

The cost-effectiveness of Vancouver's supervised injection facility

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∞ See related commentary by Des Jarlais and colleagues, page 1105

ABSTRACT

Background: The cost-effectiveness of Canada's only supervised injection facility has not been rigorously evaluated. We estimated the impact of the facility on survival, rates of HIV and hepatitis C virus infection, referral to methadone maintenance treatment and associated costs.

Methods: We simulated the population of Vancouver, British Columbia, including injection drug users and persons infected with HIV and hepatitis C virus. The model used a time horizon of 10 years and the perspective of the health care system. We compared the situation of the supervised injection facility with one that had no facility but that had other interventions, such as needle-exchange programs. The effects considered were decreased needle sharing, increased use of safe injection practices and increased referral to methadone maintenance treatment. Outcomes included life-years gained, costs, and incremental cost-effectiveness ratios discounted at 5% per year.

Results: Focusing on the base assumption of decreased needle sharing as the only effect of the supervised injection facility, we found that the facility was associated with an incremental net savings of almost \$14 million and 920 life-years gained over 10 years. When we also considered the health effect of increased use of safe injection practices, the incremental net savings increased to more than \$20 million and the number of life-years gained to 1070. Further increases were estimated when we considered all 3 health benefits: the incremental net savings was more than \$18 million and the number of life-years gained 1175. Results were sensitive to assumptions related to injection frequency, the risk of HIV transmission through needle sharing, the frequency of safe injection practices among users of the facility, the costs of HIV-related care and of operating the facility, and the proportion of users who inject in the facility.

Interpretation: Vancouver's supervised injection site is associated with improved health and cost savings, even with conservative estimates of efficacy.

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Supervised injection sites offer a safe and hygienic environment for people to inject their previously obtained illicit drugs under supervision.^{1,2} Observational studies from the facility in Vancouver, British Columbia, have demonstrated positive effects: a decrease in needle

sharing and reuse of syringes, fewer people injecting drugs in public, an increase in referrals to social services and addiction counselling, a decrease in the number of publicly discarded syringes, no apparent increase in police reports of drug dealing or crime, and no observed increase in new initiates into drug use.³⁻⁵ Although an expert advisory committee recently concluded that the Vancouver facility has beneficial effects, prominent law enforcement groups have argued that the resources allocated to the facility would be more effectively spent elsewhere.^{6,7}

We used computer simulation to estimate the projected impact of Vancouver's supervised injection site on survival, rates of HIV and hepatitis C virus infection, referral to methadone maintenance treatment and associated costs. Our goal was to assess the cost-effectiveness of the facility and thus provide important insights into this policy debate.

Methods

Simulation model

We developed a dynamic compartmental model to simulate the population of Vancouver, British Columbia. The population included injection drug users, non-users, persons with HIV and hepatitis C virus infection, and those with combinations of these states. Our model categorized populations into discrete compartments. By defining the probabilities of moving between compartments, we were able to project the prevalence of each model state throughout the time horizon of the simulation. Tracking the time spent in each state allowed us to estimate survival. Assigning a cost to each state allowed us to estimate net costs of treatment. The perspective of the model was that of a health care system. Accordingly, we included direct medical costs but did not include indirect medical costs or other societal costs. We used a time horizon of 10 years and updated the proportion in each model state every 0.1 years. We used a discount rate of 5% for both costs and life expectancy.⁸

Data sources

Whenever possible, we used Vancouver-specific data for our model, including published and unpublished data for cohorts from 2 studies — the Vancouver Injection Drug Users Study

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Table 1: Parameters used in the model to simulate the population of Vancouver, including injection drug users and persons infected with HIV and hepatitis C virus* (part 1 of 2)

Parameter	Value (range)	Data source†
Sexual transmission		
Annual risk of sexual transmission per partner		
HIV, %	1 (0.5–9)	15
Hepatitis C virus, %	0.3 (0–1)	16, 17
Relative risk with condom use	0.13 (0.01–0.3)	18
Sex acts in which condoms are used, %		
HIV negative, injection drug user	47 (20–70)	VIDUS
HIV positive, injection drug user	68 (50–90)	VIDUS, 18
HIV negative, non-user	19 (16–22)	19
HIV positive, non-user	82 (40–70)	20
Sex partners of injection drug users who are also injection drug users, %	40 (20–60)	21
No. of sex partners per year		
Injection drug users	2 (1–5)	SEOSI
Non-users	1 (1–2)	18
Transmission through needle sharing		
Risk of transmission through needle sharing per act		
HIV, %	0.8 (0.3–4.0)	18, 22–24
Hepatitis C virus, %	4 (1–13)	25
Relative risk of transmission through sharing of needles sterilized with bleach		
HIV	0.15 (0.0–0.3)	24, 26, 27
Hepatitis C virus	0.35 (0.08–1.0)	28
Needle sharing		
Injections that involve needle sharing, %	13 (5–21)	SEOSI
Injections that involve sharing of needles sterilized with bleach, %	50 (40–60)	29, 30
Relative risk of needle sharing among users receiving methadone maintenance treatment	0.30 (0.2–1.0)	31
Annual no. of injections per user	711 (365–1460)	12, 32§
Relative risk of injection by users receiving methadone maintenance treatment	0.17 (0.1–0.25)	31
Population parameters		
Injection drug users		
Prevalence of HIV infection, %	17 (10–25)	6, 33
Prevalence of hepatitis C virus infection, %	88 (75–90)	6, 33
Methadone maintenance treatment, %	11 (5–25)	SEOSI, 34, 35
Non-users		
Prevalence of HIV infection, %	0.27 (0.1–1.0)	12, 32§
Prevalence of hepatitis C virus infection, %	0.8 (0–0.23)	36, 37
Total population	578 040	11
Population aged 15–64 years	428 125	11
Population of injection drug users	7 000 (3000–20000)	12
Annual probability of death, %		
General population	0.21 (0.1–0.4)	11, 38

Table 1: Parameters used in the model to simulate the population of Vancouver, including injection drug users and persons infected with HIV and hepatitis C virus* (part 2 of 2)

Parameter	Value (range)	Data source†
HIV positive, no hepatitis C virus	1.9 (1.7–2.2)	39
Death attributable to injection drug use	3 (1–5)	18
Relative risk of death		
Non-users with hepatitis C virus infection and no HIV infection (v. general population)	1.35 (1.0–2.0)	40, 41
Injection drug users with hepatitis C virus infection and no HIV infection (v. injection drug users without hepatitis C virus or HIV infection)	1.0 (1.0–2.0)	42
Injection drug users receiving methadone maintenance treatment (v. injection drug users not receiving methadone maintenance treatment)	0.38 (0.2–1.0)	18
Individuals with HIV and hepatitis C virus coinfection (v. HIV-positive individuals without hepatitis C virus infection)	3.0 (2.0–4.0)	39, 42
Population shifts		
Migration out of population	0 (0–2.0)	Assumed
Migration into population		
By non-users without HIV or hepatitis C virus infection, %	1.7 (1.1–3.0)	43§
By injection drug users without HIV or hepatitis C virus infection, %	2.5 (1.7–5.0)	Assumed
Aging		
Aging into the population (becoming 15 years old), %	1.2 (0.5–3.0)	11
Aging out of the population (becoming 65 years old), %	1.0 (0.5–3.0)	11
Individuals who become injection drug users and have no HIV or hepatitis C virus infection, %	0.13 (0.05–0.2)	Calculated
Methadone maintenance treatment		
Injection drug users who start treatment each year, %	8 (1–20)	35
Injection drug users who end treatment each year, %	44 (5–70)	VIDUS, 18, 35
Injection drug users who end treatment and who stop injecting, %	10 (0–20)	18
Annual costs, \$		
Care for person with HIV infection	15 564 (12 000–30 000)	44, 45
Care for person with hepatitis C virus infection	2 650 (2 000–3 000)	46, 47
Care for injection drug user	3 922 (3 000–5 000)	18, 48
Care for injection drug user when receiving methadone maintenance treatment	3 138 (2 000–5 000)	18
Methadone maintenance treatment	6 000 (3 000–8 000)	49
Care for person in general population‡	1 307 (1 000–2 000)	18
Operating costs of supervised injection facility	2 948 101 (2 211 000–3 685 000)	SEOSI
Modelling parameters		
Cycle length, years	0.10	
Discount rate, annual	0.05 (0.0–0.1)	8

*Full details are available in Appendix 1 (available at www.cmaj.ca/cgi/content/full/179/11/1143/DC2). VIDUS and SEOSI indicate personal communication from the Vancouver Injection Drug Users Study (VIDUS) and the Scientific Evaluation of Supervised Injecting (SEOSI) cohorts, respectively.

†Numbers indicate the references from which the data were obtained. VIDUS (Vancouver Injection Drug Users Study) and SEOSI (Scientific Evaluation of Supervised Injecting) represent studies from which unpublished data were obtained for the model.

‡General population refers to non-users without HIV or hepatitis C virus infection.

§Values were calculated on the basis of data from these sources.

and the Scientific Evaluation of Supervised Injecting.^{9,10} We compared and supplemented these data with estimates from the medical literature. When several estimates were available, we gave the most emphasis to those from North American studies.

Model cohort and health states

We classified health states in the model according to 3 characteristics: status of HIV infection (present or absent), status of hepatitis C virus infection (present or absent) and status of injection drug use (user or non-user, with further distinction between users who receive methadone maintenance treatment and those who do not). We included all possible combinations of these states in the model, including coinfection with HIV and hepatitis C virus.

The cohort for the model included individuals aged 15–64 years. We estimated the rate at which individuals leave the cohort over time because of death, aging beyond 64 years or migration out of the Vancouver area. We also estimated the rate at which individuals enter the cohort over time by attaining an age of 15 years or by migrating into the Vancouver

area. Vancouver has an estimated population of 578 040, of whom 74% were within the age distribution of our cohort.¹¹ The supervised injection facility is located in the Downtown Eastside neighbourhood, where about 5000 injection drug users live.^{12–14} We included another 2000 users estimated to live in other areas of the city.¹² We excluded other users in the Greater Vancouver Area to facilitate homogeneity in each model compartment and to allow for effective calibration of our model against epidemiologic data. Because the epidemiology of drug use is imprecise, we varied the estimate of the number of users from 3000 to 20 000 in sensitivity analyses.

Model parameters

Full details of input parameters and data sources for the model are available in Appendix 1 and summarized in Table 1.^{6,8,11,12,15–49} Appendices 1 and 2 contain details regarding model assumptions, methods and calculations, as well as supplementary results (available at www.cmaj.ca/cgi/content/full/179/11/1143/DC2).

Modelling the effectiveness of the facility

Several methods are available to model the effectiveness of supervised injection facilities, including decreased needle sharing, increased use of safer injection practices and increased referral to methadone maintenance treatment. Assuming that all the effects occur simultaneously may overestimate the benefits of the facility if the effects are not independent (e.g., individuals who inject safely may also decrease needle sharing). Accordingly, in our base assumption we modelled a single effect of the facility, decreased needle sharing, recognizing that this introduces a conservative bias into our analysis. We assumed that this change in behaviour occurred among individuals who were regular users of the facility (self-reported that “all, most or some injections” were at the facility)³ regardless of whether the injections occurred within or without the facility. Specifically, we assumed that 21% of the injection drug users would use the facility regularly and that the frequency of needle sharing was decreased in this group compared with those who used the facility irregularly or not at all (odds ratio 0.30).

Next, we determined the cost-effectiveness of the facility if effects such as increased use of safer practices during shared injections (odds ratio 2.70) and increased referral to methadone maintenance treatment (odds ratio 1.84) were included in the model.⁴ As above, we applied these effects only to injection drug users who used the facility regularly. We did not include nonmedical benefits such as decreased criminality in the model.

Cost-effectiveness calculations and sensitivity analyses

Our main outcome of interest was the incremental cost-effectiveness ratio of the supervised injection facility. Our comparator was a situation in which there was no such facility but other interventions for injection drug users were in place, including needle-exchange programs and methadone maintenance treatment. Although there is no single threshold at which an intervention is considered “cost-effective,” we evaluated under which scenarios the incremental cost-

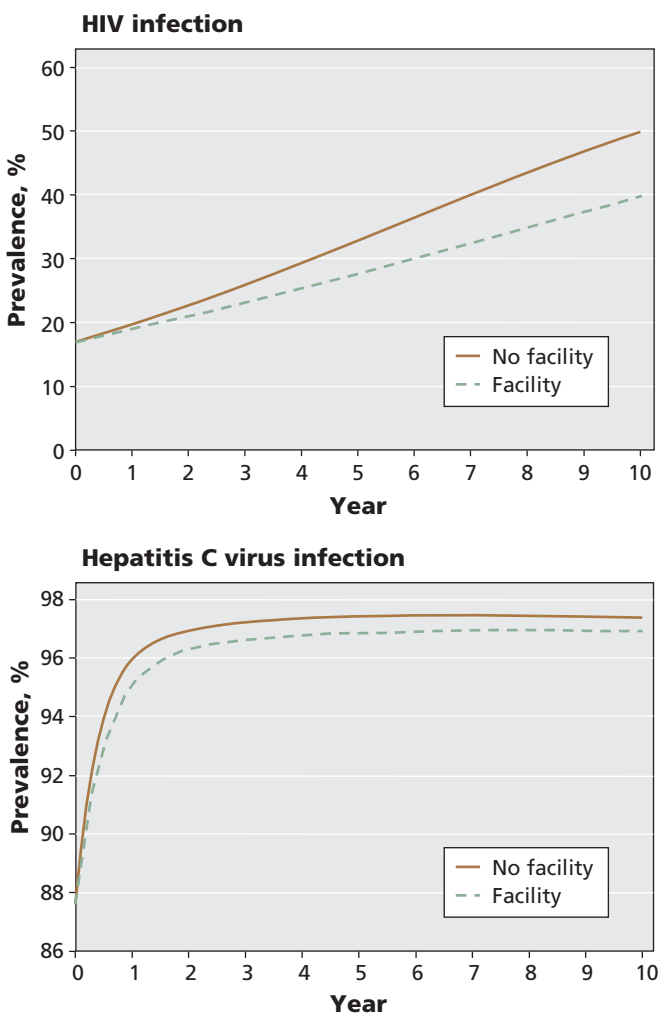


Figure 1: Projected change in the prevalence of HIV (top) and hepatitis C virus (bottom) infection among injection drug users in Vancouver with and without the supervised injection facility.

effectiveness of the facility would exceed \$50 000 per life-year gained, a commonly used benchmark.⁵⁰

We tested the robustness of our model to the input assumptions through multiple sensitivity analyses. In these analyses, we observed how our results changed when we allowed each input parameter to vary over prespecified ranges. The ranges were based on 95% confidence intervals where available or calculable and were inflated further when we were concerned about biased estimates.

Results

Effect on the population

Our model estimated that the prevalence of HIV and hepatitis C virus infections among injection drug users would continue to increase (Figure 1). The model also estimated that, with the introduction of the supervised injection facility, the size of the population of injection drug users would increase owing to fewer HIV and hepatitis C virus infections and reduced associated mortality (Table 2). We calculated that, over the 10-year time horizon, 1191 cases of HIV infection and 54 cases of hepatitis C virus infection would be averted with the introduction of the facility (Table 2). More optimistic modelling

assumptions were associated with significantly greater health benefits (Table 2).

Cost-effectiveness of the supervised injection facility

When we considered decreased needle sharing as the only effect of using the facility, the net costs of treatment of hepatitis C virus infection and of methadone maintenance treatment were higher with the supervised injection facility than with no such facility (Table 3). The net costs of HIV-related treatment were lower with the facility than without such a facility (Table 3). The net cost was negative, which indicated that the facility both saved money and improved life expectancy (Table 4).

When we also considered increased use of safer injection practices and increased referrals to methadone maintenance treatment as effects of using the facility, the cost savings and health benefits associated with the facility were even greater (Table 4).

For comparability with other analyses, we examined the ratio of costs of operating the facility to the number of cases of HIV and hepatitis C virus infections averted over 10 years. The estimates of the undiscounted cost per case averted were \$20 100 for HIV infection and \$444 500 for hepatitis C virus infection.

Table 2: Predicted health benefits of the Vancouver supervised injection facility

Assumption	No. of infections averted		Undiscounted life-years gained
	HIV	Hepatitis C virus	
Decreased needle sharing*	1191	54	1326
Decreased needle sharing + increased use of safer practices during shared injections†	1400	60	1542
Decreased needle sharing + increased use of safer practices during shared injections + increased referral to methadone treatment‡	1517	68	1695

*Assumes that needle sharing decreased among frequent injectors (odds ratio 0.30).³

†Assumes effects of decreased needle sharing and increased use of safer practices during shared injections (e.g., use of bleach to sterilize needles) among frequent injectors (odds ratio 2.70).⁴

‡Assumes effects of decreased needle sharing, increased use of safer practices during shared injections and increased referral to methadone maintenance treatment among injection drug users (odds ratio 1.84).⁴

Table 3: Predicted costs associated with the supervised injection facility and with no facility

Assumption	Cost, \$ (thousands)*				
	Facility operation	HIV treatment	Hepatitis C virus treatment	Methadone maintenance treatment	Other
No supervised safe injection facility	0	464 950	242 814	50 080	4 920 962
Supervised safe injection facility					
Decreased needle sharing	23 903	421 552	244 232	50 663	4 924 493
Decreased needle sharing + increased use of safer practices during shared injections	23 903	414 310	244 499	50 757	4 925 067
Decreased needle sharing + increased use of safer practices during shared injections + increased referral to methadone maintenance treatment	23 903	411 468	244 675	56 295	4 924 136

*Costs are over 10 years, discounted at 5% per year. Assumptions of effects are outlined in Table 2.

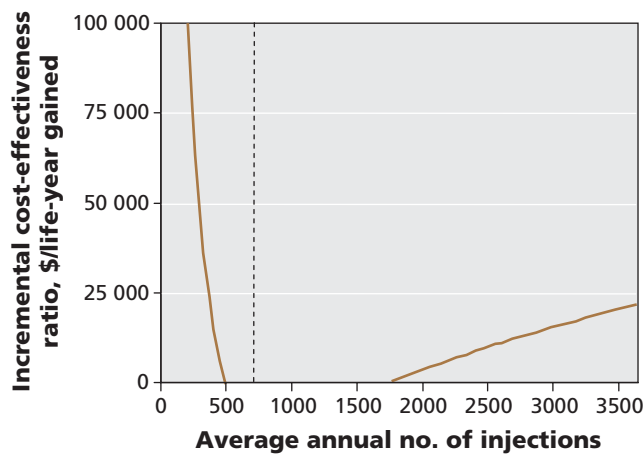


Figure 2: Incremental cost-effectiveness of the supervised injection facility at different assumptions about the number of annual injections. The model shows cost savings and improved health benefits if the number of annual injections is between 490 and 1762. The base assumption is indicated by the dotted line.

Sensitivity analyses

We found that our model was most sensitive to 3 assumptions. First, the facility was not associated with cost savings if the rates of injection drug use and needle sharing were very low or very high. The model showed no cost savings if the average number of injections was less than 490 per year (1.3 injections per day) or more than 1762 per year (4.8 injections per day) (Figure 2). The cost-effectiveness ratio exceeded \$50 000 per life-year gained if the number of injections was 284 per year (0.78 per day) or fewer. The incremental cost-effectiveness ratio, under the base assumption of decreased needle sharing as the only effect of the facility, also exceeded \$50 000 per life-year gained if the pro-

portion of injections in which needles were shared was very low (less than 5.1%).

Second, the cost-effectiveness of the facility was sensitive to assumptions about the effectiveness of both the facility and other interventions to decrease risks associated with injecting. The cost-effectiveness of the facility exceeded \$50 000 per life-year gained if the odds ratio for needle sharing among facility users was greater than 0.79 or the proportion of users who followed safer injection practices exceeded 72%. The facility was economically attractive even with relatively low uptake. For this analysis, we assumed that about \$500 000 of the facility's annual operating costs were fixed and that the remainder varied in direct proportion to the number of participants (Figure 3). The model showed cost savings if the facility was used regularly by only 4.8% of injection drug users when we assumed decreased needle sharing as the only effect of the facility, and 3.8% when we assumed all effects.

Third, the values we used for costs were important for determining cost-effectiveness. If the average annual cost of HIV-related care exceeded \$10 339, the facility would result in a net cost saving. The facility was associated with cost savings if the annual operating costs were \$4.7 million or less. The incremental cost-effectiveness ratio exceeded \$50 000 per life-year gained if the annual operating costs exceeded \$10.3 million.

Interpretation

We evaluated the cost-effectiveness of Vancouver's supervised injection facility and estimated the number of cases of HIV and hepatitis C virus infections that could be averted owing to decreased needle sharing, safer injecting practices and increased referral to methadone maintenance treatment. Our estimate for the base assumption — that decreased needle sharing would be the only effect of the facility — was conservative. On the basis

Table 4: Costs, life-years gained and cost-effectiveness with different assumptions about effects associated with the supervised injection facility*

Assumption†	Costs, \$			Life-years gained			Incremental cost-effectiveness ratio (\$/life-year gained)
	With facility	With no facility	Incremental cost	With facility	With no facility	Incremental gain	
Decreased needle sharing	5 665 million	5 679 million	-13 963 700	3 687 595	3 686 675	920	Facility dominant‡
Decreased needle sharing + increased use of safer practices during shared injections	5 659 million	5 679 million	-20 269 700	3 687 745	3 686 675	1070	Facility Dominant‡
Decreased needle sharing + increased use of safer practices during shared injections + increased referral to methadone maintenance treatment	5 660 million	5 679 million	-18 329 800	3 687 851	3 686 675	1175	Facility Dominant‡

*Costs and benefits (life-years gained) are over 10 years, discounted at 5% per year. Costs are rounded to the nearest \$100 unless otherwise indicated.

†Assumptions of the effects associated with the supervised injection facility are outlined in Table 2.

‡Dominant interventions are more effective and less costly than alternatives. The supervised injection facility dominates the situation with no facility because it is associated with positive incremental health effects and negative incremental costs.

of that assumption, we calculated that the use of the facility would be associated with improved survival and fewer net costs. When we incorporated the other 2 treatment effects, the facility was even more economically attractive. We found that there would be potential cost savings even if a relatively low percentage of injection drug users were to use the facility. Our estimate compares favourably with those associated with other health care interventions.^{51,52} For context, estimates of the cost-effectiveness of methadone maintenance treatment range from about \$5000 to \$20 000 per life-year gained.^{18,53}

The prime determinant of cost-effectiveness in our model was the number of HIV infections averted through decreased needle sharing. When the average number of injections was low or high, the facility was less economically attractive. If the number was low, too few transmissions would occur to make the intervention worthwhile. If the number was high, the risk of transmission would be so high that the facility's impact would be minimal. Sexual transmission of HIV and transmission of hepatitis C virus made relatively minor contributions. One limitation of our model is that we did not include an extended time frame beyond 10 years. Thus, we did not fully account for future costs, which may be particularly important when considering HIV-related therapy. Our finding of a cost of \$20 100 per case of HIV infection averted may be instructive in this regard, since the lifetime costs of direct HIV-related care exceeds this estimate, by a factor of about 10.⁵⁴

Supervised injection facilities exist in over 2 dozen cities in Europe and Australia.⁵⁵⁻⁵⁷ An economic evaluation of the safe injection facility in Sydney, Australia, used a cost-benefit approach and estimated that the ratio of benefits to costs may not be favourable at start-up but would probably become so in the future.⁵⁸ A previous analysis of Vancouver's facility indicated a favourable cost-benefit ratio and a cost of \$52 000–\$155 000 per case of HIV infection averted, which is considerably higher than our estimate.⁶ However, that analysis used a simpler model than ours, it focused solely on cases of HIV infection averted, and it did not account for dynamic transmissions in an epidemic model.

In our base analysis, the prevalence of HIV infection among injection drug users continued to increase over time. This reflected how the incidence of new cases of HIV infection in this population exceeded mortality with combination antiretroviral therapy. The prevalence of HIV infection also increased, although at a reduced rate, when the introduction of the supervised injection facility was considered in the model. The same was true for the prevalence of hepatitis C virus infection. In reality, however, the difference in rates with and without the facility will not be observed, because the "no facility" scenario does not exist in Vancouver. Thus, expecting the prevalence of HIV or hepatitis C virus infection to fall relative to historical controls is too stringent a criterion for evaluating effectiveness. More generally, our observations indicate the challenge of evaluating an intervention without a contemporary control group and underscore the importance of considering intermediate outcomes, such as temporal trends in injecting practices, alongside epidemiologic data.

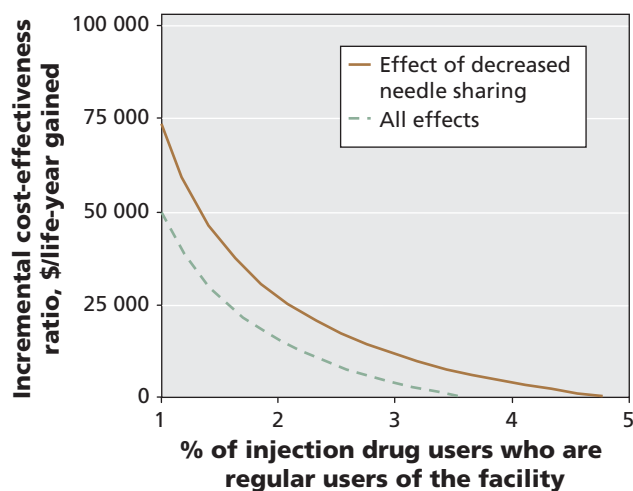


Figure 3: Incremental cost-effectiveness of the supervised injection facility at different assumptions about the percentage of injection drug users who are regular users of the facility. The solid line indicates the cost-effectiveness when decreases in needle sharing are considered the only effect of the facility. The dashed line indicates the cost-effectiveness when all effects are considered (decreased needle sharing, safer injection practices [e.g., use of bleach to sterilize shared needles] and increased referral to methadone maintenance treatment). The base assumption was 21% (not shown).

Limitations

Our model has several limitations. First, we modelled the efficacy of the facility by focusing on the injecting behaviours of regular users of the facility. We may have overestimated efficacy if injection practices of users injecting outside the facility did not change; however, available analyses to date suggest a general change in injecting practices.³ We may also have underestimated efficacy by ignoring the decreased risk associated with injections within the facility by casual users.

Second, we excluded from our analysis potentially important health benefits such as decreased overdose, reduced transmission of hepatitis B, and reduced incidence of soft-tissue infections, endocarditis and other harms associated with unhygienic injection. We also did not account for benefits such as increased access to, and delivery of, other health services, social services and crisis management as well as societal benefits such as decreased cost of crime and improved social order, which may be particularly important in economic terms.⁵⁹

Third, we considered methadone maintenance treatment as the only form of drug addiction treatment and not more expensive treatments such as residential care.

Finally, we did not consider quality of life or a full probabilistic analysis.

Our estimates are specific to the characteristics of the Vancouver supervised injection facility and may not be generalizable to other settings, since the size and geographic location of the population of injection drug users and the baseline prevalence of HIV and hepatitis C virus infections will differ across cities.

Conclusion

Our analysis indicates that the supervised injection facility in Vancouver is associated with improved health outcomes. These health benefits and cost savings are due in large part to averted cases of HIV infection, even with conservative estimates of efficacy.

This article has been peer reviewed.

Competing interests: None declared.

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