A Cost – Benefit and Cost – Effectiveness Analysis of Vancouver's Safe Injection Facility

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Executive Summary

The following study is an examination of the costs and benefits and cost-effectiveness of Vancouver's Supervised Injection Site (SIS). After a review of existing literature regarding both the efficacy of supervised injection sites generally, and Vancouver's site more specifically, we engaged in two kinds of analysis to determine benefit to cost ratios for the Vancouver SIS, and cost effectiveness: linear trend analysis and mathematical modelling. We were particularly interested in Insite's ability to impact HIV infections and overdose deaths, as we were able to obtain reliable temporal and spatial data for each of these two variables.

Linear trend analysis was hampered by the small number of observations that we could make post-Insite; the inability to demonstrate significant changes with a three year time line, post implementation, compromised the utility of trend analysis. Nonetheless, we did observe some positive changes post-Insite in rates of HIV infection within the three local health areas in Vancouver that are closest to Insite (a reduction in rates of HIV infection), and correspondingly negative changes in trends in the three local health areas of Vancouver most removed from Insite (an increase in rates of HIV infection). These

changes in trends did not, however, reach the point of statistical significance, and we are left with the observation that little can be concluded from a linear trend analysis of overdose deaths or HIV infections. Additionally, we were required to assume that new cases of HIV amount to a proxy for new HIV infections, and to assume a regional stability in rates of HIV transmission and corresponding rates of detection. In these circumstances any results from our linear trend analysis should be interpreted cautiously.

Mathematical modelling was much more usefully employed, as we have reliable data regarding the number of injection drug users in the area, the number of injections annually, both inside Insite and outside, the extent of HIV transmission, the rate of HIV infection, the rate of overdose death in the area, the extent of behavioural change produced by Insite, and the number of overdoses within Insite. In every instance we used highly conservative estimates, and we employed four different mathematical models that have been widely cited in the literature.

We were able to identify a range of ratios of benefits to cost, based on the four different models. The data suggest that Insite produces an annual return on its investment that varies between approximately one and four times its cost, based on the model employed, and the assumptions resident within that model. We stress that these ratios are substantial under-estimates of the benefit to cost ratios of Insite, as many of the likely benefits could not be factored into our equations because of incomplete data: we had no systematic method for calculation of improved health among users, resulting from increased access to detox and other treatment services, and we could not separate Insite's fixed costs from

its variable costs. Further, a number of expenses that are only tangentially related to the annual operation of Insite – addiction services, counselling, immunizations, and diagnostic services – are included in the calculations of annual costs provided by Vancouver Coastal Health. It must be stressed that our conclusions are, accordingly, based upon both an under-estimate of the full range of benefits, and an over-estimate of the annual costs of operation of the facility.

Our data suggest that both increases in the current operating hours for Insite, and the building of additional facilities of a similar kind would yield benefits much in excess of costs required for such projects. We also note, given these data, that facilities providing opiates for addicts (and hence avoiding many of the criminal justice system costs that could not be contemplated here) should be given serious consideration, given both the apparent success of such initiatives in a number of European jurisdictions, and the value added nature of the cost savings in such schemes. Finally, we note that our cost analysis of the SIS demonstrates that its benefit to cost ratios are very similar to those provided by other kinds of treatment for drug addiction – that Vancouver's SIS is properly thought of as one of many beneficial approaches for this complex problem.

1. 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 the corresponding life-threatening diseases often associated with that activity (HIV/AIDS and hepatitis B/C), the question of whether or not state health care should create programs to provide drugs and related materials to addicts (needles/syringes, cleaning kits, condoms, etc.) has emerged. The possibilities in this realm range from needle/syringe exchange programs (NEPs), to medically-prescribed drug use, and, more recently, to the provision of supervised injection or consumption facilities; the "traditional" modalities of imprisonment and various drug treatment programs remain, of course, as available options for addressing such drug use.

The provision of drugs and related materials faces a number of challenges. If the state health care system provides drugs and/or the related materials, critics argue that drug use may increase through the recruitment of new drug addicts and existing addicts, increasing usage and thereby leading to a greater level of drug use in the communities that provide such services. However, there is no evidence of these activities occurring where state care has established these programs (Des Jarlais et al. 1992; Lurie et al. 1993; Vlahov and Junge 1998; Watters et al. 1994). Regardless of this lack of evidence for increased drug use, these programs may be in direct violation of state and/or federal laws. In the case of needle/syringe distribution programs, the possession of a needle/syringe without a prescription is illegal in a number of U.S. states (Kaplan and O'Keefe 1993), and in the case of supervised injection facilities, exemptions from state

and/or federal law may be required for operation—the Vancouver safe injection facility, Insite, currently has such an exemption from Canada's Controlled Drugs and Substances Act (Vancouver Coastal Health 2007). As a consequence, the legal operation of these programs may be considered state-sanctioned illicit drug use, something that may be considered unacceptable by some governments. Additionally, though some members of a given jurisdiction may be able to use illicit drugs without threat of arrest in one location, others may be subject to the penalties of the criminal justice system for using the same (or less harmful drugs) in another location.

Many of the issues raised by these kinds of programs cannot be resolved in the present work, but there remains one issue that can be addressed: whether or not a supervised injection site creates a net benefit for society. This kind of program 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 program. Scarce resources in public health care must be allocated based on economic efficiency. For example, given the choice between two alternative programs for responding to illicit drug use, and assuming that health outcomes are the same for each program, the program with the least cost should be chosen. With regard to the possible violation of state and/or federal laws, there must be some justification for the removal of, or exemptions from those laws. If the net benefit to society is positive as a result of these programs, then we might wisely revisit the question of whether these laws provide a benefit for society.

To date, there have been no cost–effectiveness analyses or cost – benefit analyses of supervised injection facilities operating in a number of countries. This report, then, is the first such evaluation of Vancouver's supervised injection facility, Insite. The following section outlines some important concepts and issues regarding both cost – effectiveness and cost – benefit analyses. This is followed by two methodologies that attempt to calculate the number of new HIV infections prevented because of the establishment of Insite. Because of the high cost to the public health care system, the number of new HIV infections is considered to be a primary concern, as with many previous analyses of needle exchange programs (hereafter referred to as NEPs) in both Canada and the United States. Following these analyses, the number of deaths prevented by Insite is calculated, followed by the actual cost – effectiveness and cost – benefit calculations. The report concludes with a discussion of the results and directions for future research.

2. Concepts and Issues Regarding Cost – Benefit and Cost – Effectiveness Analysis

Cost – effectiveness and cost – benefit analysis are methods for the evaluation of a wide variety of programs. For example, in the current context, the establishment of a supervised injection facility costs society (notably, the public health sector) valuable and scarce resources, so it is important to know if these resources have been allocated in an appropriate manner. The use of cost – effectiveness and/or cost – benefit analysis can help is answering the question of resource allocation. As such, it is important to understand some of the basic terminology and assumptions that lie in the background

whenever such an analysis is taking place. These terms and assumptions are discussed, followed by discussion of an issue that tends to be contentious, the value of life.

The primary difference between cost – effectiveness and cost – benefit analysis is how many factors must be expressed in monetary terms. In cost – benefit analysis, all benefits and costs must be given monetary values. This allows the researcher to express costs and benefits in terms of a ratio, the cost – benefit ratio; the calculation of the ratio allows a comparison to take place between alternative strategies: if the benefit to cost ratio is higher for one policy initiative than another, then the policy initiative with the highest benefit to cost ratio may be the best policy option. In cost – effectiveness, however, only the costs need to be expressed in monetary form. The benefits are measured not in dollars, but more typically in the number of life years saved -- the number of new HIV infections prevented, the number of potential deaths prevented, and so on. If you have two alternative policies to choose from, you can calculate the cost per new HIV infection prevented – after assigning a monetary value to the new HIV infection prevented. Again, the policy maker can proceed to make choices on the basis of relative expense, if that is his or her only criterion.

Because each of cost – effectiveness and cost – benefit analysis has different factors to turn into monetary terms, each method has specific complications. Cost – benefit analysis must express all costs and benefits of a policy initiative in monetary terms. Although expressing costs in monetary terms tends not to be too difficult, especially when evaluating a policy funded by a government agency, expressing benefits

in monetary terms may be problematic. A couple of examples that are particular to Insite are useful here. As shown below, the two primary benefits analyzed for the evaluation of Insite are new HIV infections prevented and deaths prevented. The value of a new HIV infection prevented has been calculated by a number of researchers (cited below) and is based on the costs of providing the various services that an HIV patient requires. As a consequence, the benefit of preventing a new HIV infection can be quantified rather easily.

The prevention of deaths, however, is more difficult to calculate. How do we value a prevented premature death in society? Miller et al. (1996) calculate the cost of crimes that result in a death at an average of US $3 million, in 1993 dollars. If that is converted to 2006 Canadian dollars the value is approximately $5 million. Approximately one-third of this cost is classified as tangible: lost wages/productivity to society, medical costs, etc. with the remaining two-thirds classified as lost quality of life. Consequently, if we only consider the tangible portion because it is *more* objective, the value of a prevented premature death in society is approximately $1.67 million. Alternatively, considering a methodology employed by Cohen et al. (2004), the value of a prevented premature death in society is in excess of $10 million. With an annual operational cost of approximately $3 million and these estimates for the value of a prevented premature death, it would not take much for Insite to be shown to be cost – effective and to demonstrate a significant cost – benefit.

Because of this difficulty, the value assigned to a prevented premature death must be undertaken with caution. Of course, one may take the philosophical stance that life in and of itself is priceless, and that we should not undertake any methods that express life in monetary terms. At the other end of the spectrum, and notably in the context of Insite, there is a view that the IDU population in Vancouver's Downtown Eastside do not contribute to society; they are, rather, a drain on society – an ongoing cost. Indeed, in Miller et al. (1996) the vast majority of the tangible value of life is associated with lost productivity/wages resulting from the premature death. One could argue, given this framework, that there would be very little in the way of lost productivity or wages from a premature death in this population. In fact, one might argue that a premature death in this segment of the population would probably save the public health care system some clearly identifiable resources.

This callous view of human life illustrates one of the dangers of assigning monetary values to costs and benefits, and adopting a "business case" approach to policy implementation within the realm of public health care. Many goods, such as health care, are provided by the government because the private sector cannot provide them at a profit. Society considers some of these services extremely valuable and the government then provides them for society without any requirement for direct profit— health care, education, and roadways are primary examples. Let us take, for example, any kind of serious illness or disability: cancer, heart disease, rheumatoid arthritis, and the many disabilities of the aged. From a cost-benefit perspective, the most appropriate response in these circumstances is to withhold treatment, and encourage the affected individual to die

quickly. The benefits of reduced medical costs are passed on to those in the population who remain healthy, and the costs of medical care are dramatically reduced. In a very real sense this point demonstrates the limitations inherent in cost-benefit analyses in the realm of public health.

But we digress from the task we have been assigned. To be able to place a value on a prevented premature death, and with an awareness of the criticisms of doing so, we take a measure of the value of a prevented premature death that only considers tangible costs. The most direct of these tangible costs is the potential value that a person can add to the economy. Obviously this is difficult with a population that is most often not involved in the legitimate economy, but we are making a deliberate moral choice not to value the lives of injection drug users as different in value from the lives of the average person in British Columbia. We use the average income in British Columbia (this value is lower than for Canada as a whole and is, therefore, considered a more conservative estimate), measured by using the gross domestic product per capita--$33,640. If we discount future earning at 3 percent (Laufer 2001), the value of lost productivity/wages can simply be the sum of the years of income lost because of the premature death. We do not view this value as contentious, even when considering the IDU population under study. The fact that a person enters the IDU population in the Downtown Eastside does not mean that he or she will remain there until death. We acknowledge that this is a possibility, but individuals may also leave the IDU population for a variety of reasons: entering detoxification, relocation, cessation of drug use, arrest and imprisonment (Kaplan and O'Keefe, 1993). As a consequence each prevented death, and prevented HIV

infection, can be viewed as flowing from a person who could leave the IDU population and contribute to society.

Kerr et al. (2006a) find that the average age of an IDU in their study group, representative of users of Insite, is 35 years. Assuming retirement at the age of 65, there are 30 years of lost productivity/wages resulting from a premature death at the age of 35 years. However, if the premature death is the result of an HIV infection there are 20 years of lost productivity/wages resulting from a premature death because the expected survival time of an IDU newly infected with HIV is approximately 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 an overdose, respectively (discounting at 3 per cent, as noted above, leads to the apparent lack of proportionality between the two figures). Though these values are significantly large, they are far more conservative than most estimates of the value of a life, even those that use only tangible costs in their calculations.

Cost – effectiveness, on the other hand, has the advantage of having to provide a monetary evaluation of only the costs, not the benefits. The result is a cost – effectiveness ratio that represents the dollars spent for each new HIV infection prevented, for example. When comparing the effectiveness of two policy initiatives, the policy that is able to prevent new HIV infections at a lower cost is usually the preferred policy initiative. However, the limitation with cost – effectiveness is that only one outcome (benefit) can be compared at a time. For example, cost – effectiveness ratios would have to be calculated for each and every possible benefit that could emerge from a policy

initiative. A possible situation that may emerge is that policy initiative A is cheaper for benefit X (prevention of HIV infection, for example) but policy initiative B is cheaper for benefit Y (prevention of hepatitis C infection, for example). The question then becomes one of which benefit is more important. Because cost – benefit analysis transforms all benefits into monetary terms, it does not suffer from this limitation.

With these concepts in mind, the report now turns to the analysis of any impact Insite may have on new HIV infections. This is performed using two methodologies in the two following sections: linear trend analysis of actual new cases of HIV, and mathematical modeling of the impact of Insite on new HIV infections.

3. Trend Analysis of New HIV Infections in British Columbia

The first methodology used to evaluate the impact of Insite on public health expenditures, and hence its cost-effectiveness, is a linear trend analysis that follows the ecological methodology of Hurley et al. (1997) and CDHA (2002). This ecological methodology is relatively simple, but it has been shown to be instructive in analyzing the impact of NEPs in Australia and is expected to represent an underestimate of new HIV infections relative to more complex methodologies (CDHA 2002). Though this ecological methodology has acceptance in the medical literature, it has two limitations with regard to the evaluation of Insite. These two limitations are discussed after the ecological methodology itself is explained below.

3.1. Methodological Issues and Resolutions with Linear Trend Analysis

The ecological methodology is undertaken through the use of a linear regression procedure, using the following estimation equation:

$$\text{logit}(p_{it}) = \alpha_i + \beta_i t + \varepsilon_{it}, \quad (1)$$

where p_{it} is the percentage of HIV prevalence in each ecological unit i at time t; logit[1] is the transformation of the percentage into the natural logarithm of a ratio, ln (p/(1-p)), to prevent predicted values outside of the zero to one range from occurring; α_i is the intercept term for each ecological unit; β_i is the estimated annual rate of change in the logit of the prevalence in HIV for ecological unit i; t is a linear time trend that takes on a value of 1 for the first year of data available and increases by one unit in each consecutive year afterwards; ε_{it} is the remaining error term; and the ecological units are cities with and without NEPs. Equation 1 is estimated for each city and the β_i terms for the cities without NEPs are compared to the cities with NEPs by calculating weighted averages of each group of β_i terms. Hurley et al. (1997) and CDHA (2002) provide data to indicate that cities with NEPs have had declining trends in new HIV infections, whereas cities without NEPs have had increasing trends in new HIV infections. In the case of Australia, CDHA (2002) estimated that NEPs have prevented 25,000 new HIV infections, saving the public health system substantial costs, measured in terms of billions of dollars. There are a number of criticisms of this approach, discussed by CDHA (2002), and there are also some complications that arise in the current context.

[1] The logit is technically a log-odds ratio, but the medical literature uses this term in another context so it is avoided here to prevent any confusion.

Aside from the limitations discussed by CDHA (2002), this ecological methodology is unnecessarily complicated in terms of calculating the annual rate of change in the prevalence in HIV and is problematic in terms of the rate calculations. First, β_i must be transformed to obtain the estimated annual rate of change. As discussed by Greene (2000), the β_i term is itself not an annual rate of change but the annual rate of change on a logit (log-odds) scale. As such, the estimated annual rate of change can be obtained using the following transformation:

$$\text{Annual rate of change} = \Lambda(\beta' x)[1 - \Lambda(\beta' x)]\beta \quad (2)$$
$$\text{with } \Lambda(\beta' x) = e^{\beta x} \Big/ 1 + e^{\beta x},$$

where βx is the right-hand portion of equation 1. It should then be clear that the annual rate of change is a variable, changing with the value of the time trend in the current analysis. As outlined by Greene (2000), there are a number of methods of obtaining an average annual rate of change in this situation, but there is a simpler method of undertaking this analysis that is also the solution to the second limitation discussed below. However, the linear trend analysis was also undertaken using equation 1, similar to the approaches employed by both Hurley et al. (1997) and CDHA (2002); qualitatively similar results are found using both methodologies.

Second, because this methodology uses the percentage of HIV prevalence (a rate of incidence) in each ecological unit, one cannot discern whether the change has occurred in the number of new cases or in the population base in each ecological unit. The essence of the problem of inference in this situation is because of the nature of a rate calculation,

long known to be problematic in the social sciences (Boggs 1965). All rates have a numerator (the number of HIV+ people, in the Australian example) and a denominator (the population in each of the Australian cities under study). CDHA (2002) assumes that changes in the HIV infection rate of Australian cities is the result of the establishment of NEPs in particular cities. This is a reasonable inference given they have a control group (non-NEP cities). However, it is quite possible that there may be changes in the number of HIV+ people in the various Australian cities, without corresponding changes in the relative sizes of the total populations within these cities. For example, for reasons of economic opportunity, there may be substantial migration from smaller cities that tend to be less likely to have NEPs (see Gold et al. 1997) to larger cities that are more likely to have NEPs. If HIV prevalence is disproportionately higher in the populations that migrate (possibly the case because IDU populations may be drawn to the anonymity of the city and it's NEP), HIV prevalence will fall in smaller cities and rise in larger cities. Of course this is conjecture and such a possibility might be tested, but then only one of a number of alternative explanations may have been eliminated. Accordingly, there may be some difficulty in relying upon rate calculations in any methodology to assess the impact of NEPs or Insite – the numerator and the denominator in the rate calculation may not be static over time, for a number of different reasons. In an attempt to control for this issue, a secondary analysis is performed here.

Rather than using the rate of HIV prevalence in each ecological unit, the count of new HIV infections is used in the following equation:

$$\ln(HIV_{it}) = \alpha_i + \beta_i t + \varepsilon_{it}, \quad (3)$$

where HIV_{it} is the number of new HIV infections (reported new cases), ln is the natural logarithm, and the rest of equation 3 is the same as equation 1. This estimation methodology not only controls for the rate calculation issue, but also simplifies the interpretation of the regression coefficients—no calculations need to be performed in order to calculate the annual rate of change. β_i is simply the percentage change in the number of new HIV infections for ecological unit *i* each year.

The aforementioned methodological limitations and suggested changes in methodology would be common to any empirical analysis similar to that of Hurley et al. (1997) and CDHA (2002). There are also, however, a number of concerns that are specific to any evaluation of Insite. These concerns revolve around the choice of the ecological units used as well as the trends of the available ecological units. Each is discussed in turn.

As mentioned above, Hurley et al. (1997) and CDHA (2002) used cities as the ecological units of analysis. In the current analysis we focus only on British Columbia to minimize the presence of confounding variables in the analysis. Ideally, we would prefer to separate the IDU population in the vicinity of Insite from other areas of Vancouver, as well as other areas with known IDU populations. This type of analysis is somewhat

possible through the use of Local Health Areas (LHAs) of Vancouver.[2] The LHA boundaries in Vancouver are not defined ideally for the current analysis, but do allow for a reasonable separation of the IDU population in the vicinity of Insite from the remaining population in Vancouver. All other data for the remaining cities in the province are aggregated into Health Service Delivery Areas (HSDAs). Consequently, the finest resolution of analysis available only breaks British Columbia into its 16 HSDAs. Additionally, there are a number of HSDAs that contain zero values for some years. This is problematic because the natural logarithm is not defined at zero and the linear trend analysis cannot be performed using those observations. In order to facilitate the linear trend methodology, the HSDAs outside of Vancouver are aggregated into their respective Health Authorities (HA)—there are five in the province of British Columbia. The Vancouver Coastal Health Authority (Vancouver, North Shore, and Richmond) is analyzed in the aggregate, as well as separately, to provide as much information as possible.

The availability of spatially derived HIV data (raw data and our aggregations) allows for a linear trend analysis to be performed across different spatial boundaries. This analysis is critical because of the "modifiable area unit problem", as outlined by Openshaw (1984). Essentially, when one changes spatial boundaries (Local Health Areas, cities, HSDA, HA), the results of the analysis may or may not change. Because the linear trend analysis is based on consistent findings across different geographic

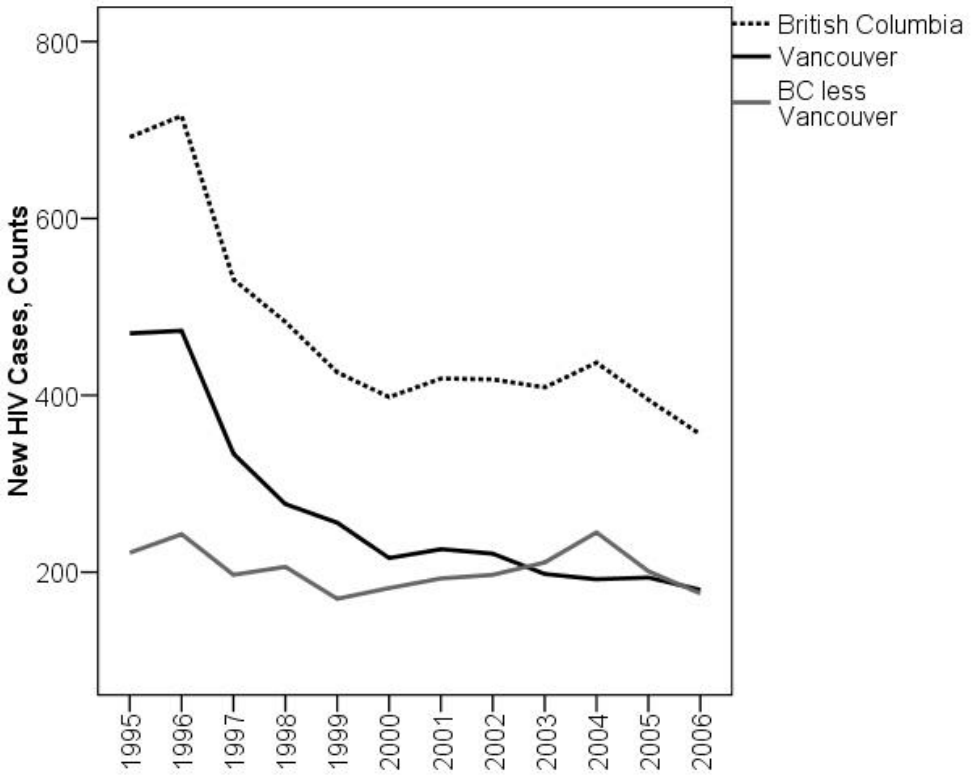
[2] The LHA data for Vancouver were provided by: Dr. Jat Sandhu, Regional Director, Public Health Surveillance Unit, Office of the Chief Medical Health Officer, Vancouver Coastal Health Authority.

spaces, if Insite is to have had its expected impact, that impact must be present in all areas -- if we are to be confident in making inferences. Of course, it is expected that the greatest impact will be found at the finest scale of resolution (the local health area) because these data are more specific to the Insite population. However, if conflicting results are found outside of these relatively narrow boundaries, any inferences regarding trends must be made with caution.

With regard to new HIV infections, it can be seen in Figure 1 that for the eight years preceding the establishment of Insite, British Columbia and Vancouver have had a steady decrease in the number of new cases of HIV.[3] As such, if Insite is to have had an effect on the new cases of HIV in Vancouver, the decrease in the trend of new HIV cases in Vancouver after the establishment of Insite must be of greater magnitude than the rest of British Columbia. If this is not the case, Insite cannot be said, using this methodology, to have had an independent effect on new HIV cases.

[3] New cases of HIV have to be used as a proxy for new infections of HIV because data on infections are not available.

Figure 1. Trends of New HIV Cases



Source. Haag et al. (2007) and MacDougall et al. (2003).

Simple inspection of the trend of new HIV cases in Vancouver relative to the rest of British Columbia demonstrates that if the methodology used by Hurley et al. (1997) and CDHA (2002) is used for British Columbia's various health regions, Vancouver has a decreasing trend in new HIV cases whereas the rest of the province has had no change in its number of new HIV cases. Consequently, one might conclude that Insite has decreased the incidence of new HIV cases in Vancouver. Such inference, however, is obviously flawed because the decreasing trend in new HIV cases was present long before the establishment of Insite. In order to control for this pre-existing decreasing trend, equation 3 is modified in the following manner:

$$\ln(HIV_{it}) = \alpha_i + \beta_i t_T + \gamma_i t_{Insite} + \varepsilon_{it}, \quad (4)$$

where t_T is the time trend for the entire study period, t_{Insite} is the time trend that begins at the establishment of Insite (2004 and onwards because annual data are used), β_i is the percentage change in the number of new HIV cases for ecological unit *i* each year before the establishment of Insite, and γ_i is the percentage change in the number of new HIV cases for ecological unit *i* each year after the establishment of Insite. Equation 4 imposes a structural break in the trends of the various health regions to control for other factors that may be impacting the trends of these data series. Because of the short time span of data available after the establishment of Insite -- three years -- statistical significance of the trends is not of particular interest, only the magnitude of the trend and whether it is increasing or decreasing.

The measurement of the structural breaks can take two different forms. Equation 4 could be estimated using the entire study period (1995 – 2006), or, alternatively, the study period can be broken into two study periods: pre- and post-Insite. The latter methodology does have a disadvantage because of the relatively small number of post-Insite observations available. For example, if equation 4 is estimated and the pre-Insite trend is below the actual data in 2003, then the post-Insite trend will begin below the actual data in 2004. This may lead to an increasing trend on new HIV cases in the post-Insite data when no such trend is truly present. In order to account for this possibility, equation 4 is estimated in a manner that separates the trends for the pre-and post-Insite study periods.

Lastly, there is a concern with the data itself. Haag et al. (2007) states that despite significant efforts to prevent double-counting of individuals and identifying new infections that occurred in British Columbia separate from new residents of British Columbia who came to the province with HIV, the trends prior to 2005 are not reliable, and any inferences should be made with caution. This is clearly problematic for the ecological methodology outlined above, despite changes in that methodology to suit the current analysis. One obvious question emerges at this point: why undertake a trend analysis if the trends need to be interpreted with caution? The answer to this question is simple. There are no data that are perfect for any analysis and the ecological methodology is an accepted methodology for identifying the effect, if any, of an operation such as Insite. If the effect of Insite is significantly strong, this effect may manifest itself in spite of the data limitations.

3.2. Results of the Linear Trend Analysis

The results of the linear trend analysis are presented in Table 1. The two columns that are labelled Before and After represent the pre- and post-Insite data for the trend analysis. The pre- and post Insite structural break trends reveal no surprises, based on casual inspection of Figure 1. Before the establishment of Insite, Vancouver Coastal maintains a 10 percent decrease in new HIV cases each year; after the establishment of Insite, the decrease continues but it is statistically insignificant.[4]

[4] The statistical insignificance is not a surprise or of concern because of the short time span of the post-Insite data.

These results are not surprising, even when one does not consider the potential problems with the data used for the analysis as outlined by Haag et al. (2007). First, only three years of data are available to assess the impact of Insite on new HIV cases. Though a new trend may be evident in such a short time span, it is difficult to assess whether a change in trend for such a short period of time is genuine. Second, though early testing may show the presence of HIV within a few months of infection, HIV may also be asymptomatic (and untested) for years before medical consultation occurs and a diagnosis is made. This is particularly true for the IDU population, who tend to have a number of other health issues that may mask the symptoms of HIV (Jane Buxton, personal communication, December 2007). And lastly, the establishment of Insite may have led to an increase in the diagnosis of new HIV cases simply because of more monitoring and testing of the IDU population. Consequently, it would not have been surprising if an increase in new HIV cases occurred after the establishment of Insite. It must be remembered that new HIV infections and new HIV cases are related but different phenomena – the notation of the case may follow the onset of infection by a considerable period of time.

Table 1: Linear Trend Analysis: Health Authority Areas and Health Service Delivery Areas

	Before	After
Vancouver Coastal	-0.107***	-0.057
Vancouver	-0.113***	-0.032
North Shore - Richmond	-0.012	-0.399
All except Vancouver	-0.017	-0.165*
Fraser	-0.026	-0.214**
Vancouver Island	-0.015	-0.156
Interior	-0.037	-0.056
North	0.092	0.019

Notes. * denotes 10 percent significance, ** denotes 5 percent significance, * denotes 1 percent significance.**

However, with these cautions in mind, there are some results to suggest that Insite has decreased the incidence of new HIV cases (see Table 2). When considering the LHAs individually, the Downtown Eastside LHA (which includes Insite) revealed a decreasing trend of new HIV cases before the establishment of Insite, but no continuation of this trend after the establishment of Insite. However, there are two other LHAs that contain areas in which IDUs reside: City Centre and Midtown. City Centre contains Vancouver's central business district, as well as some industrial and relatively impoverished areas. Midtown, just south of Insite, has a number of hotels in its northern area that are in an impoverished area of Vancouver and are likely the residences of a number of IDUs, given the proximity to the Downtown Eastside. As such, in order to

measure a more comprehensive impact of Insite on new HIV cases, these three LHAs are aggregated into one region (referred to as Insite in Table 2) and the remaining three LHAs are aggregated into another region (referred to as Non – Insite in Table 2). There is one potential problem with this aggregation: City Centre also contains a large homosexual community, a relatively high-risk group for new HIV cases. Little can be done regarding this limitation, aside from making all inferences with this data limitation in mind.

The results of the linear trend analysis using these two regions in Vancouver do show a decrease in the incidence of new HIV cases in the Insite region, albeit not a statistically significant decrease. Prior to the establishment of Insite, the Insite region had new cases of HIV decrease at a rate of 2.7 percent each year, whereas after the establishment of Insite that decrease was 3.9 percent per year. In the Non – Insite region, new cases of HIV were also decreasing prior to the establishment of Insite, but new cases of HIV began to increase by 2 percent after the establishment of Insite in the Non – Insite region.

The result of this latter linear trend analysis is that through using one set of spatial boundaries support has been found for the proposition that Insite decreases the incidence of new HIV cases. This change, however, is, as expected, not statistically significant, given the short time span since the establishment of Insite. Though this appears to be a promising result for an impact on new HIV cases, little can be drawn from this analysis. At both finer and coarser scales of spatial resolution (individual LHAs in Vancouver,

HSDAs, and HAs), no such relationship can be found. As such, this is a classic case of the modifiable area unit problem: change the spatial boundary of analysis and the results change completely. Accordingly, no inferences can be made with regard to the impact of Insite on new HIV cases, using linear trend analysis.

Table 2: Linear Trend Analysis: Local Health Areas, Vancouver

	Before	After
City Centre	-0.031	-0.16
Downtown Eastside	-0.102**	0.14
North East	-0.186	0.126
Westside	0.061	0.00
Midtown	0.344*	0.246
South	0.208	-0.091
Insite	-0.027	-0.039
Non – Insite	-0.038	0.02

Notes. * denotes 10 percent significance, ** denotes 5 percent significance, * denotes 1 percent significance.**

In order to address the limitations of the linear trend analysis, the focus now turns to the mathematical modeling of new HIV infections. This methodology, much like the linear trend analysis, adapts modeling techniques used to assess NEPs to an evaluation of Insite. The benefit of the mathematical modeling techniques is that they deal specifically with the incidence of new HIV infections rather than the new diagnoses/cases from 2004 to 2006. There are a number of mathematical modeling techniques used in the literature

assessing NEPs. This allows for a number of different frameworks of analysis regarding the impacts of Insite on new HIV infections. The presentation of the mathematical models will move from the simple to the complex in two ways. First, the mathematical models with the fewest variables used will be presented before the mathematical models with more variables. Second, the mathematical models that do not consider behavioural changes in the IDU population will be presented before the mathematical models that do consider behavioural changes in the IDU population. Additionally, whenever possible, calculation of a range of possibilities will also be undertaken within and across each of the mathematical models.

4. Mathematical Modeling of the Impact of Insite on New HIV Infections

In order to justify expenditures on NEPs, and similarly, Insite, evaluation of their impacts is necessary. And yet the evaluation of these kinds of programs -- NEPs, and Insite -- is inherently problematic. Any evaluation using actual data, most often annual time series, must wait a number of years before any inferences can be made with any degree of reliability. As we have shown above in using the linear trend analysis that was successfully applied to the NEPs in Australia, not enough time has passed to be able to make any inferential statements regarding the impacts that Insite may or may not have had on new HIV cases—the Australian study of NEPs had significantly more post-NEP data observations. And regardless of our ability to observe new trends, such linear trend analyses can only *suggest* that NEPs or Insite have had an impact, positive, negative or neutral. It may be true that the NEPs in Australia prevented a large number of new HIV

infections, but at best we have a presentation of compelling correlational data rather than data that demonstrate a cause-effect relationship.

An alternative methodology that can be used to access the impacts of NEPs or Insite is mathematical modeling or simulations. Mathematical models can use known statistics before and after the implementation of a policy initiative to estimate the impact of that policy initiative. In the case of Insite, there is a certain number of known "clean" injections that have taken place in Insite rather than potentially "dirty" injections outside of Insite that run a risk of a new HIV infection. If we use the best available data regarding the number of injection drug users, their frequency of injection, the probability of HIV transmission, the prevalence of HIV in the IDU population, and a number of other variables, the impact of these known clean injections can be estimated mathematically.

Unlike the linear trend analysis focussed on actual new cases of HIV, very little time needs to pass in order to perform an evaluation based on mathematical modeling. The facility does need to be operational for some time in order to be confident about the actual extent and character of use, but not for nearly as much time as is needed to undertake a reliable linear trend analysis. Additionally, mathematical modelling can incorporate the impact of behavioural changes in injection activities once outside of Insite – and these behavioural changes in injection activities can be included in a measurement of the impact of Insite.

It should come as no surprise that Insite has had an impact on the behavioural patterns of the IDU population; both environmental psychology and environmental criminology, as well as other disciplines, have long provided evidence of such impacts -- and the IDU population is likely not different in this regard. Some significant percentage of changes in behaviour within Insite is likely to be manifest in behaviours outside of Insite. Because of the ability of mathematical models to include these impacts (clean injections and behavioural changes) and to precisely measure an outcome, these models have been used a number of times (more often than the linear trend analysis) for the evaluation of NEPs and they are, therefore, appropriate for the evaluation of a facility such as Insite.

In order for the mathematical modeling to be performed, a number of variables need to be obtained from both the medical literature and Insite itself. The number of variables differs from mathematical model to mathematical model, but there are a number of assumptions that are common to most mathematical modeling procedures. Some of these assumptions are explicit and others are implicit in the mathematical modeling, but they should be discussed—most of the mathematical models that have evaluated NEPs have been some derivative of seminal evaluation work done by Kaplan and O'Keefe (1993) on an NEP in New Haven, Connecticut. Once these common assumptions are discussed, we will turn to the various mathematical models used, introducing variables as they are needed. To err on the side of caution, and to present as great a range as we might reasonably anticipate, four different mathematical models have been computed. Additionally, the variables within each of the models are also altered, so as to provide a

corresponding range of possible outcomes, within the model. As a consequence, we are creating a range of outcomes both within and across mathematical models currently used in the medical literature.

4.1. General Assumptions of Mathematical Modeling

The general assumptions used in mathematical modeling all relate to stability in the variables used in the analysis, aside from those variables that are manipulated in the mathematical modeling process. This is the most contentious component of mathematical modeling because these assumptions take us back to the problems outlined above regarding the linear trend analysis: 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 size of the IDU population is a critical variable because the more IDUs injecting, the more new HIV infections may take place. Over time, new IDUs will enter the population and others will leave the population, but in order for the mathematical modeling to take place, the IDU population must be in equilibrium—the new entrants perfectly replace those that exit (see Kaplan and O'Keefe, 1993, for a discussion of

reasons IDUs enter and exit the IDU population). In an established IDU population like that of Vancouver's Downtown Eastside, it is likely that such an equilibrium has established itself. However, it is possible that Insite may have disrupted that equilibrium. For example, Insite may have altered the exit rate of the IDU population through fewer deaths resulting from injections. Most notably, this may be the case for overdose deaths (this is analyzed below), but here the number of "exits" is not likely to be of a large magnitude, as illicit drug deaths in the City of Vancouver have averaged about 50 annually in the three most recent years of data (BC Coroner's Office 2008). The exit rate may also be altered by fewer deaths resulting from fewer HIV infections. However, as shown by Rehm et al. (2002), HIV/AIDS only accounts for 5 percent of deaths in Canada resulting from illegal drug use, and because of the long time span that someone may now live with HIV/AIDS, there is unlikely to be any change in the exit rate in the relatively short time period that Insite has been open. Lastly, the entrance rate may have increased because of the provision of clean injecting equipment. However, clean injecting equipment is also provided by NEPs -- and the provision of this equipment has not been shown to increase the IDU population (Des Jarlais et al. 1992; Lurie et al. 1993; Vlahov and Junge 1998; Watters et al. 1994). Insite is, accordingly, not likely to have changed the entrance rate into injection drug use.

The average injection frequency of the IDU population is remarkably consistent across a number of different studies, covering many different geographic areas in both Canada and the United States, despite significant ranges of injection frequency amongst individual IDUs. As such, there is little concern over the choice of this variable's value

below. The situation is similar for HIV transmission rates for both single injections and HIV transmission rates based upon the cumulative effect of injections for an entire year. These rates are backed by medical research into the probabilities of HIV transmission; this research has considered many years of data regarding accidental needle insertion.

Though HIV/AIDS, as mentioned above, accounts for only five percent of illegal drug deaths, if the exit rate of the IDU population is assumed to be constant, it can be assumed that the various factors that affect the exit rate are also constant. Each of the factors may change by a small degree, one compensating for the other, but this potential change should have only a small effect. Additionally, in the case of Vancouver's Downtown Eastside, a handful of studies at different points in time have calculated the HIV prevalence in the area to be similar. As shown in Figure 1 above, the number of new cases of HIV has been falling since the mid-1990s. Although it seems clear that new HIV infections are falling, the proportion of the IDU population that is infected has remained relatively stable.

Though we must assume that our variables are constant during the study period (the actual number of clean injections in Insite and any behavioural changes), there is sufficient evidence that supports these assumptions, to the point that our mathematical modeling is undertaken with little concern. It must always be remembered that any such analysis can only present estimates of impacts, not actual impacts, but if the variables are used in a conservative manner, the resulting estimates of impacts will be underestimates of the true impact of Insite.

4.2. Mathematical Models of the Impact of Insite

We begin the set of mathematical models with the simplest model available. In fact, Laufer (2001) refers to this model as a simplified needle circulation model, of which more complex versions are modeled below. This mathematical model requires the calculation of two variables: the number of needles used per client-year (E) and the number of shared injections per client-year (s). The calculation of E is relatively straightforward, as it is the ratio of the number of needles distributed to the number of people obtaining needles. As shown by Tyndall et al. (2003; 2006a), there are approximately 1700 unique IDUs using Insite every month, with Insite operating either at or close to its capacity of 236,520 injections per year – according to Tyndall (2006a), Insite was consistently operating at a minimum of 93 per cent capacity between April 2004 and March 2005: 600 injections per day. As a consequence, we consider using 100 per cent capacity three years later to be a reasonable working assumption -- this leads to 139 injections per client-year, very close to the average of 11 injections per month per IDU, leading to 132 injections per client-year.

The calculation of the number of shared injections is, however, a little more complicated. The total number of injections is needed, as well as the sharing rate of IDUs. The total number of injections is calculated by multiplying the average number of injections per day by the number of days in the year. Laufer (2001) uses 2.14 injections per day, leading to a total number of 780 injections per year for the average IDU. This number is supported by a number of other research projects (Kaplan and O'Keefe 1993,

Des Jarlais et al. 1996, Siegel et al. 1991), but other research has shown the average to be somewhat higher. For example, Holtgrave et al. (1998), citing the Center for Disease Control in the United States, use 2.8 injections per client-day, leading to 1022 injections per client-year and Jacobs et al. (1999) suggest more than 5 injections per client-day, leading to 2105 per client-year. We use 2.5 injections per client-day leading to 913 injections per client-year, something of an average flowing from the different studies.

The percentage of shared injections has a number of different estimates, but the one calculated by Kaplan and O'Keefe (1993) is used most often: 31.5 percent of injections. This value was obtained by tracking needles in the New Haven, Connecticut NEP; 31.5 percent of the time the person returning a needle was different from the person who obtained a needle. In a self-report study undertaken by Kerr et al. (2005), 11.4 percent of IDUs reported needle sharing in their drug use. However, Kerr et al. (2005) point out that this is very likely an under-reporting because of socially desirable responding—the IDUs know what the researchers want to hear. This possibility of under-reporting is quite evident when one compares the results of the self-report study undertaken by Wood et al. (2001) on the same IDU population that reported a sharing rate of 27.6 percent. In a study of the IDU population in Edmonton, Alberta, Jacobs et al. (1999) found that 37.8 percent and 24 percent of needles are shared in Edmonton, depending on how the question is phrased. Given the widespread acceptance of the 31.5 percent value calculated by Kaplan and O'Keefe (1993), we decided to use a somewhat conservative figure of 30 percent – we do, however, perform sensitivity analyses using the outliers of 20 and 40 percent. The use of 30 percent leads to 274 shared injections per

client-year. However, because clients of Insite perform an average of 139 injections within Insite, the base number of total injections is lower for these clients: 30 per cent of 774, 234 shared injections.

Using the following formula:

$$E/(E+s), \tag{1}$$

the decrease in HIV incidence among those who use Insite is calculated to be 50 percent. This simply means that because of the clean injections made within Insite, the clients of Insite have a lower probability of generating a new HIV infection -- 50 percent lower than those who do not use Insite. According to Des Jarlais et al. (1996), the cumulative annual probability of a new HIV infection is 5.26 percent, so the clients of Insite have a cumulative annual probability of a new HIV infection of 2.63 percent.

Petrar et al. (2007) have recently found that the prevalence of HIV in the clients of Insite is 17 percent—this figure has also been found by Tyndall et al. (2006) in the same IDU population. Therefore, of the 1700 users of Insite, 289 are HIV+ and 1411 are HIV-. Without Insite there would be 74 new infections of HIV within these 1411 clients (1411 X 0.0526), whereas there would be 44 new infections of HIV within these 1411 clients (1411 X 0.0263) with Insite: this leads to the prevention of 28 new HIV infections (HIV infections prevented and new HIV infections do not sum to 74 because of rounding). Clearly, this mathematical modeling procedure shows significant benefits of Insite through reduced new HIV infections.

Though these numbers are impressive, Insite has also been shown to have an impact on the behaviour of its IDUs that extends beyond Insite. Kerr et al. (2005a) found that attendance at Insite significantly reduced needle sharing. They estimate, calculating an odds-ratio, that an Insite client shares needles at 0.30 the frequency of a non-Insite IDU. Despite the goodness of fit reported by Kerr et al. (2005a), we wished to be even more conservative and only consider 50 percent of their reported effect on needle sharing, an odds-ratio of 0.60. This still leads to a significant drop in needle sharing, but errs on the side of caution and attempts to discount for any bias because of socially biased responding. When we consider this behavioural effect, the number of shared injections is then141 for the year. This leads to the prevention of 37 new HIV infections. The magnitude of the behavioural effect in this particular mathematical model is not large, but it certainly has a significant impact.

If we turn to Laufer's (2001) more complex mathematical model[5], the number of new HIV infections avoided is directly calculated, rather than new HIV infections with and without the policy intervention (Insite). The number of new HIV infections avoided, *A*, is calculated as follows:

$$A = c(1-p)ar, \qquad (2)$$

where *c* is the number of IDUs in the population, *p* is the percentage with HIV, *a* is the participation rate, and *r* is the reduction in risk from participation. The number of IDUs

[5] Laufer's (2001) more complex mathematical model is very similar to that of Des Jarlais et al. (1996), with the difference being the method of calculating the decrease in risk of infection. Both models produce very similar results, so the Des Jarlais et al. (1996) mathematical model results are not presented here—the results are almost identical. They are, however, available upon request.

in Vancouver's Downtown Eastside is estimated to be 5000 (McClean 2002, Kerr et al. 2005b); the participation rate at Insite is 34 percent, 1700/5000 (Tyndall et al. 2003); and the percentage of this IDU population with HIV is 17 percent (Petrar et al. 2007, Tyndall et al. 2006). The only new variable in this mathematical model is the reduction in risk from participation. This is calculated very simply as the percentage of injections that is performed in Insite; in the case of the behavioural changes, the reduction in risk is the equivalent of the number of injections in Insite through actual injections, plus what are de facto injections in Insite because of behavioural change. The results of this model by Laufer (2001) are more conservative than in his simple model of needle circulation. If we do not consider behavioural changes, there are 16 new HIV infections prevented per year because of the facility. When we consider the version of this model that incorporates behavioural impacts, the number of new HIV infections prevented rises to 19.

Jacobs et al. (1999) provides a Canadian (Edmonton, Alberta) context for the second most complex mathematical model used to assess NEPs. In addition to the proportion of the IDU population that is HIV-negative (*I)* and rates of needle sharing (*s*), Jacobs et al. (1999) also consider the following variables: the number of needles in circulation (*N*), the percentage of needles not cleaned before use (*d*), the probability of HIV transmission when using an HIV-infected needle (*t*), HIV prevalence in the IDU population (*q*), and the number of sharing partners when injections are shared (*m*), resulting in the following estimation equation:

$$\text{New HIV Infections} = INsd\left[1-(1-qt)^{m}\right]. \tag{3}$$

The number of needles distributed in Vancouver has ranged from 2.5 to 3.5 million per year in recent years (Buxton 2008, McClean 2002), with the return rate for Vancouver being 101 percent (McClean 2002). With such a high return rate for needles, it is safe to assume that the number of needles circulating in Vancouver is in that same range, averaging 3 million annually. Vancouver's Downtown Eastside contains approximately 42 percent of Vancouver's IDU population (McClean 2002), but Insite alone (there are other places in Vancouver's Downtown Eastside to obtain clean needles) orders approximately 50 percent of the needles in Vancouver. Therefore, we estimate that 2 million needles are circulating annually in Vancouver's Downtown Eastside. Given that there are more than 4.5 million injections per year (5000 IDUs times 913 injections per year) occurring in Vancouver's Downtown Eastside, this seems a reasonable estimate.

The percentage of needles not cleaned before use is calculated at 50 percent by Jacobs et al. (1999), using interview data. However, to make our estimates more conservative we use 17 percent, a number used by Kaplan and O'Keefe (1993). The probability of HIV transmission per injection is set to 0.67 percent (Kaplan and O'Keefe 1993). The number of sharing partners is set to 1.38, the value Jacobs et al. (1999) obtained through interview data. No other study was found that included the number of sharing partners, so the Jacobs et al. (1999) value was used. Lastly, the HIV prevalence in the IDU population is set to 22.54 percent. Though the Insite IDU population has an HIV prevalence rate of 17 percent, it is suspected that those who are HIV negative are more likely to use Insite; if an IDU knows s/he has HIV/AIDS, clean injections are not

going to be as important as for someone without HIV/AIDS. Indeed, Tyndall et al. (2003) found HIV prevalence to be 30 percent among the Vancouver Downtown Eastside IDU population and Jacobs et al. (1999) report that HIV prevalence for Alberta IDUs was 26.4 percent in 1996. Using a methodology outlined by Kaplan and O'Keefe (1993), we estimate that the HIV prevalence among non-users of Insite is 25.4 percent. The weighted average of the users and non-users of Insite is then 22.54 percent.

The results of this mathematical model indicate that the number of new HIV infections falls from 165 to 157 with the establishment of Insite, a reduction of 8 new HIV infections. However, once we consider the behavioural changes in Insite users, the number of new HIV infections prevented rises to 27 per year.

The last mathematical model used to analyze Insite is the original model developed by Kaplan and O'Keefe (1993) for assessing the impact of the New Haven, Connecticut NEP. This mathematical model considers HIV prevalence in the IDU population (π), the number of shared injections (λ), the probability of cleaning a used needle (θ), the percentage of needles infected with HIV (β), and the probability of HIV transmission with a single injection (α):

$$\text{New HIV Infections} = (1-\pi)\lambda(1-\theta)\beta\alpha\,. \tag{4}$$

The only new variable included in this mathematical model that is not in any of the previous mathematical models is the percentage of needles infected with HIV. Without a NEP in operation in New Haven, Connecticut, Kaplan and O'Keefe (1993) found, testing

actual needles, that 67 percent of street needles were infected with HIV. After the New Haven NEP was in operation, that percentage reached a low of 40.5 percent of all needles being infected with HIV. Though these percentages are rather high, these are based on the testing of actual needles used by IDUs and there is no reason, *a priori*, to believe that the Vancouver IDU population would be operating under any different circumstances. This is particularly the case, given that Vancouver has one of the highest HIV rates in North America. Incidentally, Kaplan and O'Keefe (1993) found that the percentage of infected needles used in shooting galleries is 92 percent.

The results for this last model are the greatest, in comparison to the previous reported results. However, there is a complication that needs to be stated. The baseline number of new HIV infections (without Insite) is calculated at 365. This number seems particularly high, as the total number of new HIV cases for the City of Vancouver has been a little less than 200 annually in recent years (BCCDC 2007). Though it would not be surprising that the number of new HIV infections is greater than the number of new HIV cases (because of a lack of reporting in the IDU population), estimating that the number of new HIV infections in Vancouver's Downtown Eastside is 75 percent greater than all of the new HIV cases in Vancouver is suspicious. Regardless of this calculation, the number of new HIV infections prevented is not extraordinarily high, 17 new infections prevented by Insite every year, a modest impact.

However, when we consider the behavioural impact of Insite on its users, the number of new cases of HIV prevented every year rises significantly to 57. Needless to say, the behavioural changes that have resulted from Insite have had a significant impact on new HIV infections in these latter two models. To further illustrate this effect, if we use the odds-ratio provided by Kerr et al. (2005a), OR = 0.30, 95 new infections of HIV are prevented every year.

Though one may consider 95 new infections of HIV as an overestimate of the impact of Insite (because of the baseline number of new HIV infections of 351 infections per year), this represents a 26 percent drop in the number of new HIV infections. Consequently, if this percentage drop is applied to the Jacobs et al. (1999) baseline number of new HIV infections that is far more reasonable (165), there would still be a decrease of 43 new infections of HIV each year, because of Insite.

Clearly, a wide range of results has been presented here with mathematical modeling. However, it should also be clear that the number of new HIV infections prevented because of Insite is not insignificant. In order to better evaluate the effectiveness of the prevented new HIV infections, the cost of treating such an infection is now to be calculated.

5. Number of Lives Saved Through Insite: HIV and Overdoses

The prevention of new HIV infections is clearly a positive outcome from the establishment of Insite in Vancouver's Downtown Eastside. This prevention of new HIV infections translates into direct cost savings to our public health care system, an important consideration in the cost – effectiveness and cost – benefit analyses of Insite. However, there is a further benefit to the presence of Insite through the prevention of deaths that can be attributable to Insite's existence. Of course, such a discussion is subject to the issues stated above regarding the value of life and cost – benefit analysis, but conservative figures are used in the cost – benefit analysis below to mitigate critiques of the value of life, while recognizing that all human life has some measureable value. In this context, there are two sources of these prevented deaths, one direct and one indirect: the prevention of deaths attributable to HIV infections (indirect) and the prevention of deaths attributable to overdoses (direct). Each is discussed, in turn.

The prevention of deaths attributable to new HIV infections is a relatively straightforward calculation that involves the number of new HIV infections prevented through the presence of Insite and the percentage of illicit drug deaths that is attributable to HIV infections. The latter figure is the least contentious, as it is available in Coroners' data and published in Rehm et al. (2006) (reporting on Canadian deaths in 2002 related to illicit drug use). In the case of 2002, 5.1 percent of illicit drug related deaths were attributed to HIV infections—Single et al. (1996) calculate this percentage to be 8 percent in 1992, but we will use the more conservative 5.1 percent figure. If we use the average number of new HIV infections prevented from the four mathematical models, 35 new

HIV infections prevented[6], and the 5.1 percent figure, 1.785 deaths attributed to HIV infections are prevented through the establishment of Insite.

The direct prevention of death is measured using data on the number of overdose deaths. As found in a number of studies (see Davidson et al. 2003, Rehm et al. 2006, Wood et al. 2005), overdose is a common cause of morbidity in IDU populations. In the case of Canada in 2002, there were 958 accidental overdose deaths (Rehm et al. 2006). This number is approximately 40 percent greater than the number of homicides each year, a result similar to that found by Coffin et al. (2003) for New York City. Consequently, efforts to reduce deaths from overdose should be of significant societal interest. The number of overdose deaths prevented is calculated using data from two sources: the British Columbia Coroners Service (2008), reporting on the number of overdoses in British Columbia's IDU population, and overdose rates within Insite, provided by Kerr et al. (2006b).

Kerr et al. (2006b) reported 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 it is possible that overdose rates are higher in Insite than from injections on the street because users know there is a nurse present with access to medical interventions, the Insite overdose rate is actually on the lower end of the range found internationally by Kimber et al. (2005). In

[6] This value is used below in the cost – effectiveness and cost – benefit analysis below. Justification for using this number is given in section 6.3.

fact, Kimber et al. (2005) find that the overdose rates in supervised injecting facilities are far greater in Germany and Australia, 6.4 and 7.2, respectively per 1000 injections. Consequently, the value of 1.3 is considered representative of the overdose rate before the establishment of Insite.[7] Kerr et al. (2006b) also report that there were 55 cases (16.4 percent) of stopped breathing attributed to the overdose—this number had to be estimated through inspection of a bar graph as the actual number is not provided in the publication. Though there may have been other factors that could lead to a potential death from overdose, we only consider stopped breathing as a potential death, in order to err on the side of caution.

Based on these percentages and the fact that there are 236,520 injections per year performed in Insite and a total of 4,562,500 injections per year in Vancouver's Downtown Eastside, there are 50 potential deaths from overdose occurring in Insite each year and 973 potential deaths from overdose for the Downtown Eastside as a whole, without Insite. According to British Columbia Coroners Service (2008), however, there have been approximately 50 deaths from drug overdoses each year in Vancouver since the opening of Insite. With 42 percent of the IDU population residing in Vancouver's Downtown Eastside (McClean 2002), that translates into 21 overdose deaths per year in Vancouver's Downtown Eastside.[8] With 21 actual deaths and 973 potential deaths in

[7] Kerr et al. (2006b) also note that the differences in overdose rates may be because of different classifications of overdoses in different facilities.

[8] One could argue that the nature of the IDU population in Vancouver's Downtown Eastside makes it more susceptible to potential overdose deaths, calling into question the use of 42 percent. However, we choose

Vancouver's Downtown Eastside, 2.16 percent of potential deaths from overdose result in an actual death in the absence of Insite. Therefore, of the 50 potential deaths from overdose that are expected to occur in Insite each year, it would be expected that 1.08 actual deaths from overdose would actually occur if Insite did not have its current record of no overdose deaths. Consequently, through the prevention of death from overdose, Insite has prevented a further 1.08 deaths.

The total number of deaths prevented because of the presence of Insite is then 2.87 (combining HIV and overdose deaths). As shown below, this small number of deaths prevented has a significant impact on the cost – benefit analysis. As a result, any cost – benefit analysis that does not consider such an effect is biasing the potential benefits downward.

6. A Cost – Effectiveness and Cost – Benefit Analysis of Vancouver's Supervised Injection Facility

A cost – effectiveness and cost – benefit analysis of Insite, or any operation for that matter, must consider a number of costs and benefits in order to provide the best possible information regarding its continuing presence in Vancouver's Downtown Eastside. As discussed above, if all costs are not properly assessed, then the effectiveness or benefit of a program may be over-estimated. Conversely, if the benefits of a program

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to err on the side of caution and distribute these potential deaths evenly across Vancouver's IDU population.

are not completely assessed, the effectiveness or benefit of a program may be under-estimated.

The operational costs of Insite were provided by Vancouver Coastal Health, in confidence, with the following breakdown: labour ($1,978,155), non-labour ($235,788), administrative costs ($202,143), and facilities ($532,015). The total is, accordingly, $2,948,101 for the annual expenses associated with Insite. This total is used in our cost – benefit analysis below, but a caveat is necessary. These costs include the full operations of Insite, costs greater than the provision of a supervised injection facility. Other services of Insite include addiction counselling and case management, primary healthcare, public health screening (immunizations and diagnostics), referrals to addiction and housing services, education and peer counselling. As such, this figure of close to $ 3 million is an overestimate of the annual operational costs of the facility. In sum, the benefit to cost calculations are also underestimates of the ratio, not only in relation to benefits (an underestimate) but also in relation to annual operating costs (an overestimate).

The easily calculable benefits we have chosen to focus on are the prevention of new HIV infections and the prevention of overdose deaths resulting from Insite. As shown by other research (see Frei et al. 2000), supervised injection sites and the medical prescription of heroin in Switzerland have provided a number of health care savings flowing from a decreased incidence of ailments that relate to in- and out-patient services, emergency and psychiatry wards, access to general practitioners, therapists, and prescription drugs. Because of a lack of availability of data, we were not able to investigate such potential cost savings that likely emerge from the large number of clean

injections occurring in Insite. Our actual cost – effectiveness and cost – benefit analyses of Insite are undertaken below, after canvassing the medical cost of a new HIV infection and discussing the operating costs of Insite.

6.1. The Medical Cost of a New HIV Infection

The lifetime medical costs of a new HIV infection on society have been estimated with a rather large range of values, partially because some of these estimates are dated (some were calculated in the early 1990s). This range of values is from US$50,000 (Kaplan and O'Keefe 1993) to US$200,000 (Holtgrave and Pinkerton 1997, Pinkerton and Holtgrave 1998). Because the impact of the number of new HIV infections prevented may be of critical importance when trying to establish the cost – effectiveness and cost – benefit ratio of Insite, the lifetime medical costs of a new HIV infection must be chosen with care. Two further concerns when choosing which lifetime medical cost to adopt 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 will be employed. With regard to the second concern, estimated lifetime medical costs of treating a new HIV infection will be obtained from both Canadian and US sources.

There are two cost – benefit analyses in Canada that report separate lifetime medical costs of a new HIV infection. Gold et al. (1997) use the value of CDN $100,167 (1991 dollars), based on the calculations of Grover et al. (1993). This is based on the expectation of just over 10 years of survival with HIV/AIDS. Jacobs et al. (1999) use the value of CDN $150,000 (1998 dollars) based on the calculations of Albert and Williams (1998). This latter estimate of the lifetime medical costs of a new HIV infection is based on a 17 year survival with HIV/AIDS. Lastly, Holtgrave and Pinkerton (1997) and Pinkerton and Holtgrave (1998) estimate that an intermediate cost of a new HIV infections is US$195,188 whereas a low cost of new HIV infections is US$87,045. This latter low cost method is suggested by Holtgrave and Pinkerton (1997) and Pinkerton and Holtgrave (1998) to be used for IDU populations that are expected to use medical resources less intensely than the average citizen.

With these three values, the first two need to be converted into 2006 dollars in order to set them against the current operational costs of Insite. This calculation is performed using Canada's consumer price index, increasing by approximately 2 percent for the past twenty years. The third value must not only be converted into 2006 dollars for a proper comparison with operational costs, but also must be converted into Canadian dollars. The base value of US$87,045 is converted into Canadian dollars using the average Canada – United States exchange rate for 1998, approximately 1.48 Canadian dollars per US dollar, and then converted into 2006 dollars using the same consumer price index as the first two value. These conversions produce the following estimates of lifetime medical costs for a new HIV infection: $132,000, $179,000, and $154,000. We

chose to use $150,000, a value slightly lower than the middle value, that is based on the low cost treatment of a new HIV infection calculated by Holtgrave and Pinkerton (1997) and Pinkerton and Holtgrave (1998).

Though the choice of $150,000 may not be considered the conservative approach derived from the analysis above, we do consider this value choice to be conservative for the evaluation of Insite. All of the base values for these estimated lifetime medical costs of a new HIV infection are calculated using medical technologies that are now 10 to 15 years old. Given the rapid advancement of this field, new techniques and drugs are likely available and these techniques and drugs raise these costs, both in terms of the funds spent on development, and the costs passed on to the medical system.

6.2. Operational Costs of Insite

Ideally, the operational costs of Insite would be separated into fixed and variable costs, as discussed in section 4.2 above. This would allow for the calculation of cost – effectiveness and cost – benefit ratios that would realistically consider the impact of Insite being open for 24 hours per day. Because of the nature of the mathematical models used to estimate the number of new HIV infections prevented, increases in the operation of Insite (more hours or more facilities in operation) will be linear. This means that two Insites would prevent twice as many new HIV infections as one Insite. However, because there are a number of costs (fixed costs) that do not change whether Insite is open for 18 hours per day or 24 hours per day, if Insite is open for 6 more hours per day,

a 33 percent increase in hours of operation, some costs of operating Insite would not increase by 33 percent. Unfortunately, such data were not made available to us, as accounting categories are not generated to facilitate an evaluation using mathematical modeling. We were provided, however, with the operational costs for Insite's annual operation as a whole, as noted above.[9]

6.3. The Cost – Effectiveness and Cost – Benefit of Insite

The cost – effectiveness and cost – benefit analysis below is based on Insite being operational 18 hours per day. Additionally, all of the results below include the impact of behavioural changes within the Insite population as a relevant variable for calculation of the benefits of the establishment of Insite. This clearly increases the benefits of the establishment of Insite but we stress that our calculation of behaviour 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. Though the number of new HIV infections prevented may be considered high from the Kaplan and O'Keefe (1993) model, particularly because of the high baseline number of new HIV infections, when the odds-ratio reported by Kerr et al (2005a) is used in the Jacobs et al. (1999) model —t he number of new HIV infection prevented rises to 43 per year. Consequently, we feel that none of the estimates for the

[9] These data were provided by Chris Buchner at Vancouver Coastal Health. We would like to thank him for his providing these data.

number of new HIV infections is unreasonably high, and calculating the simple average mediates that effect even more.

Table 3: Cost - Effectiveness and Cost - Benefit of Prevented HIV Infections, Expressed as Annual Amounts

	Number Prevented	$ Saved (Millions)	Cost – Effectiveness Ratio	Cost – Benefit Ratio
Laufer (2001) - Simple	37 (44, 32)	5.55 (6.6, 4.8)	$79,678 ($67,002, $92,128)	1.88 (2.24, 1.63)
Laufer (2001) - Complex	19 (18, 20)	2.85 (2.7, 3.0)	$155,163 ($163,783, $147,405)	0.97 (0.92, 1.02)
Jacobs et al. (1999)	27 (18, 36)	4.05 (2.7, 5.4)	$109,189 ($163,783, $81,892)	1.37 (0.92, 1.83)
Kaplan and O'Keefe (1993)	57 (38, 76)	8.55 (5.7, 11.4)	$51,721 ($77,582, $38,791)	2.90 (1.93, 3.87)
Average	35 (30, 41)	5.25 (4.5, 6.15)	$84,232 ($98,270, $71,905)	1.78 (1.53, 2.09)

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.

As shown in Table 3, the cost savings to society from the prevention of new HIV infections alone is substantial, ranging from $2.85 to $8.55 million. However, the cost of providing the service of Insite is also substantial: almost $3,000,000 per year, generating cost –benefit ratios ranging from .97 to 2.90 and cost-effectiveness, ranging from approximately $52,000 to $155,000 (meaning that it costs between 52k and 155k to prevent each case of HIV infection). Though all but one of these cost – effectiveness ratios are significantly less than the lifetime medical cost of a new HIV infection, Insite does not perform as well as NEPs that have been studied previously. Gold et al. (1997), Jacobs et al. (1999), and Laufer (2001) all generate cost – effectiveness ratios ranging

from $15,000 to $35,000, once their numbers are adjusted for inflation and the exchange rate. Likewise, the cost – benefit ratios are all of moderate magnitude, with the average having a value of 1.78. If one further considers the sensitivity analyses using 20 and 40 percent rates of needle sharing, reported in parentheses in Table 3, the results do not change significantly. In only two of the 10 reported results does the benefit to cost ratio not exceed unity – and this only occurs when a 20 per cent needle sharing rate is used (a value well below the accepted standard in the medical literature). When we consider the benefit to cost ratio of the "average" model, we find a range of 1.5 to 2.0, a clear indication that Insite can be seen to have a positive economic return on investment.

This result should not be a surprise, however. The NEP in Vancouver's Downtown Eastside is well-established. Assuming that the NEP has reached it maximum effectiveness, any further impact on the number of new HIV infections is likely to be more expensive. This is particularly the case for Insite, as it not only provides needles, but other injecting equipment necessary, as well as staff to assist users in particular ways. Despite this lack of a high magnitude cost – benefit ratio, the facility very clearly pays for itself, regardless of which model is employed.

Table 4: Savings From Average Number of Annual Deaths Prevented at Insite

	Number 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

If we turn to the number of premature deaths prevented as a result of Insite, (Table 4), the average number prevented per year (2.87) is quite low. But again, given the high value per death prevented, even with our very conservative figures, total savings per year from prevented premature deaths cover approximately 50 percent of Insite's operating costs alone. The large magnitude of savings becomes manifest when considered in conjunction with the savings from new HIV infections prevented. Table 5 shows that once prevented premature deaths are included in the analysis, benefit to cost ratios are never below 1.5, have a high 4.02, and an average of 2.56. Again, because of the very conservative values applied to capture the change in needle-sharing by those IDUs who use Insite (and because of the expansive range of services included in costs), these ratios should be considered as underestimates: the benefit to cost ratios are almost certain to be significantly greater.

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	2.70
Laufer (2001) - Complex	2.85	1.58	4.43	1.50
Jacobs et al. (1999)	4.05	1.94	5.99	2.03
Kaplan and O'Keefe (1993)	8.55	3.31	11.86	4.02
Average	5.25	2.31	7.56	2.56

7. Discussion and Directions for Future Research

The establishment of Insite has had a positive impact on the health outcomes of the IDU population in Vancouver's Downtown Eastside. Through reductions in new HIV infections and reductions of premature deaths, public health has improved in a measureable manner for this population. Therefore, as discussed above, while using a business model of cost – effectiveness and cost – benefit to evaluate a public health concern may be problematic, even within this framework Insite is still a good value for the resources that it consumes.

This research shows that the establishment of North America's first supervised injecting facility has a net positive effect on Canadian society, from a cost perspective, in particular. Whether or not this particular policy initiative saves public health care funds may aid in the decision of whether or not to keep Insite open, but we recognize that this decision also encompasses a myriad of other moral and political dimensions that cannot be addressed here.

We should also note that the current analysis is not without its limitations. On the costing side, greater detail in fixed versus variable costs would have allowed a better assessment of how an expansion of Insite would impact public health care costs. On the benefit side, a number of health care outcomes such as those investigated by Frei et al. (2000) were not included because of a lack of availability of data. 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. Consequently, the factors not considered in our analysis of Insite may very well be significant in terms of increasing the benefit to cost ratios and further justifying the presence of Insite from the perspectives of cost-benefit and cost-effectiveness analysis. Lastly, there are the limitations of the mathematical modeling itself. All benefits are assumed to be linear, and this restricts the ways in which expansions of Insite can be assessed. And, of course, like any empirical analysis, the mathematical modeling is only as reliable as the data used in the calculations. However, as stated repeatedly in the analysis, conservative values have been used as much as possible when making the calculations within each of the models used.

Directions for future research primarily flow from the limitations mentioned previously – and all of these limitations would likely point to even more positive outcomes for the economic benefits of Insite. Proper assessment of the costs of 24 hour operation of Insite should be undertaken to investigate whether or not the benefits from increased operating hours are greater than the increased operating costs; this would be expected, given the nature of fixed and variable costs. Second, 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, and a correspondingly diminished use of various medical treatments. Third, as shown by Tyndall et al. (2006a), Wood et al. (2006) and Wood et al. (2007), referral rates to detoxification services are significantly higher for those who use Insite relative to those who do not – this, in turn, would be expected to further diminish the costs of medical treatment. Additionally, given the demonstrated effectiveness of opiate maintenance in Switzerland, where 75 percent of economic benefits flow from decreased criminal justice costs (crime decreasing because of a reduced need for acquisitive crime), programs of opiate maintenance would appear to deserve serious consideration (Frei et al, 2000).

Finally, when considering Insite's role in responding to the problems of drug addiction, it is important to place our results alongside those of other treatment programs. Belenko et al. (2005) conducted a substantial review of drug treatment programs 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 were below 5 to 1 and many were below 3 to 1. This analysis places Insite alongside a variety of treatment programs that could be put in place for injection drug users 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 programs, voluntary prison treatment programs, and drug courts. It should be noted, however, that Belenko et al. (2005) do not believe it

is possible to make any generalizations across the different studies of drug treatment. In making this argument Belenko et al. (2005) note that each study has used different methodologies, assessed different populations, and measured different benefits. As a consequence, separating the different ranges for particular types of treatment is done for illustrative purposes only.

With regard to drug treatment programs, the benefit to cost ratios ranged from 1.33 to 4.34. Though many of the benefit to cost ratios for Insite fall within this range, the difficulty 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 programs – 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. And 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. And perhaps this is the point: Insite can be seen, in economic terms, to be one of many productive treatment modalities for responding to the problems of drug addiction in Vancouver's Downtown Eastside.

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