The Potential Role for Supervised Injection Facilities in Canada’s Largest City, Toronto

Ehsan Jozaghi1 and Andrew A. Reid1

Abstract
Supervised injection facilities (SIFs) or supervised consumption rooms are a component of harm reduction strategies that attempt to reduce drug overdoses and risky injection behaviors among injection drug users. The purpose of this study is to determine whether expanding SIFs into the City of Toronto, Ontario, would be a fiscally responsible decision. By analyzing secondary data gathered in 2013, this article relies on mathematical models to estimate the number of new HIV and hepatitis C virus infections prevented as a result of SIF locations in Toronto. After factoring in the costs associated with SIFs, the models produce cost–benefit and cost-effectiveness outputs. With very conservative estimates, it is predicted that establishing SIF locations in Toronto is cost effective with an average benefit–cost ratio of 1:1.2 for the first two facilities based on the sensitivity analysis at 30% sharing rate. Consequently, funding SIFs in Canada’s largest city appears to be an efficient and effective use of financial resources in the public health domain with cost savings in excess of CAN$728,620 per year for the first two facilities.

Keywords
supervised injection facility, supervised consumption rooms, cost–benefit, cost-effectiveness, injection drug users

Introduction
The injection of illicit drugs is associated with many serious health concerns. Drug overdose and diseases such as human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) and hepatitis C virus (HCV), for example, have been found to be among the leading causes of death for people who inject drugs (Mathers et al., 2013). In addition, high rates of abscess, endocarditis, and osteomyelitis have been found among injection drug user (IDU) populations

1 School of Criminology, Simon Fraser University, Burnaby, British Columbia, Canada

Corresponding Author:
Ehsan Jozaghi, School of Criminology, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia, Canada V5A 1S6.
Email: eja2@sfu.ca
Rachlis et al., 2010; Reddon et al., 2011). These consequences are troubling given that globally, approximately 16 million people inject drugs (World Health Organization, 2013). In recognizing the size and scope of health issues among IDU populations, many jurisdictions around the world have developed harm reduction strategies in attempts to reduce risky injection behaviors.

Since 2009, 92 supervised injection facilities (SIFs) have been opened in 61 cities from around the world (Dooling & Rachlis, 2010; Hyshka, Bubela, & Wild, 2013; McKnight, 2011). Currently in North America, however, there is only one government-sanctioned SIF. Insite, a small facility in Vancouver’s Downtown Eastside (DTES), has been in operation since 2003 (Jozaghi & Andresen, 2013). Insite currently operates under an exception to the Controlled Drug and Substances Act and is required to abide by strict regulations (Kerr, Small, Moore, & Wood, 2007). All clients are required to register with the facility and are further forbidden to share substances or assist during injections (Kerr et al., 2007). Moreover, during each visit, clients are encouraged to consult nurses, doctors, and social workers who are employed in the facility (Fast, Small, Wood, & Kerr, 2008).

Clients who register at the front desk are then called by their registration name to inject their pre-obtained illicit drugs under supervision of registered nurses. At the injection booth, the clients have access to harm reduction supplies such as sterile syringes, water, and cookers (Wood et al., 2005). In addition, in the chill lounge, the clients have access to coffee, juice, water, food, and access to emergency care in case of drug overdose (Wood et al., 2005). The facility also operates a detox center upstairs and makes referrals to other detox centers in the region. Since opening, Insite has been examined by more than 60 peer-reviewed studies with the vast majority revealing positive impacts of its operation. In fact, Insite has been found to reduce needle sharing, reduce overdose deaths, and improve service uptake and public order within the DTES (Kerr et al., 2003; Kerr, Tyndall, Li, Montaner, & Wood, 2005; Marshall, Milloy, Wood, Montaner, & Kerr, 2011). In addition, the facility has been found to be cost effective, providing a net saving to the publicly funded health care system (Andresen & Boyd, 2010; Andresen & Jozaghi, 2012; Bayoumi & Zaric, 2008; Pinkerton, 2010, 2011).

Vancouver’s DTES is not the only community in Canada, however, with a significant population of IDUs. It is estimated that Canada has approximately 125,000 IDUs, many of whom reside in major city centers such as Toronto, Montreal, and Ottawa (Jozaghi, 2012). With the demonstrated success of facilities such as Insite, an obvious public policy question is: Should other city centers in Canada open SIFs? This is not a simple question, however, given that jurisdictions across the country vary considerably with respect to their IDU populations, patterns of drug use practices, and systems of health care provision. As a result, empirical research should demonstrate the need, the likelihood and magnitude of successful impact, and the economic viability of SIFs for every potential expansion.

Interestingly, Canada’s largest urban metropolis, Toronto, has not been found to have indicators of problematic injection drug use that greatly exceed other large city centers. In fact,

[t]here is research evidence of significant declines in sharing of both needles and other injection equipment in Toronto since the early 1990’s. Toronto has also experienced a stable prevalence of HIV infection, indicating that although new HIV infections occurred, they have not outpaced the numbers of deaths and dropouts from injecting. (Millson, Leonard, Remis, Strike, & Challacombe, 2004, p. 11)

Researchers have suggested that this pattern may be attributable to differences in needle exchange policies. A comparison of needle exchange policies between Toronto and Ottawa, for example, found that

the lower HIV and HCV prevalence in Toronto may be linked to early initiation of services, including outreach and peer workers, relatively decentralized services, and especially with relatively liberal
exchange policies (not requiring 1:1 exchange, no limits on numbers of needles exchanged) and distribution of other injection materials (sterile water, filters, cookers). (Millson et al., 2004, pp. 11–12)

Despite these relatively improved conditions, and lower prevalence of HIV and HCV, a team of University of Toronto researchers conducted a study that concluded the operation of three SIFs in Toronto would prevent the spread of HCV and HIV, save money, and further reduce sharing of needles within the IDU population (Moses, 2000). Similar to Bayoumi and Zaric (2008), the Bayoumi and Strike’s (2012) study employed a complex dynamic compartmental simulation model that accounted for a wide range of variables. Bayoumi and Strike’s Toronto costing study projected the prevention of 2–3 HIV cases and a modest 15–20 cases of HCV per facility.

The difference between Bayoumi and Strike’s (2012) research and the current study, however, is the mathematical model used. Bayoumi and Strike’s study used a complex dynamic compartmental simulation model that incorporated coinfections, smoking-related drug use, and the proportion receiving methadone. While the model proposed by Bayoumi and Strike was comprehensive in terms of its design and specification, it is argued here that the inclusion of variables such as smoking-related drug use is not directly related to the intended purpose of an SIF and thus, make it difficult to tease out the effect of proposed SIFs. This is especially true since the relationship between the transmission of blood-borne infections and the practices of sharing smoking paraphernalia is not well understood (Jozaghi, 2014; McNeil, Kerr, Lampkin, & Small, 2015). In addition, a static model with fewer variables can be more compelling (and potentially accurate) to policy makers who must understand the “science” behind empirical research.

In fact, the complex model used by Bayoumi and Zaric (2008) and Bayoumi and Strike (2012) has raised concern among researchers with respect to its practicality in predicting real cases of HIV and HCV (Des Jarlais, Arasteh, & Hagan, 2008; Jozaghi, Reid, & Andresen, 2013). More simple mathematical models utilized by previous costing studies such as Andresen and Boyd (2010), Pinkerton (2011), Jozaghi, Reid, and Andresen (2013), Jozaghi, Reid, Andresen, and Juneau (2014), and Jozaghi (2014) have proven reliable in predicting real blood-borne infections, as they relate to known HIV and HCV occurrences. This is also true with respect to calculations made by other authors such as Des Jarlais, Arasteh, and Hagan (2008).

As a result, the current study examines if opening SIFs in Toronto would be an effective use of fiscal resources and differs from the Bayoumi and Strike (2012) analysis with respect to the mathematical model and sensitivity analysis used. This is done by conducting cost–benefit and cost-effectiveness analyses for operating an SIF in the Toronto area. Specifically, the costs of operating an SIF in Toronto are compared to the savings incurred by the health care system after accounting for the prevention of new HIV and HCV infections. Further, sensitivity analyses are used to determine the optimal number of SIFs if it is found that the operation of at least one would be cost effective. The section that follows presents a discussion of related research, including previous studies that have assessed the economic viability of SIFs in Canadian jurisdictions. Subsequently, the methods, results, discussion, and conclusions of the current study are presented.

Related Research

Convinced of the economic viability of the Insite facility, some researchers have gone on to assess whether its services should be expanded. Andresen and Jozaghi (2012), for example, used a mathematical model to assess the economic practicality of expanding Insite in terms of its stand-alone operating capacity and the potential for further SIFs in the city of Vancouver. Although increased hours and expanded service delivery by the current facility would produce moderate benefits, they found that the establishment of additional SIFs in other areas of Vancouver would produce a greater impact and easily justifiable economic feasibility. In fact, the benefit–cost ratios supported
the expansion of up to five additional SIFs. This was consistent with the Jozaghi and Andresen (2013) study that reported on findings from 31 in-depth interviews conducted with IDUs from the cities of Vancouver, Surrey, and Victoria in British Columbia. The authors of that study concluded that Insite’s current operations failed to meet the needs of the entire IDU population in Vancouver (Jozaghi & Andresen, 2013).

Vancouver is, however, only one of many urban centers in Canada and although it has received a lot of attention because of the Insite facility, recent research has extended beyond this location. Jozaghi et al. (2013), for example, conducted a cost–benefit/cost-effectiveness analysis of proposed SIFs in the City of Montreal. In that study, the authors estimated the number of new HIV and HCV infections that would be averted with the establishment of SIFs in the city. They found that an annual net cost saving of CAN$686,000 (HIV) and CAN$800,000 (HCV) would be expected for each additional SIF that was opened in the city. By including several SIF operation scenarios, the authors were able to assess the threshold for diminishing returns. Jozaghi et al. found that cost savings could be expected with the expansion of up to three SIFs in Montreal.

More recently, Jozaghi et al. (2014) conducted similar analyses to assess the economic viability of opening SIFs in Ottawa. Producing two separate mathematic models and a sensitivity analysis, the authors found that the marginal annual cost model supported a single SIF and the cumulative annual cost model supported two SIFs. In terms of HCV, their analysis projected 48–191 prevented cases resulting in a cost saving of CAN$45,475 for the first facility. The savings were more modest for HIV, preventing 15–19 HIV cases resulting in a cost savings of $436,560 for the first facility. Importantly, the authors note that when factoring in the prevention of HIV or HCV, alone, the models rarely produced results that supported the establishment of SIFs. When considering the prevention of both HIV and HCV, however, both models supported the establishment of SIFs in the city.

With these recent positive projections, natural questions arise: Are SIFs an economically viable option for other major cities in Canada? With respect to this study specifically, are SIFs a cost-effective harm reduction strategy for Toronto, Ontario, where the prevalence of HIV and HCV have been estimated to be lower than other major cities in Canada? Similar to the recent costing studies noted previously, the current study uses two mathematical models and a sensitivity analysis to predict the number of HIV and HCV cases that would be prevented with the establishment of SIFs in Toronto. The cost savings accrued by the prevention of new cases of HIV and HCV are compared to the operational cost of running a potential SIF in the city. The analysis is then expanded to consider the impact of opening additional SIFs in Toronto. This issue is of critical importance because the Canadian Federal Government has recently established new legislation, Bill C-65 (now called Bill C-2): The Respect for Communities Act, requiring evidence of the economic viability for proposed SIFs (Jozaghi, in press). Given that only one such study has been conducted for the City of Toronto and that study produced a complex dynamic mathematical model that considered a comprehensive collection of variables making it difficult to replicate, the current study offers a more practical alternative using a simple, static model.

**Method**

**Models**

For the purposes of this study, two different models (Jacobs et al., 1999; Kaplan & O’Keefe, 1993) were used to evaluate the fiscal impact of opening potential SIFs in the City of Toronto, Ontario. Both models were used for two primary reasons. First, both of these models are commonly used in the cost–benefit and/or cost-effectiveness empirical literature. Second, using two models allows for a sensitivity analysis to see if one model is more realistic in its predictions, knowing the local conditions of the study area. The variable values and sources for each are listed in Table 1. Both
models also consider the effects of providing clean injection equipment and adopting safer injecting behaviors within its scope of calculation. Two different mathematical models were employed to estimate the number of HIV cases prevented as a result of the hypothetical establishment of SIFs in Toronto.

The first model was initially used in an evaluation of Edmonton, Alberta’s needle exchange program (Jacobs et al., 1999). Later, the model was used in economic evaluations of Insite (Andresen & Boyd, 2010; Andresen & Jozaghi, 2012). In addition, the model has been used to estimate the cost–benefit/cost-effectiveness of potential SIFs in Montreal, Quebec (Jozaghi et al., 2013), Ottawa, Ontario (Jozaghi, Reid, Andresen, & Juneau, 2014), and recently an unsanctioned inhalation facility in Vancouver’s DTES (Jozaghi, 2014). The number of new HIV infections averted, \(A\), is calculated as follows:

\[
\text{New HIV infections}(A) = INsd[1 - (1 - qt)^m],
\]

where \(d\) is the percentage of needles not cleaned before use, \(N\) is the number of needles in circulation, \(q\) is the HIV prevalence in the IDU population, \(I\) is the population of people who inject drugs and are HIV seronegative, \(s\) is the rates of needle sharing, \(t\) is the probability of HIV transmission when using an HIV-infected needle, and \(m\) is the number of sharing partners per shared needle.

The second model was originally used in an evaluation of the New Haven, Connecticut, needle depot (Kaplan & O’Keefe, 1993). The model was later used in an economic evaluation of Insite (Andresen & Boyd, 2010). The number of new HIV infections avoided, \(B\), is calculated as follows:

\[
\text{New HIV infection rate}(B) = (1 - \pi)\lambda(1 - \theta)\beta\alpha,
\]

where \(\beta\) is the percentage of HIV-infected needles, \(\lambda\) is the rate of needle sharing, \(\pi\) is the prevalence of HIV infections in the neighborhood, \(\alpha\) is the probability of acquiring HIV or HCV from a single injection with contaminated syringe, and \(\theta\) is the probability that a borrowed syringe is decontaminated. To calculate the number of HIV using the second model, the researcher multiplied the incidence by the number of IDUs in order to determine how many IDUs would be infected with HIV.

The population of IDUs in Toronto has been estimated to be as high as 25,000 (Appleby, 2011). However, a lower estimate of 10,000 was chosen since this number represents the lower estimate reported by Bayoumi and Strike (2012). Also, when values for calculations were not reported in

Table 1. Sources for Variables Used in Mathematical Modeling.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Source</th>
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<tbody>
<tr>
<td>Proportion of IDUs HIV- (I)</td>
<td>96.00%</td>
<td>Bayoumi and Strike (2012)</td>
</tr>
<tr>
<td>Rate of needle sharing (s) or (L)</td>
<td>20%</td>
<td>Bayoumi and Strike (2012)</td>
</tr>
<tr>
<td>Number of needles in circulation (N)</td>
<td>800,000</td>
<td>Ontario Harm Reduction Program (2013); Millson, Leonard, Remis, Strike, and Challacombe (2004)</td>
</tr>
<tr>
<td>Percentage of needles not cleaned (d)</td>
<td>17.00%</td>
<td>Kaplan and O’Keefe (1993); Jacobs et al. (1999)</td>
</tr>
<tr>
<td>Probability of HIV infections from a single injection (I) or ((\alpha))</td>
<td>0.67%</td>
<td>Kaplan and O’Keefe (1993)</td>
</tr>
<tr>
<td>Number of sharing partners (m)</td>
<td>1.38</td>
<td>Jacobs et al. (1999)</td>
</tr>
<tr>
<td>Proportion of IDUs HIV+ (q) or ((\pi))</td>
<td>4.00%</td>
<td>Bayoumi and Strike (2012)</td>
</tr>
<tr>
<td>Proportion IDUs HCV- (I)</td>
<td>30.00%</td>
<td>Bayoumi and Strike (2012)</td>
</tr>
<tr>
<td>Proportion of IDUs HCV+ (q)</td>
<td>70.00%</td>
<td>Bayoumi and Strike (2012)</td>
</tr>
<tr>
<td>Probability of HCV infection from single injection (I)</td>
<td>3%</td>
<td>Gore and Bird (1998)</td>
</tr>
<tr>
<td>Proportion of HIV infected needles ((\beta))</td>
<td>40.50%</td>
<td>Kaplan and O’Keefe (1993)</td>
</tr>
<tr>
<td>Probability of needles cleaned (I)</td>
<td>83%</td>
<td>Kaplan and O’Keefe (1993); Jacobs et al. (1999)</td>
</tr>
</tbody>
</table>

Note. HCV = hepatitis C virus; IDU = injection drug user.
published studies, such as total injections within Toronto as a whole, several values were combined to estimate that there are 9.13 million injections (e.g., 10,000 IDUs × 913 injections per year; Holgrave, Pinkerton, Jones, Lurie, & Vlahov, 1998; Jacobs et al., 1999; Laufer, 2001; McClean, 2002). This number called $V$ was later multiplied by the initial sharing rate to determine the number of shared injections in the City of Toronto.

In addition, since there was no reported value for the number of needles in circulation, this value was calculated based on the total number of IDUs in the province of Ontario (41,000) reported in Millson, Leonard, Remis, Strike, and Challacombe (2004) and total number of needles in circulation in Ontario (3,200,000), as reported by the Ontario Harm Reduction Program (2013) where it was estimated to be 800,000 (e.g., [10,000 population of IDUs in Toronto × 3,200,000 needles in circulation in Ontario]/[41,000 population of IDUs in Ontario]). In addition, it was assumed that the potential SIF in Toronto would contain the same number of booths for injection operating 24 hr per day. As result, this number was calculated to be 315,360 injections per year ($Y$; e.g., 12 booths × 3 injection per hour $1 \times 24 \text{ hr} \times 365 \text{ days}$). $Y$ was also multiplied by the sharing rate to determine averted shared injections ($Z$). Later, after taking into consideration the odds ratio (0.3), $V$ was added to $Z$ to determine the total averted cases of sharing in the City of Toronto. The rates without an SIF, followed by the rate with an SIF, and then the difference were calculated. This method was repeated with increased numbers of SIFS.

**Variables and Parameters**

Medical and scientific literature was used to obtain estimates when specific data for the City of Toronto were not available. To make the estimates conservative, selection preference was given to lower bound estimates when several estimates were available.

At its basis, the cost-effectiveness and cost–benefit analyses of this study relied on the number of HIV and HCV infections prevented. Previous costing studies have shown that it is reasonable to assume that SIFs are able to prevent shared or “dirty” injections (Andresen & Boyd, 2010; Andresen & Jozaghi, 2012; Jozaghi & Andresen, 2013; Pinkerton, 2010). Behavioral changes for those who attend SIF have been highlighted as an important factor in previous literature as well (Andresen & Boyd, 2010; Andresen & Jozaghi, 2012; Bayoumi & Zaric, 2008; Jozaghi et al., 2013; Jozaghi et al., 2014). More specifically, the clientele of an SIF in Europe and Vancouver have shown lower risk of sharing their syringes with others (Kerr et al., 2005; Bravo et al., 2009). In fact, clientele of an SIF will share their needles outside of the facility at a 30% lower rate than those who do not visit an SIF (Kerr et al., 2005; Bravo et al., 2009). Similar to previous costing studies, the current study employs an odds ratio of 0.3 for behavioral change (Andresen & Boyd, 2010; Andresen & Jozaghi, 2012; Bayoumi & Strike, 2012; Bayoumi & Zaric, 2008; Jozaghi et al., 2013; Jozaghi et al., 2014). This odds ratio ($OR$) has the following mathematical formula:

$$OR = \left( \frac{q}{1 - q} \right) \left/ \left( \frac{p}{1 - p} \right) \right.$$

where $q$ is the post-intervention probability and $p$ is the baseline probability. This study assumed that clients of an SIF in Toronto would have the same odds ratio of sharing as those using the site in Vancouver. Since we cannot expect all IDUs to start utilizing SIFs and eventually alter their injecting behavior, similar to Andresen and Boyd (2010), Andresen and Jozaghi (2012), Jozaghi et al. (2013), and Jozaghi et al. (2014), an odds ratio of 0.3 was only employed twice (for the first and second SIFs only).

The current study also assumed that, based on the participation rate at Insite reported in Andresen and Boyd (2010), 34% of the IDU population would utilize the potential SIF in Toronto. The rate of needle sharing was derived from the previous costing study of potential SIF in Toronto (Bayoumi &
Strike, 2012), where it was defined that 20% of IDUs shared needles in the past year. The ultimate objective of this article is to calculate a cost–benefit for each successive expansion of SIF. These expansions include the assumption that the potential SIFs will operate for 24 hr a day. Expansion at the margin and cumulative (benefit–cost ratio) is calculated for each successive expansion.

The Medical Cost of New HIV and HCV Cases

The lifetime cost savings from avoided cases of HIV is substantial. For example, some studies have placed the cost savings at CAN$289,970 (see, e.g., Werb et al., 2011). Some Canadian studies have varied substantially in their estimation of the life cost treatment of HIV ranging from CAN$174,410 to CAN$667,000 for the very expensive highly active antiretroviral therapy (HAART) program (Albert, Williams, Legowski, & Remis, 1998). However, recognizing that IDUs may experience societal limitations or certain self-imposed barriers, a value of CAN$210,555 was chosen (Martin et al., 2012). In other words, IDUs are less likely to benefit from the more expensive and very successful multidrug combinations of HAART for HIV treatment (Chen et al., 2006; Holtgrave & Pinkerton, 1997). Some researchers attribute this phenomena to the intensive regime and low adherence rate within the IDU population (Chen et al., 2006; Holtgrave & Pinkerton, 1997). This value is chosen because it is based on the most recent research in this area that seems to be more realistic in estimating the potential cost of HIV (Andresen & Jozaghi, 2012; Jozaghi et al., 2013; Jozaghi et al., 2014).

The costing studies in the realm of HCV have ranged from CAN$20,000 per completed patient course of treatment (Krajden, Kuo, Zagorski, Yu, & Krahn, 2010) to CAN$30,000 (National Centre in HIV Epidemiology and Clinical Research, 2010; Werb et al., 2011) to more than CAN$69,188 (Martin et al., 2012). However, this article uses $35,143 (2013 CAN Dollars), the same as that adopted in Jozaghi et al. (2013), Jozaghi et al. (2014), and National Centre in HIV Epidemiology and Clinical Research (2010) because these recent studies are more conservative and realistic regarding the complications arising from HCV (e.g., by not considering the costs for liver failure, hepatocellular carcinoma, and liver transplant cases). The value of HIV and HCV are based on per patient lifetime cost of treatment.

Cost of SIFs

In order to estimate the cost of establishing SIFs in Toronto, the current study drew data from Insite, the only available comparison facility in North America. Insite’s total annual operating cost was estimated to be CAN$3 million (Andresen & Jozaghi, 2012; Jozaghi et al., 2013; Jozaghi et al., 2014; Tyndalla, 2006; Pinkerton, 2010). The $3 million figure included public health screening (immunization and diagnostic), addiction counseling, primary health care, peer counseling, education, housing services, and case management (Health Canada, 2008; Jozaghi et al., 2013; Jozaghi et al., 2014; Pinkerton, 2010). If the annual operating cost of Insite only considers staff salaries, ancillary equipment (e.g., insulin syringes with attached needles, bottles of sterile water for injection, latex condoms, alcohol swaps, and cost of disposal of used syringes), property rental, and equipment purchases, then the estimated cost is approximately CAN$1.53 million (Andresen & Jozaghi, 2012; Jozaghi et al., 2013; Jozaghi et al., 2014). However, when an Insite expansion from 18 hr to 24 hr is considered, the operational cost of Insite reaches $2.182 million (2012 dollars)—a one third increase in the hours of operation (Andresen & Jozaghi, 2012). Consequently, in line with Jozaghi et al. (2013), Bayoumi and Strike (2012), and Jozaghi et al. (2014), for each potential SIF in Toronto, a total of CAN$2.182 million is considered. For simplicity, we assume that the Toronto SIFs would provide the same staff salaries, have similar costs associated with property rental and equipment purchases overall, and have the same service provision as in the Vancouver SIF.
Results

Both models, based on the needle-sharing rate, predicted the number of HIV cases prevented. The first model also predicted the number of HCV cases prevented. Tables 2 and 3 demonstrate that increasing the scope of SIFs increases the number of HIV and HCV prevented. However, these increases are not enough to cover the cost of the program.

The model predicts that the number of cases averted would be 2–5 for HIV and 41–122 for HCV, with the marginal range being much smaller: 0.4–2 for HIV and 9–41 for HCV. Marginal costs and benefits are measurements for producing one more unit. In contrast, the cumulative benefits and cost are the running total of benefit and cost with each successive unit.

As outlined in Tables 2 and 3, there is a substantial difference between the economic evaluation of SIFs with respect to the cumulative (the total impact of SIFs considered) versus marginal estimates (the impact of adding more SIF). Benefit–cost ratios range from 0.2 to 0.07 and cost-effectiveness values range from $1,091,400 to $3,055,920 (cost per lifetime treatment). The cumulative annual estimates of new HCV cases averted translate into cumulative benefit–cost ratios that range from 0.7 to 0.3, and incremental cost-effectiveness values range from $53,239 to $125,343 (cost per lifetime treatment). In contrast, the marginal estimates of Toronto’s SIF expansion translate into a much smaller return. This is particularly true with respect to its benefit–cost and cost-effectiveness ratios.

Furthermore, Tables 2 and 3 show that based on cost-effectiveness and benefit–cost ratios, establishment of an SIF may not be economically viable. However, sensitivity analysis conducted for the model demonstrated that the establishment of SIFs saves tax payer’s money. The sensitivity analysis employed different initial needle-sharing rates (see Tables 2 and 3). Similar to Andresen and Boyd (2010), Andresen and Jozaghi (2012), Bayoumi and Strike (2012), Jozaghi et al. (2013), and Jozaghi et al. (2014), the current analysis used 10% and 30% initial needle-sharing rates.

This article used the second mathematical model as a secondary sensitivity analysis (see Table 4). Therefore, based on the first and second model, establishing at least two SIFs in Toronto is cost-effective. On average, benefit-to-cost ratios are never below unity for the first two facilities with an average of 1.1.

Discussion

This analysis reviewed the literature on the potential of expanding SIFs in Toronto and applied economic analyses to determine whether operating SIFs would represent an efficient use of scarce public resources. Based on the number of HIV and HCV cases averted owing to the provision of clean injecting equipment and safer injecting behaviors, additional SIFs would be a good value for the resources they consume if the higher sharing rate were considered, or the HIV prevalence rate were at a higher rate. The sensitivity analysis conducted for the model demonstrated that establishing at least two SIFs does in fact save tax payer’s money. The results presented here suggest that establishing SIFs in Toronto will benefit the publicly funded health care system. Although these cost savings only become apparent after the sensitivity analysis, they are still considered accurate because every costing study is based on a number of assumptions that may bring some forms of uncertainties into the analysis (Jain, Grabner, & Onukwugha, 2011).

Sensitivity analysis in this study has facilitated ways to evaluate and measure this uncertainty. Specific sources of uncertainty in this analysis have been attributed to a number of factors that have reduced the overall benefits. For instance, not included in this calculation were the potential cost savings for the prevention of overdose deaths, cellulitis, subcutaneous abscesses, endocarditis, and incidence of soft-tissue infections. Furthermore, we did not consider the benefits of reduced discarded syringes in public. We also did not consider the secondary HIV transmission through sexual transmission or the quality-adjusted life years.
Table 2. The Cumulative Annual Cost—Effectiveness and Benefit–Cost of SIF in Toronto Using the First Model.

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<tbody>
<tr>
<td>Post SIFs</td>
<td>$2,182,800</td>
<td>17% (25%, 8%)</td>
<td>2 (3, 1)</td>
<td>41 (61, 21)</td>
<td>$53,239 ($35,784, $103,943)</td>
<td>$1,091,400 ($727,600, $2,182,800)</td>
<td>0.7 (1, 0.3)</td>
<td>0.2 (0.3, 0.1)</td>
<td>0.85 (1.2, 0.4)</td>
</tr>
<tr>
<td>Two SIFs</td>
<td>$4,365,600</td>
<td>14% (20%, 7%)</td>
<td>4 (5, 2)</td>
<td>77 (115, 38)</td>
<td>$56,696 ($37,961, $114,884)</td>
<td>$1,091,400 ($873,120, $2,182,800)</td>
<td>0.6 (0.9, 0.3)</td>
<td>0.2 (0.2, 0.1)</td>
<td>0.81 (1.1, 0.4)</td>
</tr>
<tr>
<td>Three SIFs</td>
<td>$6,548,400</td>
<td>13% (19%, 6%)</td>
<td>4 (5, 2)</td>
<td>85 (128, 42)</td>
<td>$77,040 ($51,159, $155,914)</td>
<td>$1,637,100 ($1,309,680, $3,274,200)</td>
<td>0.5 (0.7, 0.2)</td>
<td>0.1 (0.2, 0.06)</td>
<td>0.6 (0.8, 0.3)</td>
</tr>
<tr>
<td>Four SIFs</td>
<td>$8,731,200</td>
<td>12% (18%, 6%)</td>
<td>4 (6, 2)</td>
<td>95 (142, 47)</td>
<td>$91,907 ($61,487, $185,770)</td>
<td>$2,182,800 ($1,455,200, $4,365,600)</td>
<td>0.4 (0.6, 0.2)</td>
<td>0.1 (0.1, 0.05)</td>
<td>0.5 (0.7, 0.2)</td>
</tr>
<tr>
<td>Five SIFs</td>
<td>$10,914,000</td>
<td>11% (17%, 6%)</td>
<td>4 (6, 2)</td>
<td>104 (156, 52)</td>
<td>$104,942 ($69,961, $209,885)</td>
<td>$2,728,500 ($1,819,000, $5,457,000)</td>
<td>0.3 (0.5, 0.2)</td>
<td>0.08 (0.1, 0.04)</td>
<td>0.4 (0.6, 0.2)</td>
</tr>
<tr>
<td>Six SIFs</td>
<td>$13,096,800</td>
<td>10% (16%, 5%)</td>
<td>5 (7, 2)</td>
<td>113 (164, 57)</td>
<td>$115,900 ($79,858, $229,768)</td>
<td>$2,619,360 ($1,870,971, $6,548,400)</td>
<td>0.3 (0.4, 0.1)</td>
<td>0.08 (0.1, 0.03)</td>
<td>0.4 (0.5, 0.1)</td>
</tr>
<tr>
<td>Seven SIFs</td>
<td>$15,279,600</td>
<td>9% (15%, 5%)</td>
<td>5 (7, 3)</td>
<td>122 (182, 61)</td>
<td>$125,243 ($83,953, $250,485)</td>
<td>$3,055,920 ($2,182,800, $5,093,200)</td>
<td>0.3 (0.4, 0.1)</td>
<td>0.07 (0.1, 0.04)</td>
<td>0.3 (0.5, 0.1)</td>
</tr>
<tr>
<td>Average</td>
<td>$8,731,200</td>
<td>12% (18%, 6%)</td>
<td>4 (6, 2)</td>
<td>91 (135, 45)</td>
<td>$89,281 ($60,023, $178,664)</td>
<td>$2,058,068 ($1,462,624, $4,157,714)</td>
<td>0.44 (0.6, 0.2)</td>
<td>0.12 (0.2, 0.06)</td>
<td>0.4 (0.7, 0.2)</td>
</tr>
</tbody>
</table>

Note. The numbers in parentheses represent the results of the sensitivity analysis: (30% sharing rate, 10% sharing rate). SIF = supervised injection facility; HCV = hepatitis C virus.

Table 3. The Marginal Annual Cost—Effectiveness and Benefit–Cost of SIF in Toronto Using the First Model.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Post SIFs</td>
<td>$2,182,800</td>
<td>17% (25%, 8%)</td>
<td>2 (3, 1)</td>
<td>41 (61, 21)</td>
<td>$53,239 ($35,784, $103,943)</td>
<td>$1,091,400 ($727,600, $2,182,800)</td>
<td>0.7 (1, 0.3)</td>
<td>0.2 (0.3, 0.1)</td>
<td>0.9 (1.3, 0.4)</td>
</tr>
<tr>
<td>Two SIFs</td>
<td>$2,182,800</td>
<td>14% (20%, 7%)</td>
<td>2 (2, 1)</td>
<td>36 (54, 18)</td>
<td>$60,633 ($40,422, $121,267)</td>
<td>$1,091,400 ($1,091,400, $2,182,800)</td>
<td>0.6 (0.9, 0.3)</td>
<td>0.2 (0.2, 0.1)</td>
<td>0.7 (1.1, 0.4)</td>
</tr>
<tr>
<td>Three SIFs</td>
<td>$2,182,800</td>
<td>13% (19%, 6%)</td>
<td>0.4 (0.5, 0.2)</td>
<td>9 (13, 5)</td>
<td>$242,533 ($167,907, $436,560)</td>
<td>$5,474,500 ($4,365,600, $10,914,000)</td>
<td>0.1 (0.2, 0.08)</td>
<td>0.04 (0.05, 0.02)</td>
<td>0.2 (0.3, 0.1)</td>
</tr>
<tr>
<td>Four SIFs</td>
<td>$2,182,800</td>
<td>12% (18%, 6%)</td>
<td>0.4 (0.5, 0.2)</td>
<td>9 (14, 5)</td>
<td>$242,533 ($155,914, $436,560)</td>
<td>$5,474,500 ($4,365,600, $10,914,000)</td>
<td>0.1 (0.2, 0.08)</td>
<td>0.04 (0.05, 0.02)</td>
<td>0.2 (0.3, 0.1)</td>
</tr>
<tr>
<td>Five SIFs</td>
<td>$2,182,800</td>
<td>11% (17%, 6%)</td>
<td>0.4 (0.5, 0.2)</td>
<td>9 (14, 5)</td>
<td>$242,533 ($155,914, $436,560)</td>
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<td>0.04 (0.05, 0.02)</td>
<td>0.2 (0.3, 0.1)</td>
</tr>
<tr>
<td>Average</td>
<td>$2,182,800</td>
<td>13% (19%, 6%)</td>
<td>1 (1, 0.4)</td>
<td>17 (26, 9)</td>
<td>$189,505 ($123,967, $344,001)</td>
<td>$4,222,185 ($3,378,142, $8,419,371)</td>
<td>0.3 (0.4, 0.14)</td>
<td>0.08 (0.1, 0.04)</td>
<td>0.4 (0.5, 0.2)</td>
</tr>
</tbody>
</table>

Note. The numbers in parentheses represent the results of the sensitivity analysis: (30% sharing rate, 10% sharing rate). SIF = supervised injection facility; HCV = hepatitis C virus.
Instead, we focused on the most simple benefits of SIFs—needle distribution and behavioral change. In addition, the cost of operating an SIF is substantially higher because Vancouver is the most expensive real-estate market in Canada (Ley & Dobson, 2008). However, many of these sources of uncertainties are difficult to quantify due to lack of reliable data when it comes to factors such as cellulitis, subcutaneous abscesses, endocarditis, and incidence of soft-tissue infections and economic benefits of reduced discarded syringes in public. However, some of the variables that we employed were the lower bound estimates that could potentially increase the benefits. For example, instead of using 5.5% rate for the proportion IDUs who are HIV positive, we used 4.0% as shown in Table 1 (Millson et al., 2004). Moreover, the proportion of IDUs who are HCV positive has been reported to be as high as 85%, yet again we used a conservative estimate of 70% (Millson et al., 1994; Millson et al., 2004).

In addition, we used the IDU population reported by Bayoumi and Strike (2012)—10,000. However, some studies have estimated the population of Toronto’s IDU population to range from 11,600 to 16,500 (Millson et al., 2004; Remis et al., 1998). Finally, the rate of needle sharing has been reported to be as high as 40% in some epidemiological studies in the city of Toronto (Millson et al., 2004). Therefore, if we had not considered these conservative estimates in our baseline estimation, the number of HIV cases would have been 5 and number of HCV cases, 50. This would have produced a benefit–cost ratio of 1.3 for the first potential SIF at the baseline sharing rate. Consequently, regardless of the costing study, Bayoumi and Strike (2012) and the sensitivity analysis of the current study suggest that establishing SIFs in Toronto would save public funds.

However, the police department and the mayor of Toronto are against the idea (Blackwell & Alcoba, 2012; CTV, 2012). According to the Toronto Police chief, “these sites will threaten public safety” (Paperny, 2012). Furthermore, the province of Ontario is against SIFs (Roche, 2012). The federal government of Canada has also introduced legislation, Bill C-2, that will make it more difficult to maintain and open additional SIFs despite the overwhelming scientific evidence in Vancouver, supporting the need and operation of such facilities (Zlotorzynska, Wood, Montaner, & Kerr, 2013). Such government policy and attitudes toward IDUs prioritize the opinions of people such as police officers and members of the community “over the need to use effective measures to limit the spread of disease and save lives” (Zlotorzynska et al., 2013, p. 1303).

### Conclusion

In moving forward, instead of focusing on whether such facilities should be opened in Toronto, we should concentrate on how to facilitate the implementation of new SIFs in Toronto (Zlotorzynska et al., 2013). It is important to emphasize the potential role that the local health officials in Toronto...
could play in implementing such facilities based on the positive impact of SIFs such as reductions in public injections, infectious diseases, and overdose fatalities (Andresen & Boyd, 2010; Kerr et al., 2007; Marshall et al., 2011; Wood et al., 2005). Moreover, SIFs have contributed to public order and have not increased drug dealing, public injection, and public syringe disposal (Drucker, 2006; Hathaway & Tousaw, 2008; Stoltz et al., 2007). Consequently, “concerns that arise out of prejudice and ignorance for which there are no sound arguments should be set aside” (Zlotorzynska et al., 2013, p. 1304). It is our hope that the Canadian Conservative Government will reverse its opposition to SIFs when presented with overwhelming positive findings.

Declaration of Conflicting Interests
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Notes
1. This number was calculated based on the reported injection that takes place on daily basis at Insite (Tyndall et al., 2006). On average, 600 injections take place at Insite (Tyndall et al., 2006). This number is divided by 216 (12 booths × 18 hr) to get a ratio of three injections per hour at each booth.
2. Cost-effective ratio was calculated by dividing the cost of operations by the number of HIV/hepatitis C virus prevented. Cost–benefit ratio was calculated by dividing the cost savings by the cost of the operations.

References


**Author Biographies**

**Ehsan Jozaghi** is a PhD candidate in the School of Criminology at Simon Fraser University. His research interests include supervised injection facilities, social network analysis, evaluation, quantitative and qualitative methods. Ehsan has published numerous peer reviewed articles related to North America’s only supervised injection facility using qualitative and quantitative methods.

**Andrew A. Reid** is a Ph.D. student in the School of Criminology at Simon Fraser University. His Doctoral research is concerned with case processing patterns in British Columbia’s (BC) justice system. Andrew has published a number of articles in fields such as environmental criminology, crime prevention and complex systems modelling.