A cost–benefit and cost-effectiveness analysis of Vancouver's supervised injection facility

Article *in* The International journal on drug policy · June 2009
DOI: 10.1016/j.drugpo.2009.03.004 · Source: PubMed

2 authors:

Martin A Andresen
Simon Fraser University
156 PUBLICATIONS **2,931** CITATIONS
SEE PROFILE

Neil Boyd
Simon Fraser University
4 PUBLICATIONS **56** CITATIONS
SEE PROFILE

International Journal of Drug Policy 21 (2010) 70–76

Contents lists available at ScienceDirect

International Journal of Drug Policy

journal homepage: www.elsevier.com/locate/drugpo

Policy Analysis

A cost-benefit and cost-effectiveness analysis of Vancouver's supervised injection facility

Martin A. Andresen*, Neil Boyd

School of Criminology, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, Canada

ARTICLE INFO

Article history:
Received 2 June 2008
Received in revised form 27 January 2009
Accepted 27 March 2009

Keywords:
Supervised injection facility
Insite
Cost-benefit analysis

ABSTRACT

Background: A supervised injection facility (SIF) has been established in North America: Insite, in Vancouver, British Columbia. The purpose of this paper is to conduct a cost-effectiveness and cost-benefit analysis of this SIF using secondary data gathered and analysed in 2008. In using these data we seek to determine whether the facility's prevention of infections and deaths among injecting drug users (IDUs) is of greater or lesser economic cost than the cost involved in providing this service – Insite – to this community.

Methods: Mathematical modelling is used to estimate the number of new HIV infections and deaths prevented each year. We use the number of these new HIV infections and deaths prevented, in conjunction with estimated lifetime public health care costs of a new HIV infection, and the value of a life, in order to calculate an identifiable portion of the societal benefits of Insite. The annual costs of operating the SIF are used to measure the social costs of Insite. In using this information, we calculate cost-effectiveness and benefit-cost ratios for the SIF.

Results: Through the use of conservative estimates, Vancouver's SIF, Insite, on average, prevents 35 new cases of HIV and almost 3 deaths each year. This provides a societal benefit in excess of $6 million per year after the programme costs are taken into account, translating into an average benefit-cost ratio of 5.12:1.

Conclusion: Vancouver's SIF appears to be an effective and efficient use of public health care resources, based on a modelling study of only two specific and measurable benefits—HIV infection and overdose death.

Introduction

Some uses of illicit drugs are causing many nation-states to reconsider previously accepted principles of public health. With injectable use of illicit drugs and often corresponding life-threatening diseases (HIV/AIDS and hepatitis B/C), the question of whether or not state health care should create programmes for the safer provision of drugs and related materials to drug users (needles/syringes, cleaning kits, condoms, etc.) has emerged.

The possibilities in this realm range from needle/syringe exchange programmes (NEPs), to medically prescribed drug substitution, and, more recently, to the provision of supervised injection or consumption facilities. However, the provision of drugs and related materials faces a number of challenges. If the state health care system provides illicit drugs and/or materials to facilitate drug consumption, some critics argue that drug use may increase. This increase may occur through the recruitment of new IDUs and/or the increasing usage of existing IDUs, leading to a greater level of drug use in the communities that provide such services. There is, however, no evidence of such increases occurring where governments have established these programmes (Des Jarlais, Friedman, Choopanya, Vanichsenis, & Ward, 1992; Lurie et al., 1993; Vlahov & Junge, 1998; Watters, Estilo, Clark, & Lorvick, 1994).

Additionally, some argue that these programmes may be in direct violation of state and/or federal laws: the possession of a needle/syringe without a prescription is illegal in a number of U.S. states (Kaplan & O'Keefe, 1993). In the case of SIFs, exemptions from state and/or federal law may be required for operation. For example, the Vancouver SIF, Insite, currently has such an exemption from Canada's Controlled Drugs and Substances Act (Vancouver Coastal Health, 2007), allowing users to consume at a specific location without arrest. The British Columbia Supreme Court recently ruled that Insite should remain open (PHS Community Services v. Attorney General of Canada, BCSC, 2008). Irrespective of this finding, however, the legal operation of these programmes may be considered state-sanctioned illicit drug use, considered unacceptable by some governments.

* Corresponding author. Tel.: +1 778 782 7628; fax: +1 778 782 4140.
E-mail address: andresen@sfu.ca (M.A. Andresen).

0955-3959/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.drugpo.2009.03.004

Many of the issues raised by these kinds of programmes cannot be resolved in this article, but there remains one issue that can be addressed: whether or not a SIF creates a net economic benefit for society. This kind of programme may be a benefit for illicit drug users, but public funds are not always able to be allocated simply because one group within the larger population benefits from that programme. Scarce resources in public health care must be allocated based on some form of economic efficiency. For example, given the choice between two alternative programmes for responding to illicit drug use, and assuming that health outcomes are the same for each programme, the programme with the least cost should be chosen.

If the net benefit to society from Insite is positive, then we may consider SIFs one of the many public health care options for IDUs. To date, there have been no published cost-effectiveness or cost-benefit analyses of SIFs. This article provides the first such evaluation of Vancouver's SIF, Insite. The SIF in Vancouver opened in September of 2003. This facility is the first SIF in North America, located in Vancouver's Downtown Eastside, an area known for its high incidence of HIV infection. This urban neighbourhood is the most impoverished in Canada, with an IDU population estimated at 5000 (Wood et al., 2006). We calculate the number of new HIV infections and deaths prevented using mathematical modelling and secondary data. The dollar costs of illness and deaths avoided are calculated and compared to the operational costs of Insite.

Methods

In order to perform a cost-benefit and cost-effectiveness analysis of Vancouver's SIF, there are a number of methodological issues that must be considered: operational costs of the facility, the number of HIV infections and overdose deaths prevented, the costs of treating HIV infections, and the economic value placed on the deaths prevented. Where possible, numbers specific to Vancouver are used in the analysis, but when these are not available, numbers widely used in the medical and public health literatures are employed. We chose to employ conservative parameter values, in order to calculate the lower bound of benefits in all cases. We do undertake a sensitivity analysis, however, through employing the different mathematical models found within the existing literature.

The operational costs of Insite

The annual operational cost (2007) of the SIF portion of Insite has been cited as $1.5 million (CTV News, 2008, an interview of Dr. Thomas Kerr, Principal Investigator, Insite). Operational costs of Insite have also been set at $2 million (CBC News, 2003) and $3 million (Health Canada, 2008), but these other cost estimates included such services as addiction counselling and case management, the provision of primary healthcare, public health screening (immunisations and diagnostics), addiction and housing services, education, and peer counselling. We use the $1.5 million figure for two reasons: first, it only considers the operational costs of the SIF portion of Insite; and second, the source is the Principal Investigator contracted by Health Canada to evaluate Insite.

The medical cost of a new HIV infection

The lifetime medical cost of a new HIV infection has been estimated with a large range of values: US$50,000 (Kaplan & O'Keefe, 1993) to US$200,000 (Chen et al., 2006; Holtgrave & Pinkerton, 1997; Pinkerton & Holtgrave, 1998)—details of the breakdown of medical costs are provided in these references. Because the impact of new HIV infections prevented is critical to establish the cost-effectiveness and benefit-cost ratios, the lifetime medical cost of a new HIV infection must be chosen with care. Two further concerns for this analysis must be acknowledged. First, it can be argued that an IDU population is less likely to take full advantage of the medical system, in contrast to an "average" citizen, whether this restraint is self-imposed or not (Laufer, 2001). And second, the lifetime medical costs of treating a new HIV infection may be different in Canada from the United States. In order to address the first concern, more conservative (i.e., lower) lifetime medical costs of a new HIV infection are employed. With regard to the second concern, estimated lifetime medical costs of treating a new HIV infection are obtained from both Canadian and U.S. sources.

There are two cost-benefit analyses in Canada that report lifetime medical costs of new HIV infections. Gold, Gafni, Nelligan, & Millson (1997) use CDN $100,167 (1991 dollars), based on Grover et al. (1993). This estimate uses the expectation of just over 10 years of survival with HIV/AIDS. Jacobs et al. (1999) use CDN $150,000 (1998 dollars) based on Albert and Williams (1998). This latter estimate of the lifetime medical costs of a new HIV infection assumes a 17-year survival with HIV/AIDS. In the U.S., Holtgrave and Pinkerton (1997) and Pinkerton and Holtgrave (1998) estimate an intermediate cost of a new HIV infection (US$195,188) and a low cost (US$87,045). These authors suggest that this latter low cost is appropriate for IDU populations that are expected to use medical resources less intensely than the average citizen. As such, we use this lower figure here. If we convert figures from these studies into 2006 Canadian dollars, the following estimates of lifetime medical costs are: $132,000 (Holtgrave & Pinkerton, 1997), $179,000 (Jacobs et al., 1999), and $154,000 (Gold et al., 1997). We chose to use $150,000, a value slightly lower than the median value, based on an anticipated lower cost treatment of an HIV infection for IDUs.

More recent methods of HIV/AIDS treatment include the very successful multidrug combinations Highly Active Antiretroviral Therapy (HAART). Despite being highly effective, HAART treatment regimens are intensive, and treatment uptake and adherence tends to be poorer among IDUs than other patient groups with HIV infection (Lert & Kazatchkine, 2007). If IDUs do use such a treatment, however, it will obviously produce greater costs than the figure used above: based on a 10 year survival rate, the lifetime cost of HAART per patient was US$160,000 in 2001 (Chen et al., 2006). If we convert this figure into 2006 Canadian dollars, the lifetime medical cost of HAART are calculated at more than $250,000. Though the most recent changes in the Canada–United Stated exchange rate and decreased costs of HAART drugs may have decreased the HAART figure, it is most certainly greater than the $150,000 figure used in the analysis. Accordingly, the lifetime medical cost of a new HIV infection used in the analysis below is considered an underestimate of the actual lifetime medical costs, providing conservative estimates of the benefits from Insite. However, if the reader considers the HAART programme treatment costs more appropriate, the benefit-to-cost ratios reported below should be multiplied by 1.67.

Value of a prevented death

Miller, Cohen, & Wiersema (1996) calculate the value of a prevented death as US $3 million, 1993 dollars–CDN $5 million, 2006 dollars. Approximately one-third of this cost is tangible: lost wages/productivity and medical costs, with the remaining two-thirds lost quality of life. Therefore, if we only consider tangible costs, the value of a prevented death is approximately $1.67 million. Alternatively, considering contingent evaluation employed by Cohen, Rust, Steen, & Tidd (2004), the value of a prevented death is in excess of $10 million. However, one could argue there is little lost productivity or lost wages flowing from an IDU death. In fact, one might argue that such a death would save public health care resources.

This reality raises ethical concerns with respect to the provision of services such as NEPs or SIFs: do we have a real regard for those of

us in society dependent on drugs, or do we employ a "cynical economic rationalism" that only legitimates public health policies that pay for themselves? (Kleinig, 2006, p 823). Kleinig (2006) believes the provision of such services is simply an ethical response to illness, and we agree. The prevention of an unnecessary death is a benefit to society and because some programmes will prevent more deaths than others, a value must be placed on a prevented death in order to properly assess program benefits. At the same time, however, we do recognise that many will not accept that a positive economic value can be placed on the life of an IDU. In our view this is a limitation that is inherent in cost-benefit analyses of the provision of public health services. Unlike the realm of private business, the role of public health is not one of simply seeking to achieve benefits that are in excess of expenses. Given the differences of opinion within this realm, however, we present our results, both with and without the use of prevented deaths.

In order to place an economic value on prevented deaths, we considered only tangible costs. The most direct measure of tangible costs is the potential value that a person may add to the economy. We use the average income in British Columbia, measured by the gross domestic product per capita, $33,640. If we discount future earnings at 3 percent (Laufer, 2001), the value of lost productivity/wages is the sum of the income lost. Kerr et al. (2006a) have found the average age of Insite users is 35 years. Assuming retirement at 65, there are 30 years of lost productivity/wages from an overdose death. However, if the death is the result of an HIV infection, there are 20 years of lost productivity/wages, as the expected survival time of an IDU newly infected with HIV is 10 years (Gold et al., 1997). These values lead to a loss to society of $500,000 and $660,000 for a new HIV infection and a fatal overdose, respectively. Though these values are significantly large and may not be representative of a "typical" Insite client, they are far more conservative than most estimates of the value of a life and it is the value of a life – any life – that we wish to quantify. Moreover, this value signifies the *potential* value lost to society if a life is lost because of a fatal overdose or HIV/AIDS. The use of this value, however, is not necessary to show the net positive benefit of Insite; it only strengthens the result obtained from the prevention of HIV infection.

Deaths prevented: HIV and overdoses

As we have noted above, we had two sources of data on deaths prevented from the establishment of Insite, one direct and one indirect: the prevention of deaths attributable to HIV infections (indirect) and the prevention of deaths attributable to overdoses (direct). The calculation of the indirect prevention of deaths attributable to new HIV infections is relatively straightforward, the percentage of illicit drug deaths attributable to HIV infections in Canada is available in Coroners' data and published in Rehm et al. (2006). In 2002, 5.1 percent of illicit drug related deaths were attributed to HIV infections. Single, Robson, Xie, & Rehm (1996) calculate this percentage to be 8 percent in 1992, but we use the more conservative 5.1 percent figure. In the results below, we calculate an average of 35 new HIV infections prevented using the four mathematical models (see Table 4). The number of deaths prevented is simply 5.1 percent of the number of new HIV infections prevented among IDUs. This calculation (35×0.051) leads to 1.785 potential deaths prevented annually because of the establishment of Insite. Ideally, we would use 5.1 percent of actual IDU deaths for this calculation, but these data are not available for our analysis.

The direct prevention of death is measured using data on the number of fatal overdoses. As found in a number of studies (see Davidson et al., 2003; Rehm et al., 2006; Wood et al., 2005), drug overdoses are a common cause of morbidity and mortality in IDU populations. In Canada (2002) there were 958 accidental fatal overdoses (Rehm et al., 2006). This number is approximately 40 percent greater than the number of homicides each year in Canada, a result similar to that found by Coffin et al. (2003) for New York City. Such comparisons suggest that efforts to reduce fatal overdoses should be of significant social interest.

Table 1
Savings from average number of estimated annual deaths prevented at Insite.

	Estimated deaths prevented	Savings per death prevented	Total savings
HIV deaths	1.785	$500,000	$892,500
Overdose deaths	1.08	$660,000	$712,800
Total deaths	2.87		$1,605,300

The number of fatal overdoses prevented is calculated using the British Columbia Coroners Service (2008) data, reporting the number of IDU overdoses in British Columbia, and overdose rates within Insite provided by Kerr, Tyndall, Lai, Montaner, & Wood (2006b). Kerr et al. (2006) report that over the time period 01 March 2004 to 30 August 2005 there were 336 overdose events in Insite, none of which resulted in a death: 1.3 overdoses per 1000 injections, 0.13 percent of injections. Though overdose rates may be higher in Insite than on the street because users know there is access to medical intervention, the Insite overdose rate is at the lower end of the range found internationally by Kimber, Dolan, van Beek, Hedrich, & Zurhold, 2003; Kimber, Dolan, & Wodak, 2005. In fact, Kimber et al. (2005) find that the overdose rates in SIFs are far greater in Germany and Australia, 6.4 and 7.2, respectively, per 1000 injections—some of this difference is likely attributable to varying definitions of overdose and different drug usage patterns in different countries and cities. Because of a lack of pre-Insite data, 1.3 overdoses per 1000 is used to represent the overdose rate without the establishment of Insite as well. Kerr et al. (2006) also reported that in 16.4 percent of all Insite overdose cases the individual stopped breathing. There may have been other factors leading to a potential fatal overdose, but we only consider "stopped breathing" as a potential fatal overdose, to err conservatively.

The overdose deaths prevented are calculated in the following manner. Each year there are 236,520 injections within Insite (Tyndall et al., 2003; Tyndall et al., 2006a) and a total of 4,565,000 injections estimated within the Downtown Eastside as a whole (Holtgrave, Pinkerton, Jones, Lurie, & Vlahov, 1998; Jacobs et al., 1999; Laufer, 2001; McClean, 2002). With an overdose rate of 1.3 per 1000 injections, there are 307 and 5935 overdoses each year within Insite and the Downtown Eastside, respectively. But if we limit ourselves to "stopped breathing" as a potentially fatal overdose (16.4 percent of overdoses), this leads to lower numbers—50 and 973 potential fatal overdoes each year within Insite and the Downtown Eastside, respectively. However, data from British Columbia Coroners Service (2008) indicate that within the last few years there have been only approximately 50 fatal drug overdoses each year in the entire city of Vancouver. With 42 percent of Vancouver's IDU population residing in the Downtown Eastside (McClean, 2002), the Downtown Eastside can then be expected to experience 21 of these 50 fatal overdoses. With 973 potential fatal overdoses and 21 actual fatal overdoses each year, we estimate 2.16 percent of potential fatal overdoses lead to an actual death. In the context of Insite, 2.16 percent of its potentially fatal overdoses (50) are 1.08 potential deaths prevented.

The total number of potential deaths prevented from the presence of Insite is 2.87 (combining HIV and fatal overdoses). As shown in Table 1, this small number of potential deaths prevented has a significant impact on the cost-benefit analysis.

Table 2
Mathematical models and variables.

Laufer (2001)–Simple $E/(E+s)$		Laufer (2001)–Complex New HIV infections avoided = $c(1-p)ar$		Jacobs et al. (1999) New HIV infections = $INsd(1-(1-qt)^m)$		Kaplan and O'Keefe (1993) New HIV infections = $(1-\pi)\lambda(1-\theta)\beta\alpha$	
Variable	Value	Variable	Value	Variable	Value	Variable	Value
E: number of needles used per client-year	139	*c*: number of IDUs in population	5000	*I*: proportion IDUs HIV−	77.46%	π: HIV prevalence	17% (Insite) 25.4% (non-Insite)
s: number of shared injections per client-year	20, 30, 40%	*p*: HIV prevalence rate	17%	*N*: number of needles in circulation	2 million	λ: rate of needle sharing	20, 30, 40%
HIV prevalence rate	17%	*a*: participation rate at Insite	34%	*s*: rate of needle sharing	20, 30, 40%	θ: percent needles not cleaned	17%
Cumulative probability of HIV infection	5.26%	*r*: reduction of risk from participation	0.75	*d*: percent needles not cleaned	17%	β: percent HIV infected needles	40.5%
				q: proportion IDUs HIV+	22.54%	α: probability of HIV infection from single injection	0.67%
				t: probability of HIV infection from single injection	0.67%		
				m: number of sharing partners	1.38		

Mathematical modelling of new HIV infections

Mathematical models use known statistics before and after policy implementations to estimate change. In the case of Insite, there are a certain number of "clean" injections that are taking place rather than potentially "dirty" injections, running the risk of a new HIV infection. Through the use of established data regarding the number of IDUs, injection frequency, HIV transmission probability, IDU HIV prevalence, behavioural changes of IDUs, and a number of other variables, the impact of Insite can be estimated mathematically. In order for the mathematical modelling to be performed, a number of variables need to be obtained from both the medical and public health literatures.

Four different models from three sources (Kaplan & O'Keefe, 1993; Laufer, 2001; Jacobs et al., 1999) are used to assess the impact of Insite on new HIV infections. The equations, variables, and variable values are outlined in Table 2, and the sources for each of those values are listed in Table 3. These models estimate the number of new HIV infections avoided directly (Laufer, 2001), and calculate the number of new HIV infections with and without Insite, comparing the difference (Kaplan & O'Keefe, 1993; Jacobs et al., 1999; Laufer, 2001). We also extend these models to consider other variables of relevance, as existing data demonstrated that Insite impacts IDU injecting risk behaviour outside of the facility (Kerr, Tyndall, Li, Montaner, & Wood, 2005a). Kerr et al. (2005a) found attendance at Insite significantly reduced needle sharing: Insite IDUs share needles at 0.30 the frequency of non-Insite IDUs. The MSIC Evaluation Committee (2003) also found a reduction in injecting risk behaviour after the establishment of a SIF (Sydney, Australia), but no significant changes in needle sharing. Despite the goodness of fit reported by Kerr et al. (2005a) we wished to be conservative and so considered 50 percent of their reported effect on needle sharing as our benchmark, an odds-ratio of 0.60. This calculation still assumes a significant drop in needle sharing, but errs on the side of caution, attempting to discount any inflation of effect from socially biased responding.

The general assumptions used in mathematical modelling all relate to stability in the variables used in the analysis. As such, we must assume that the only variables that change to any marked degree are those that we manipulate. If this is not the case, we cannot be confident in the impacts that are calculated. Fortunately, the assumptions in these models are not likely to be subject to substantial error. These assumptions revolve around the size of the IDU population, the injection frequency of the IDU population, HIV prevalence in the IDU population, and HIV transmission rates (for both individual injections and cumulative probabilities for an entire year of injecting). The values for these variables are well documented in the medical and public health literatures, outlined in Table 3.

Cost-effectiveness and cost-benefit analysis of Insite

Our cost-effectiveness and cost-benefit analysis is based on Insite being operational 18 h per day. Additionally, all results include the impact of behavioural changes within the Insite population. These data clearly increase the benefits of the establishment of Insite, but we stress that our calculation of behavioural impact is based on a conservative odds-ratio, not the odds-ratio provided by Kerr et al. (2005a)—we do, however, use an odds-ratio that falls within the statistical limits of Kerr et al. (2005a). For additional reference, the average number of new HIV infections prevented is provided in the tables below.

As shown in Table 4, there is substantial range in the number of new HIV infections prevented: 19–57, with an average of 35 each year. This translates into cost savings to society ranging

Table 3
Sources for variables used in mathematical modeling.

Variable	Source
Number of needles used per client-year	Tyndall et al. (2003), Tyndall et al. (2006a)
Number and rate of shared injections per year	Kaplan and O'Keefe (1993), Laufer (2001), Jacobs et al. (1999), Des Jarlais et al. (1996), Siegel, Weinstein, & Fineberg (1991), Holtgrave et al. (1998), Kerr et al. (2005a), Wood et al. (2001)
HIV prevalence rate	Petrar et al. (2007), Tyndall et al. (2006b)
Cumulative probability of HIV infection	Des Jarlais et al. (1996)
Number of IDUs in population	McClean (2002), Kerr, Tyndall, Li, Montaner, & Wood (2005b)
Participation rate at Insite	Tyndall et al. (2003)
Reduction of risk from participation	Des Jarlais et al. (1996)
Number of needles in circulation	McClean (2002), Buxton (2008)
Percentage of needles not cleaned	Kaplan and O'Keefe (1993), Jacobs et al. (1999)
Probability of HIV infection from a single injection	Kaplan and O'Keefe (1993)
Number of sharing partners	Jacobs et al. (1999)
Percentage of HIV infected needles	Kaplan and O'Keefe (1993)

Table 4
Cost-effectiveness and cost-benefit of prevented HIV infections, expressed as annual amounts.

	Number prevented	$ Saved (millions)	Cost-effectiveness ratio	Benefit-cost ratio
Laufer (2001)–Simple	37 (44, 32)	5.55 (6.6, 4.8)	$40,541 ($34,091, $46,875)	3.76 (4.48, 3.26)
Laufer (2001)–Complex	19 (18, 20)	2.85 (2.7, 3.0)	$78,947 ($83,333, $75,000)	1.94 (1.84, 2.04)
Jacobs et al. (1999)	27 (18, 36)	4.05 (2.7, 5.4)	$55,556 ($83,333, $41,667)	2.74 (1.84, 3.66)
Kaplan and O'Keefe (1993)	57 (38, 76)	8.55 (5.7, 11.4)	$26,316 ($39,474, $19,737)	5.80 (3.86, 7.74)
Average	35 (30, 41)	5.25 (4.5, 6.15)	$42,857 ($50,000, $36,585)	3.56 (3.06, 4.18)

Notes: The numbers reported represent the 30 percent shared injection numbers. The numbers reported in parentheses are for 20 and 40 percent shared injection numbers, respectively.

from $2.85 to $8.55 million, benefit-cost ratios ranging from 1.94 to 5.80, and cost-effectiveness ranging from $26,000 to $79,000. Though these cost-effectiveness ratios are significantly less than the lifetime medical cost of a new HIV infection, Insite does not perform as well on this variable as NEPs. Gold et al. (1997), Jacobs et al. (1999), and Laufer (2001) all generate cost-effectiveness ratios ranging from $15,000 to $35,000, after adjustment for inflation and the exchange rate. However, given that a NEP is already in operation in Vancouver, this higher relative cost for Insite is not surprising. In only two of the 10 reported results does the benefit-to-cost ratio not exceed 2.0, though 1.84 still provides the public health care system a 84 percent return after covering the costs of Insite—this relatively low benefit-to-cost ratio only occurs when a 20 percent needle sharing rate is used (a value well below the standard in the medical and public health literature, and Vancouver studies specifically). When we consider the benefit-to-cost ratio of the "average" model, we find a range of 3.0–4.0, a more clear indication that Insite provides a positive economic return on investment.

If we add to the mix the number of premature deaths prevented (Table 1), Table 5 shows that benefit-to-cost ratios are never below 3.0, have a high of 8.04, and an average of 5.12. Again, because of the very conservative values employed in the mathematical models, these ratios should be considered as underestimates: the benefit-to-cost ratios are almost certain to be significantly greater.

Interpretation

The results presented here suggest that the establishment of Insite has had a positive impact on the health outcomes of the IDU population in Vancouver's Downtown Eastside; we have been able to estimate that Insite is a good value for the resources that it consumes. It is difficult to compare cost-benefit studies because of different methodologies, but when considering Insite's role in responding to the problems of injection drug use, it is important to place our results alongside those of other treatment programme. Belenko, Patapis, & French (2005) conducted a substantial review of drug treatment programme and provided accompanying cost-benefit analyses. They found that the range for benefit-to-cost ratios is quite substantial, from 1.33 to 1, to 39 to 1. However, most of these benefit-to-cost ratios are below 5 to 1 and many were below 3 to 1. Accordingly, our analysis places Insite alongside a variety of treatment programme for IDUs living in Vancouver's Downtown Eastside.

When we consider the alternatives reviewed by Belenko et al. (2005), there are three broad categories of "treatment" for which the benefit-to-cost ratios for Insite can be compared: non-prison drug treatment programme, voluntary prison treatment programme, and drug courts. Drug treatment programs have benefit-to-cost ratios ranging from 1.33 to 4.34. Though many of the benefit-to-cost ratios for Insite fall within this range, the difficulty

Table 5
Annual cost-effectiveness and cost-benefit of prevented HIV infections and deaths.

	HIV $ saved (millions)	Death $ saved (millions)	Total $ saved (millions)	Cost-benefit ratio
Laufer (2001)–Simple	5.55	2.40	7.95	5.40
Laufer (2001)–Complex	2.85	1.58	4.43	3.00
Jacobs et al. (1999)	4.05	1.94	5.99	4.06
Kaplan and O'Keefe (1993)	8.55	3.31	11.86	8.04
Average	5.25	2.31	7.56	5.12

with any comparison here is that the benefits of drug treatment are largely based on reductions in criminal activity of those involved in the treatment programme—the treated individuals no longer use drugs and therefore have no need to steal to obtain drugs. Insite does not provide drugs to its users and is therefore not expected, a priori, to impact criminal activity. Drug courts, in comparing the operating costs of the courts with the net change in prison time, generate benefit-to-cost ratios ranging from 1.74 to 6.32; again, most of the benefit-to-cost ratios for Insite fall within this range, but without any consideration of reduced impacts on the criminal justice system. Lastly, voluntary drug treatment in prison generates benefit-to-cost ratios ranging from 1.79 to 5.74, the benefits again derived from reduced criminal justice costs. In sum, regardless of the particular type of treatment, the conservative (underestimated) benefit-to-cost ratios of Insite fall within the ranges of a number of different types of treatment for drug dependence (but without contemplating any reductions in criminal justice costs). As a result, we can conclude that conventional forms of treatment are, on average, not shown to be better alternatives to Insite in cost savings to the public health sector. Additionally, the calculation of the nature of the benefits derived varies from one cost-benefit analysis to the next. In any event, we can conclude that Insite can be seen, in economic terms, to be one of many productive treatment modalities for responding to the problems of illicit drug addiction in Vancouver's Downtown Eastside.

The generation of the benefits from Insite stems from two sources. The first source is the provision of clean injecting equipment. Though this has been provided for many years in Vancouver through a NEP, this provision of a new source for that equipment has additional benefits and is currently operating at capacity. The second source is Insite's facilitation of change in injecting behaviours in the IDU population, also found in Sydney, Australia (MSIC Evaluation Committee, 2003). When IDUs use Insite, their injecting behaviour outside of Insite becomes less risky, through fewer shared injections.

Expansions of Insite should be considered in order to accommodate a greater proportion of the injections taking place in Vancouver's Downtown Eastside—in order to further reduce the harm from injecting drug use. We should also note that the current analysis is not without its limitations. Greater detail in fixed versus variable costs would allow for a better assessment of how an expansion of Insite (18 h per day versus 24 h per day) would impact public health care costs. More crucially, we have only studied a small number (two) of easily measurable benefits. Other health care outcomes such as those investigated by Frei, Greiner, Mehnert, & Dinkel (2000) are not included because of a lack of data. It seems intuitively likely that the provision of immunisation, diagnostics, and referrals would all create additional health benefits for this population. In the evaluation of an opiate maintenance programme in Switzerland, Frei et al. (2000) found that health-related savings accounted for almost 18 percent of total savings without even considering the impact of new HIV infections or overdose deaths. These factors, not considered in our analysis of Insite, may be significant in terms of increasing the benefit-to-cost ratios, further justifying Insite's operating expenses. Lastly, there are the limitations of the mathematical modelling. All benefits are assumed to be linear, restricting the ways expansions of Insite can be assessed. Of course, like any empirical analysis, the mathematical modelling is only as reliable as the data used in the calculations. However, as stated repeatedly, we have used conservative values as often as possible within each of the models.

Directions for future research primarily flow from the limitations of our work—the need to incorporate more data of relevance. First, proper assessment of both the expansion of Insite to other locations and the costs of 24 h operation of the facility should be undertaken to determine whether the benefits from increased operating hours and increased facilities are greater than the increased operating costs. Second, study of the scope of public health benefits should be expanded to include more "mundane" benefits from the provision of clean injecting equipment, similar to those benefits found by Frei et al. (2000) in Switzerland—improvements in the general health of the user population, flowing from diagnostics, immunisation, and referral to detoxification facilities, and a correspondingly diminished use of various medical resources.

References

Albert, T., & Williams, G. (1998). *The economic burden of HIV/AIDS in Canada*. Ottawa, ON: Canadian Policy Research Networks.

Belenko, S., Patapis, N., & French, M. T. (2005). *Economic benefits of drug treatment: A critical review of the evidence for policy makers*. Philadelphia, PA: Treatment Research Institute, University of Pennsylvania.

British Columbia Coroners Service (2008). British Columbia Coroners Service, Vancouver, Canada. Retrieved 01 February 2008 from http://www.pssg.gov.bc.ca/coroners/.

Buxton, J. (2008). *Vancouver drug use epidemiology: Site report for the Canadian community epidemiology network on drug use*. Ottawa, ON: Canadian Community Epidemiology Network on Drug Use, Canadian Centre on Substance Abuse.

CBC News (2003). Vancouver's heroin users get safe-injection site, Vancouver, Canada. Retrieved 31 March 2008 from http://www.cbc.ca/news/story/2003/09/15/safe_injection030915.html.

Chen, R. Y., Accortt, N. A., Westfall, A. O., Mugavero, M. J., Raper, J. L., Cloud, G. A., et al. (2006). Distribution of health care expenditures for HIV-infected patients. *Clinical Infectious Diseases*, *42*, 1003–1010.

Coffin, P. O., Galea, S., Ahern, J., Leon, A. C., Vlahov, D., & Tardiff, K. (2003). Opiates, cocaine, and alcohol combinations in accidental drug overdose deaths in New York City 1990–98. *Addiction*, *98*, 739–747.

Cohen, M. A., Rust, R. T., Steen, S., & Tidd, S. T. (2004). Willingness-to-pay for crime control programs. *Criminology*, *42*, 89–109.

CTV News (2008). Experts table findings on drug-injection site, Vancouver, Canada. Retrieved 12 April 2008 from http://www.ctv.ca.

Davidson, P. J., McLean, R. L., Kral, A. H., Gleghorn, A. A., Edlin, B. R., & Moss, A. R. (2003). Fatal heroin-related overdose in San Francisco, 1997–2000: A case for targeted intervention. *Journal of Urban Health*, *80*, 261–273.

Des Jarlais, D. C., Friedman, S. R., Choopanya, K., Vanichsenis, S., & Ward, T. P. (1992). International epidemiology among injecting drug users. *AIDS*, *6*, 1053–1068.

Des Jarlais, D. C., Marmor, M., Paone, D., Titus, S., Shi, Q., Perlis, T., et al. (1996). HIV incidence among injecting drug users in New York City syringe-exchange programmes. *Lancet*, *348*, 987–991.

Frei, A., Greiner, R.-A., Mehnert, A., & Dinkel, R. (2000). Socioeconomic evaluation of heroin maintenance treatment final report. In F. Gutzwiller, & T. Steffen (Eds.), *Cost-benefit analysis of heroin maintenance treatment, medical prescription of narcotics* (pp. 37–133). Basel: Karger Verlag.

Gold, M., Gafni, A., Nelligan, P., & Millson, P. (1997). Needle exchange programs: An economic evaluation of a local experience. *Canadian Medical Association Journal*, *157*, 255–262.

Grover, S. A., Gilmore, N., Tsoukas, C., Falutz, J., Sewitch, M., & Fakhry, R. (1993). A prospective study of direct health care costs of HIV infected adults in Canada [abstract PO-D28-4226]. *International Conference on AIDS*, *9*, 922.

Health Canada (2008). Expert Panel Report on Supervised Injection Site Released, Ottawa, Canada. Retrieved 23 April 208 from http://www.hc-sc.gc.ca/ahc-asc/media/nr-cp/2008/2008_57_e.html.

Holtgrave, D. R., & Pinkerton, S. D. (1997). Updates of cost of illness and quality of life estimates for use in economic evaluations of HIV prevention programs. *Journal of Acquired Immune Deficiency Syndromes and Human Retrovirology*, *16*, 55–61.

Holtgrave, D. R., Pinkerton, S. D., Jones, T. S., Lurie, P., & Vlahov, D. (1998). Cost and cost-effectiveness of increasing access to sterile syringes and needles as an HIV prevention intervention in the United States. *Journal of Acquired Immune Deficiency Syndromes and Human Retrovirology*, *18*(Suppl. 1), S133–S138.

Jacobs, P., Calder, P., Taylor, M., Houston, S., Saunders, L. D., & Albert, T. (1999). Cost effectiveness of Streetworks' needle exchange program of Edmonton. *Canadian Journal of Public Health*, *90*, 168–171.

Kaplan, E. H., & O'Keefe, E. (1993). Let the needles to the talking! Evaluating the New Haven needle exchange. *Interfaces*, *23*, 7–26.

Kerr, T., Tyndall, M., Li, K., Montaner, J., & Wood, E. (2005). Safer injection facility use and syringe sharing in injection drug users. *Lancet*, *366*, 316–318.

Kerr, T., Tyndall, M., Li, K., Montaner, J. S., & Wood, E. (2005). Potential use of safer injecting facilities among injection drug users in Vancouver's downtown eastside. *Canadian Medical Association Journal*, *169*, 759–763.

Kerr, T., Stoltz, J., Tyndall, M., Li, K., Zhang, R., Montaner, J., et al. (2006). Impact of a medically supervised safer injection facility on community drug use patterns: A before and after study. *British Medical Journal*, *332*, 220–222.

Kerr, T., Tyndall, M. W., Lai, C., Montaner, J. S. G., & Wood, E. (2006). Drug-related overdoses within a medically supervised safer injection facility. *International Journal of Drug Policy*, *17*, 436–441.

Kimber, J., Dolan, K., van Beek, I., Hedrich, D., & Zurhold, H. (2003). Drug consumption facilities: An update since 2000. *Drug and Alcohol Review*, *22*, 227–233.

Kimber, J., Dolan, K., & Wodak, A. (2005). A survey of drug consumption rooms: Service delivery and perceived public health and amenity impact. *Drug and Alcohol Review*, *24*, 21–24.

Kleinig, J. (2006). Thinking ethically about needle and syringe programs. *Substance Use and Misuse*, *41*, 815–825.

Laufer, F. N. (2001). Cost-effectiveness of syringe exchanges as an HIV prevention strategy. *Journal of Acquired Immune Deficiency Syndromes*, *28*, 273–278.

Lert, F., & Kazatchkine, M. D. (2007). Antiretroviral HIV treatment and care for injecting drug users: An evidence-based overview. *International Journal of Drug Policy*, *18*(4), 255–261.

Lurie, P., Reingold, A. L., Bowser, B., Chen, D., Foley, J., Guydish, J., et al. (1993). *The public health impact of needle exchange programs in the United States and abroad: Summary conclusions and recommendations*. Berkeley, CA: School of Public Health, University of California.

MSIC Evaluation Committee (2003). *Final report on the evaluation of the Sydney Medically Supervised Injecting Centre*. Sydney: Authors.

McClean, M. E. (2002). *Vancouver drug use epidemiology–2001: Vancouver and BC Site Report for the Canadian Community Epidemiology Network on Drug Use*. Vancouver, BC: Vancouver–Richmond Health Board.

Miller TR, Cohen MA, Wiersema B (1996). *Victim costs and consequences: A new look*. Research report. NCJ 155282. Washington, DC: U.S. Department of Justice, National Institute of Justice.

Petrar, S., Kerr, T., Tyndall, M. W., Zhang, R., Montaner, J. S. G., & Wood, E. (2007). Injection drug users' perceptions regarding use of a medically supervised safer injection facility. *Addictive Behaviors*, *32*, 1088–1093.

Pinkerton, S. D., & Holtgrave, D. R. (1998). Assessing the cost-effectiveness of HIV prevention interventions: A primer. In D. R. Holtgrave (Ed.), *Handbook of economic evaluation of HIV programs* (pp. 33–43). New York, NY: Plenum.

Rehm, J., Ballunas, D., Brochu, S., Fischer, B., Gnam, W., Patra, J., et al. (2006). *The costs of substance abuse in Canada 2002, highlights*. Ottawa, ON: Canadian Centre on Substance Abuse.

Siegel, J. E., Weinstein, M. C., & Fineberg, H. V. (1991). Bleach programs for preventing AIDS among IV drug users: Modelling the impact of HIV prevalence. *American Journal of Public Health*, *81*, 1273–1279.

Single, E., Robson, L., Xie, X., & Rehm, J. (1996). *The costs of substance abuse in Canada 1992, highlights*. Ottawa, ON: Canadian Centre on Substance Abuse.

Tyndall, M. W., Currie, S., Spittal, P., Li, K., Wood, E., O'Shaughnessy, M. V., et al. (2003). Intensive injection cocaine use as the primary risk factor in the Vancouver HIV-1 epidemic. *AIDS*, *17*, 887–893.

Tyndall, M. W., Kerr, T., Zhang, R., King, E., Montaner, J. G., & Wood, E. (2006). Attendance, drug use patterns, and referrals made from North America's first supervised injection facility. *Drug and Alcohol Dependence*, *83*, 193–198.

Tyndall, M. W., Wood, E., Zhang, R., Lai, C., Montaner, J. S. G., & Kerr, T. (2006). HIV seroprevalence along participants of a supervised injection facility in Vancouver, Canada. *Harm Reduction Journal*, *3*, 36–40.

Vancouver Coastal Health (2007). Insite–Supervised Injection Site–Health Services–Vancouver Coastal Health, Vancouver, Canada. Retrieved 01 December 2007 from http://www.vch.ca/sis/.

Vlahov, D., & Junge, B. (1998). The role of needle exchange programs in HIV prevention. *Public Health Reports*, *113*(Suppl. 1), 75–80.

Watters, J., Estilo, M., Clark, G., & Lorvick, J. (1994). Syringe and needle exchange as HIV/AIDS prevention for injection drug users. *Journal of the American Medical Association*, *271*, 115–120.

Wood, E., Tyndall, M. W., Spittal, P. M., Li, K., Kerr, T., Hogg, R. S., et al. (2001). Unsafe injection practices in a cohort of injection drug users in Vancouver: Could safer injecting rooms help? *Canadian Medical Association Journal*, *165*, 405–410.

Wood, E., Tyndall, M. W., Stoltz, J., Small, W., Lloyd-Smith, E., Zhang, R., et al. (2005). Factors associated with syringe sharing among users of a medically supervised safer injecting facility. *American Journal of Infectious Diseases*, *1*, 50–54.

Wood, E., Tyndall, M. W., Zhang, R., Stoltz, J., Lai, C., Montaner, J. S. G., et al. (2006). Attendance of supervised injecting facilities and use of detoxification services. *New England Journal of Medicine*, *354*, 2512–2514.