the program were obtained from Streetworks' financial records and were organized in a manner described in Wright-de Agüero, Gorsky and Seeman.¹⁵ We included Streetworks' expenses as well as the foregone costs of unpaid volunteers and donated facilities. All costs were assigned to one of five Streetworks program areas - needle exchange, condom provision, nursing, education and research, and administration/overhead. In the cases of nursing resources, allocation was done on the basis of time spent in each program/service. We assigned all fixed Streetworks administration/overhead costs and needle exchange costs to the needle exchange program (i.e., as costs which would be required to operate a stand-alone needle exchange component.). In order to operate its programs at its current level of service, Streetworks is dependent on volunteers who usually assist in manning the van. An oppor-

TABLE III
Needle Use Behaviour of Intravenous Drug User Sample

1.	Did you use a used needle last time?	8% yes, (2 % bleached)
2.	% of new needles that you use currently (with Streetworks)	88%
3.	% of new needles that you would use without Streetworks	34%
4.	% of needles in Edmonton that are shared	37.8% (SD 23.9%)
5.	% of needles that you get from Streetworks	88.7% (SD 21.03%)
6.	Number of fixes:	day 8.7(9.57) week 46.7(56.38) year 2105 (2441.15)
7.	# of needles distributed:	565,754

TABLE IV
Costs of Streetworks by Program

Category	Needle Exchange	Condoms	Nursing	Education/ Research	Administration/ Overhead
Personnel	\$50,001	\$0	\$25,518	\$25,764	\$16,561
Equipment - van				\$900	
Needles	\$79,206				
Condoms		\$26,732			
Other	\$1,924	\$0	\$1,924	\$0	\$17,268
Donated	\$28,032				
Total	\$161,087	\$26,732	\$37,538	\$25,764	\$33,829

tunity cost of \$15.00 per hour was allotted for their service. Facilities which were donated were costed at the rate which was required to rent them.

Rate of HIV transmission

The rate of transference of infection for accidental needle-stick injuries has been estimated at between 0.2 to 0.4 percent.¹⁶ Presumably the transmission rate among IDU sharing contaminated needles should be somewhat above those of accidental needle-stick injuries where the needle isn't purposely put into a vein, but less than that of regular transfusion of contaminated blood. Alcabas and Friedland¹⁷ and Friedland and Klein¹⁸ cite a rate of transmission of 0.5% per injection. Kaplan and Heiner¹⁹ place the rate at 0.67 % per contact. We use 0.5%.

Needle use predictive model of program effectiveness (HIV infections averted)

We developed a model of program effectiveness, adapted from the circulation equation of Kaplan and O'Keefe.⁹ Our equation, shown in Table I, has three components. The first ($I \times N \times s \times d$) is the number of needles which are not cleaned and shared with at-risk (uninfected) persons. The second component ($q \times t$) is the percent of at-risk injections which result in a new infection. The third component (m) is the number of sharing partners per shared needle. This is expressed in exponential form because its effect on $q \times t$ is multiplicative; however, if there were only

one sharing partner per needle, then the transmission factor would only be $q \times t$. This model is based on the measurable variable – the number of needles in circulation – and the assumption that each needle is used in one sharing session. We also assumed that no selection takes place in who does the sharing and that the behaviour rates and infection rates from the samples were the same for all individuals who used needles from the program. To the greatest extent possible, we sought to obtain values for the variables directly from the Streetworks program and population. The equation was estimated using two different values for the variable named "s" – the number of needles that are shared: these are the estimated actual values and the projected values if Streetworks (or some facsimile) did not exist. The outcome of the effectiveness equation is the number of new infections occurring in a year.

Program cost effectiveness

Cost effectiveness is the net difference in program costs with and without the program divided by the net difference in new HIV infections. We examined the operations of the Streetworks needle exchange program for only one year. A cost-effectiveness analysis was carried out for the base case and for alternative assumptions to determine sensitivity.

RESULTS

The results are reported in sequence.

Results of behaviour survey

Results of the client survey are summarized in Tables II and III. As can be seen from Table II, the program serves a group of individuals who generally speaking are long-term heavy drug users and many of whom are Aboriginal. There is considerable variation between persons in the reported number of needles consumed, suggesting that one might not be dealing with a single population. The interviews pointed to differences in drug of choice (cocaine versus Talwin and Ritalin). While most individuals routinely used new needles, there was some indication of slippage.

With regard to the perceived effect of the program on needle use (Table III), intravenous drug users reported that they would use approximately three times the number of used or shared needles (12:34) if the needle exchange program were terminated. As well, 8% of the IDUs reported using a used needle the last time they injected, which was our best estimate of sharing. Putting these two findings together, we concluded that the percentage of shared needles that would be used in the absence of the program was 24 (i.e., $3 \times 8\%$).

Sero-prevalence testing

Sero-prevalence testing of 100 individuals indicated that there was an HIV infection rate of 7% in the sample tested. During the sampling, 8 individuals refused to be tested saying that they already knew that they were positive. If these individuals were accepted as being positive and added to the sample, the rate would increase to 15 out of 108 or 13.9%.

Program cost

Streetworks' costs are shown by program in Table IV. The annual cost of the needle exchange program is \$194,916. These are the costs which would be required to maintain the program at its level of 1997 if it were a stand-alone entity; they include *all* of Streetworks' administration costs, operating costs of the needle exchange program, and the costs of volunteer or donated services which are dedicated to the needle exchange function.

Program effectiveness

Using the equation shown in Table I, we estimated that, in the first year, there would

be 10.1 infections with the program and 30.4 without the program. Program effectiveness was therefore 20.3 new infections.

Program cost-effectiveness

Using the base case assumptions, we estimated that the cost per HIV case averted for one year was \$9,537.

Sensitivity analysis

We conducted sensitivity analyses based on possible alternative values for each variable. The values which were used were for the HIV prevalence rate (0.14) to account for respondents who, though refusing testing, claimed that they were HIV positive; for the proportion of shared needles (0.03) based on the answer to a less direct question; for the number of sharing partners per shared needle, based on the lowest possible value for this variable (1.0); and for the estimate of the number of times that more sharing would occur due to the absence of the program (2 instead of 3). The highest value of cost per HIV case averted under any of these alternative assumptions was \$25,568 (if 3%, rather than 8%, of needles were shared.)

DISCUSSION

Our results indicate that a program cost of \$9,537 is associated with a one-year delay in contracting a case of HIV. We do not know whether this deferral will buy time until IDUs change their drug-using behaviour; because the population is so young, behaviour change in the future is a possibility. However, even if the needle exchanging results in the delay, rather than avoidance, of HIV infection, the continuation of the Streetworks program is fully justified on economic grounds. If the needle-exchanging activity were to continue for 17 years, which is the expected remaining survival time for a person who has just contracted AIDS,⁴ the present value (annual cost = \$9,537, discount rate = 4%) of this activity would be \$116,024. This is less than the present value of a case of HIV/AIDS, which is \$150,000. Therefore, the Streetworks needle-exchange program results in net savings and fewer AIDS cases, and is therefore a dominant strategy.

Our base case analysis was conducted with conservative assumptions and our

results were robust under alternative model specifications. As well, we ignored factors which would militate in favour of the program: the concomitant avoidance of the spread of other types of disease (hepatitis) and of secondary transmissions of HIV through sexual contact. At the same time, we should recognize that the Streetworks' population is made up of very active users in comparison with other populations: 2,000 needles per person per year as compared to 700 as cited in Caslyn, Saxon, Freeman et al.²⁰ This is a consideration in generalizing to other programs.

The use of self-reported estimates of drug use behaviour, while inescapable, has considerable difficulties.²¹ Individuals simply may mis-report their use of drugs and how their behaviour might change in the absence of the needle exchange program. We have attempted to determine more accurate estimates of needle sharing by asking for the same information in several different ways. We asked interviewees how their behaviour might change in the absence of the needle exchange program, and how much sharing took place for IDUs outside of the program (which they were aware of). The results were similar (see Table III). Nevertheless, we should be aware of the possibility of exaggerating effects.

ACKNOWLEDGEMENTS

We acknowledge funding from Health Canada through a grant to the Canadian Policy Research Networks. We gratefully acknowledge the participation of Streetworks, their staff and board and the Alberta Provincial Laboratory of Public Health and Dr. Talbot. Advice about this study was obtained from Barbara Jones and Julia Martin of Health Canada and from Barbara Legowski of the Canadian Policy Research Networks.

REFERENCES

1. Streetworks Program. Report of evaluation consultation for the period October 1995 to June 1996. Edmonton: Streetworks Program, 1997.
2. Health Canada. Inventory of HIV Incidence/Prevalence Studies in Canada. Ottawa: Division of HIV Epidemiology Research, Laboratory Centre for Disease Control, Health Protection Branch, Health Canada, 1996.
3. Alberta Health. HIV Serological Testing - Alberta (January 1986 to 31 December, 1996).

- Edmonton, Alberta: Alberta Health, Provincial AIDS Program, 1997.
4. Albert T, Williams G. The Economic Burden of HIV/AIDS in Canada. Ottawa: Canadian Policy Research Networks, 1998.
5. Holtgrave DR, Qualls NL, Graham JD. Economic evaluation of HIV prevention programs. *Annu Rev Public Health* 1996;17:467-88.
6. Gold M, Gafni A, Nelligan P, Millson P. Needle exchange programs: An economic evaluation of a local experience. *Can Med Assoc J* 1997;157:255-62.
7. Kahn JG. The cost-effectiveness of HIV prevention targeting: How much more bang for the buck? *Am J Public Health* 1996;86:1709-12.
8. Kaplan EH. Needles that kill: Modeling human immunodeficiency virus transmission via shared drug injection equipment in shooting galleries. *Rev Infect Dis* 1989;11:289-98.
9. Kaplan EH, O'Keefe E. Let the needles do the talking! Evaluating the New Haven needle exchange. *Interfaces* 1993;23:7-26.
10. Kaplan EH. Economic analysis of needle exchange. *AIDS* 1995;9:1113-19.
11. Lurie P, Reingold A, Bowser B. The public health impact of needle exchange programs in the United States and abroad. Atlanta, Georgia: US Centers for Disease Control and Prevention, 1993.
12. Weinstein MC, Graham JD, Siegel JE, Fineberg HV. Cost-effectiveness analysis of AIDS prevention programs: Concepts, complications, and illustrations. In: Turner CF, Miller HG, Moses LE (Eds.), *AIDS: Sexual Behavior and Intravenous Drug Use*. Washington, DC: National Academy Press, 1989; 471-99.
13. Kerlinger F. *Foundations of Behavioral Research* 3rd edition. New York: Holt, Reinhart, Winston, 1986.
14. Isaac S, Michael WN. *Handbook in Research and Evaluation* 2nd edition. San Diego, CA: EdITS Publishers, 1981.
15. Wright-De Aguerro LK, Gorsky RD, Seeman GM. Cost of outreach for HIV prevention among drug users and youth at risk. *Drugs and Society* 1996;9:185-97.
16. Laufer FN, Chiarello LA. Application of cost effectiveness methodology to the consideration of needlestick prevention technology. *Am J Infect Control* 1995;22:75-82.
17. Alcabes P, Friedland G. Injection drug use and human immunodeficiency virus infection. *Clin Infect Dis* 1995;20:1467-79.
18. Friedland GH, Klein RS. Transmission of HIV. *N Engl J Med* 1987;317:1125-35.
19. Kaplan EH, Heiner R. HIV incidence among New Haven needle exchange participants: Updated estimates from syringe tracking and testing data. *J Acquired Immune Deficiency Syndromes* 1995;10:175-76.
20. Caslyn DA, Saxon AJ, Freeman G, Whittaker S. Needle-use practices among intravenous drug users in an area where needle purchase is legal. *AIDS* 1991;5:187-93.
21. Harrell AV. Valuation of self-report: The research record. In: Rouse BA, Kozel NJ, Richards LG (Eds.), *Self-report Methods of Estimating Drug Use: Meeting Current Challenges to Validity*. Rockville, MD: National Institute on Drug Abuse, 1985; 12-21.

Received: June 22, 1998

Accepted: November 25, 1998