International Journal of Drug Policy 67 (2019) 9–18

Contents lists available at ScienceDirect

International Journal of Drug Policy

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

Research Paper

The projected costs and benefits of a supervised injection facility in Seattle, WA, USA

J.E. Hood[a,*], C.N. Behrends[b], A. Irwin[c], B.R. Schackman[b], D. Chan[f,d], K. Hartfield[a], J. Hess[e], C. Banta-Green[d], L. Whiteside[e], B. Finegood[f], J. Duchin[a,d,e]

[a] Public Health – Seattle & King County, 401 Fifth Avenue, Suite 1250, Seattle, WA, United States
[b] Weill Cornell Medical College, 1300 York Ave. Box 65, New York, NY, 10065, United States
[c] Law Enforcement Action Partnership, Silver Spring, MD, United States
[d] University of Washington, School of Public Health, 1959 NE Pacific St, Seattle, WA, 98195, United States
[e] University of Washington, School of Medicine, 1959 NE Pacific St, Seattle, WA, 98195, United States
[f] King County Department of Community and Health Services, 401 Fifth Avenue, Suite 500, Seattle, WA, United States

ARTICLE INFO

Keywords:
Supervised injection facility
Cost-benefit
Cost-effectiveness
People who inject drugs
Harm reduction
Overdose

ABSTRACT

Background: As one strategy to improve the health and survival of people who inject drugs, the King County Heroin & Opioid Addiction Task Force recommended the establishment of supervised injection facilities (SIF) where people can inject drugs in a safe and hygienic environment with clinical supervision. Analyses for other sites have found them to be cost-effective, but it is not clear whether these findings are transferable to other settings.
Methods: We utilized local estimates and other data sources deemed appropriate for our setting to implement a mathematical model that assesses the impact of a hypothetical SIF on overdose deaths, non-fatal overdose health service utilization, skin and soft tissue infections, bacterial infections, viral infections, and enrollment in medication assisted treatment (MAT). We estimated the costs and savings that would occur on an annual basis for a small-scale pilot site given current overdose rates, as well as three other scenarios of varying scale and underlying overdose rates.
Results: Assuming current overdose rates, a hypothetical Seattle SIF in a pilot phase is projected to annually reverse 167 overdoses and prevent 6 overdose deaths, 45 hospitalizations, 90 emergency department visits, and 92 emergency medical service deployments. Additionally, the site would facilitate the enrollment of 41 SIF clients in medication assisted treatment programs. These health benefits correspond to a monetary value of $5,156,019. The annual estimated cost of running the SIF is $1,222,332. The corresponding cost-benefit ratio suggests that the pilot SIF would generate $4.22 for every dollar spent on SIF operational costs. The pilot SIF is projected to save the healthcare system $534,453. If Seattle experienced elevated overdose rates and Seattle SIF program were scaled up, the health benefits and financial value would be considerably greater.
Conclusion: This analysis suggests that a SIF program in Seattle would save lives and result in considerable health benefits and cost savings.

Introduction

Drug overdose deaths in the United States have more than tripled between 1999 and 2015 (CDC, 2017). The increase in overdose mortality rates accelerated in recent years, coinciding with an increase in the rate of synthetic opioid (e.g. fentanyl) involved overdose deaths (CDC, 2017). The unprecedented increase in drug overdose mortality rates has prompted some cities, including Denver, Ithaca, Philadelphia, San Francisco, and Seattle, to consider establishing supervised injection facilities (SIF) (Ducharme, 2018). Currently, no government-sanctioned SIFs operate in the United States, though approximately 100 sites exist in Canada, Europe, and Australia (Ducharme, 2018). Evaluations of existing SIFs provide evidence that such facilities can effectively (1) prevent fatal overdose, (2) prevent infection by providing a clean environment and supplies for injection, (3) connect people who use drugs to social services, health services, treatment programs, and a supportive social network, and (4) decrease community impacts of injection drug use (Jozaghi, 2012; May, Bennett, & Holloway, 2018; Potier, Laprevote,

* Corresponding author at: Public Health – Seattle & King County, 401 5th Avenue, Suite 1250, Seattle, WA, 98104, United States.
E-mail address: julia.hood@kingcounty.gov (J.E. Hood).

https://doi.org/10.1016/j.drugpo.2018.12.015

Dubois-Arber, Cottencin, & Rolland, 2014).

In 2016, the King County Heroin and Prescription Opiate Addiction Task Force made eight recommendations for combatting the opioid epidemic in King County, Washington, including the recommendation to establish two facilities where people can inject drugs in a safe and hygienic environment with medical supervision by a trained nurse (Heroin & Prescription Opiate Addiction Task Force Final Report & Recommendations, 2016). To inform program planning, we projected the costs and benefits of a single SIF located in Seattle, WA, USA, where one-third of King County residents reside and half of the county's overdose deaths occur (King County Medical Examiner Office, 2018). Although similar assessments have been conducted for other settings (Andresen & Boyd, 2010; Enns et al., 2016; Irwin, Jozaghi, Bluthenthal, & Kral, 2017, Irwin, Jozaghi, Weir et al., 2017; Jozaghi, Reid, & Andresen, 2013; Larson, Padron, Mason, & Bogaczyk, 2017; Pinkerton, 2011), it was unclear whether their findings were applicable to Seattle, which is unique in the following ways: overdose mortality rates have increased less dramatically than that in other North American cities, few HIV diagnoses occur among people who inject drugs, most people with HIV are virally suppressed and thus unlikely to transmit HIV to others, and large needle exchange programs are well-established (CDC, 2017; HIV/AIDS Epidemiology Unit, 2017).

We assessed the potential impact of a hypothetical Seattle SIF on overdose death, healthcare utilization for overdose, healthcare utilization for drug-related infections, prevention of HIV and hepatitis C, and linkage of SIF clients to opioid use disorder treatment programs. We estimated the costs and savings that would occur on an annual basis for one small-scale pilot site given current overdose rates. Alongside this base model, we also projected benefits and savings for three additional scenarios: (1) Seattle experiences elevated overdose rates during the pilot period; (2) SIF program is scaled-up and overdose rates remain constant; and (3) SIF program is scaled-up and Seattle experiences elevated overdose rates.

Methods

Estimated cost of hypothetical SIF in Seattle

The current estimated annual budget to operate a single SIF in the Seattle area includes funding for safe injection services and supplies. Of the $1,222,332 annual operating budget estimated for the pilot SIF, 57% was dedicated to King County salaries and benefits (corresponding to 1.5 registered nurses, 1 SIF manager, and 4.5 education specialists). One-third of the pilot SIF's budget was dedicated to the following expenses: supplies, disposal costs, staff training, cell phones, janitorial services, security, peer educators, computers, and rent. Of the $3,033,340 annual operating budget estimated for the scaled-up SIF program, 54% was dedicated to King County salaries and benefits (corresponding to 3.8 registered nurses, 2 SIF managers, and 11 education specialists) and 36% was dedicated to expenses (listed above). Neither budget included costs associated with establishing the SIF or ancillary services (e.g. naloxone distribution, on-site medication assisted treatment services, case management, or wound care) (Table 1).

Population estimates

The proportion of people who inject drugs (PWID) in the past 12 months in King County has previously been estimated as 1.43% of the King County population (ages 15–69 years old) (Thiede & Buskin, 2014). This proportion was applied to 2015 King County population estimates (Office of Financial Management, 2017), resulting in the estimate that 21,863 PWID live in King County, which served at the denominator for the estimated King County incidence of HIV, HCV, and hospitalizations for skin and systemic infections.

The pilot SIF site was assumed to operate 9 hours per day, 5 days per week; the scaled-up program was assumed to operate 18 hours per day,

Table 1
Assumptions Underlying Cost Analysis.

Input Parameter					Notes	Source
Annual cost of Seattle SIF: Pilot Project: $1,222,332 Scaled-Up Program: $3,033,340					Based upon King County internal estimates of staff salaries, fringe benefits, supplies, training, communications, rent, janitorial services, and indirect rate.	
21,863 PWID in King County					Assume that 1.43% of 2015 King County population estimates (15-69 years old, n = 1,528,909) have injected drugs in the past year. This estimate serves as the denominator for the hospitalization rate calculation and HCV incident rate calculation.	(Office of Financial Management, 2017; Thiede & Buskin, 2014)
Pilot: The Seattle SIF would have capacity for 35,100 injection visits annually.					The pilot SIF would have 6 booths that could accommodate 15 clients per hour; it will operate 45 hours per week, 52 weeks per year.	
Scaled-up Program: The Seattle SIF would have capacity for 112,812 injection visits annually.					The scaled-up SIF program would have 10 booths that would accommodate, on average, 17.2 clients per hour. It will operate 18 hours per day, 365 days per year.	
SIF Client Type	Pilot		Scaled-up Program		Survey respondents asked how often would use a SIF; the distribution of responses to this question applied to the projected number of annual SIF visits (see Methods Section).	2017 Needle Exchange Survey
	# of annual visits	# of clients	# of annual visits	# of clients		
High SIF Utilizers	130	201	182	462		
Moderate Utilizers	65	101	91	231		
Low Utilizers	26	71	36	163		
Sporadic Utilizers	13	41	18	93		
Total # of Clients	–	**414**	–	**950**		

7 days per week. The facility in the pilot was assumed to include 6 injection booths, whereas the facility in the scaled-up program was assumed to have 10 booths. In consultation with program planners, we assumed that each booth could accommodate, on average, 2.5 clients per hour. We assumed that utilization would equal capacity for the pilot site (e.g. 2.5 visits per booth-hour) and utilization would be slightly lower than capacity in the scaled-up site (e.g. 1.7 visits per booth-hour[1]), due to the expanded hours of operation and number of booths. Thus, we estimated that the pilot SIF would accommodate 35,100 annual visits and the SIF in the scaled-up program would accommodate 112,812 annual visits.

Public Health - Seattle & King County (PHSKC) conducts a bi-annual survey among its needle exchange clients; methods of this survey have been described elsewhere (Jenkins et al., 2011; Kummer, Thiede, & Hanrahan, 2015). The 2017 Syringe Exchange Survey asked how often clients would visit a hypothetical SIF, a measure that has been correlated with actual use elsewhere (DeBeck et al., 2012). We assumed that factors including illness, incarceration, travel, and changes in drug use patterns would cause actual SIF utilization, averaged across a 12-month period, to be roughly half that reported in the survey. Among survey respondents who indicated they would use the SIF (80% of all respondents), 49% reported they would use the SIF "daily" (assumed to visit the SIF on 50% of days in operation), 24% a "couple of times per week" (assumed to visit the SIF on 25% of days in operation), 17% a "couple of times per month" (assumed to visit the SIF on 10% of days in operation), and 11% a "couple of times per year" (assumed to visit the SIF on 5% of days in operation). We triangulated these relative proportions and the annual number of days of operation to estimate the average number of times a client would visit the SIF in a given year, as represented in the denominator in the equation below. Assuming that the SIF would be located in an area with sufficient demand to meet the operational capacity of the site, we divided the visit capacity of the site by the estimated average number of visits completed per client each year in order to estimate the number of unique clients, as represented in this equation:

$$C = \frac{V}{\sum_{i=1}^{4} (P_i \times F_i \times D)}$$

Where,

C = number of unique clients

V = annual SIF visits (e.g. 35,100 for pilot site & 112,812 for scaled up site)

i = category of client type (e.g. frequent, moderate, low, sporadic SIF utilizers)

P = proportion of all SIF clients

F = frequency of SIF visits (e.g. proportion of days in operation that the client would visit SIF)

D = days the SIF will operate each year (e.g. 260 for pilot site and 365 for scaled-up site)

Through this calculation, we estimated the pilot site would serve 414 unique clients who would complete, on average, 85 visits each year. The scaled-up program was estimated to serve 950 unique clients who would complete, on average, 119 annual visits.

Estimation of SIF's potential to impact health outcomes & healthcare expenditures

Previous cost-benefit analyses of SIFs were oftentimes focused upon averted HIV infections and thus used dynamic models that accounted for infection transmission and indirect benefits of averted infections (Andresen & Boyd, 2010; Enns et al., 2016; Jozaghi et al., 2013; Pinkerton, 2011). After considering local HIV and HCV epidemiological data (described below) we decided to focus our model on the following outcomes: overdose death, healthcare utilization for overdose, healthcare utilization for injection drug-related infections, and linkage of SIF clients to opioid use disorder treatment programs. Since we were projecting the direct effect of the SIF on clients' overdose mortality risk and healthcare utilization, outcomes unlikely to indirectly affect non-SIF clients, we used a static model (Pitman et al., 2012). The static model was implemented in Microsoft Excel. Projections related to fatal and non-fatal overdose analyses were conducted separately for the four scenarios (e.g. scale of program by underlying overdose rates). All other projections were conducted for two scenarios (e.g. pilot versus scaled-up site), since overdose rates were assumed to not impact drug-use related infections and treatment referrals.

Non-fatal overdose

Several of the parameters used to predict benefits related to overdose prevention are derived from Vancouver, Canada, a city approximately 150 miles (240 km) north of Seattle of comparable population size. Largely as a result of the influx of fentanyl in the drug supply, the number of overdose deaths in Vancouver increased suddenly from 160 in 2015 to 281 in 2016 to 436 in 2017 (BC Coroners Service, 2018). Seattle has not yet experienced such an increase in fentanyl use; consequently, the number of overdose deaths increased more modestly between 2015 and 2017, from 147 to 184, respectively (King County Medical Examiner Office, 2018).

We based the overdose prevention benefits of the Seattle SIF on the rate of overdoses (# of overdoses per # of injection room visits) at InSite, a large SIF that operates in Vancouver (Vancouver Coastal Health, 2017). The 2015 InSite overdose rate (4.8 overdoses per 1000 visits) served as the "current" overdose rate, while the 2016 InSite rate (9.5 overdoses per 1000 visits) served as the "elevated" overdose rate (Vancouver Coastal Health, 2015; Vancouver Coastal Health, 2016). These rates were applied to the anticipated number of visits to the pilot SIF and scaled-up SIF program in order to estimate the number of reversed overdoses at the Seattle SIF under the four modeled scenarios. In this manuscript "reversed overdose" refers to all overdoses that are effectively clinically managed (e.g. administer naloxone and/or provide respiratory support) by SIF staff.

To estimate the savings corresponding to each non-fatal overdose, we assumed that clinical staff at the SIF would manage 97.8% of overdoses that occur at the facility (MSIC Evaluation Committee, 2003), thus preventing Emergency Medical Service (EMS) deployments, Emergency Department (ED) visits, and hospitalizations relating to these overdoses. Local data suggest that currently, in the absence of a SIF, 911 is called for 56% of overdoses (Kummer et al., 2015), 77% of overdoses with EMS response result in an ED visit[2], and 47% of ED patients presenting for drug overdose are admitted to the hospital.[3] These estimates were used to estimate the frequency of non-fatal overdose (in absence of SIF) and number of healthcare encounters that could be averted through the SIF's management of overdoses (Box 1).

In these equations, O_{KC} represents the number of overdoses that occurred in King County in 2016, O_{hosp} represents the number of hospitalizations for overdoses among King County residents in 2016 (n = 1782), V represents number of annual SIF visits, R represents the rate of overdose per SIF visit, O_{SIF} represents the number of overdoses that will be managed by the SIF, and A represents averted EMS deployments, ED visits, and hospitalizations. Hospitalization data was derived from the Washington State Comprehensive Hospital Abstract Reporting System (CHARS), which contains diagnosis codes, dates of admittance/discharge, and billing charges for all hospitalizations that occur in Washington State (Washington Department of Health, 2017).

[1] The 1.7 visits per booth-hour was based upon InSite's reported utilization (Vancouver Coastal Health, 2018).

[2] Unpublished King County EMS programmatic data.

[3] Unpublished estimate from 2017 UW Medicine and Harborview Medical Center Emergency Department visits.

Box 1
Inputs for Overdose Projections.

# of overdoses that occurred in King County in 2017	$O_{KC} = \frac{O_{hosp}}{.56 \times .77 \times .47}$
# of overdoses that will be managed by the SIF	$O_{SIF} = V \times R \times .978$
# of averted EMS deployments	$A_{EMS} = O_{SIF} \times .56$
# of averted ED visits	$A_{ED} = A_{EMS} \times .77$
# of averted hospitalizations	$A_{hosp} = A_{ED} \times .47$

We used CHARS data to estimate the annual number of hospitalizations in King County tied to ICD-10 codes signifying overdose and the corresponding charges (WADOH). In collaboration with analysts at the University of Washington, we analyzed ED visit data from the University of Washington Medical Center (UWMC) and Harborview Medical Center (HMC); these health systems account for one-quarter of King County's drug-related hospitalizations (per CHARS data). The mean adjusted charge for an ED visits with ICD-10 codes indicating a drug-related diagnosis was $6815; we assumed this adjusted charge was comparable to that of other EDs in King County.

To estimate the *cost* for hospitalization for overdose, we applied a cost-to-charge ratio (0.39, derived from a Washington State report (WADOH, 2017)) to the mean hospital charge and subtracted the estimated ED cost from the estimated hospitalization cost, since ED costs are included into the hospitalization charge if patients are transferred from the ED (DHHS, 2015; HMSA, 2016). We assumed that all patients admitted for overdose transferred from the ED. These calculations are represented by the following in which H represents hospitalizations and $R_{C:C}$ represents the cost to charge ratio:

$$Cost_H = (Charge_H \times R_{C:C}) - Cost_{ED}$$

Ultimately, we estimated that hospitalization for a non-fatal overdose on average represented a cost of $17,083 (Table 2).

Fatal overdose

To date, no overdose deaths have ever been reported to occur at a SIF (Potier et al., 2014). An evaluation of InSite clients concluded that SIF utilization is not associated with increased overdose risk (Milloy et al., 2008). To estimate the number of overdose deaths prevented by the SIF, we multiplied the number of overdoses anticipated to occur at the SIF by a ratio of fatal to non-fatal overdoses, as represented in this equation:

$$A_{Deaths} = O_{SIF} \times \frac{O_{KCdeaths}}{O_{KC}}$$

In this equation, A_{Deaths} represents the number of deaths averted by the SIF, O_{SIF} represents the number of overdoses that will be managed by the SIF, O_{KC} represents the number of overdoses that occurred in King County in 2016 (8793, derived above), and $O_{KCdeaths}$ represents the number of drug overdose deaths that occurred in King County in 2016 (337, King County Medical Examiner Office, 2018). This approach yielded the estimate that 1 in 26 overdoses in King County is fatal, which is similar to that estimated elsewhere (Darke, Mattick, & Degenhardt, 2003; Neale et al., 2003).

There are different approaches to assigning monetary value to a prevented death. We adopted a productivity valuation approach similar to the one used in recent SIF cost analyses (Irwin, Jozaghi, Bluthenthal et al., 2017; Irwin, Jozaghi, Weir et al., 2017), but based on the productivity value on the median per capita income in King County (Department of Commerce, 2016). We also adjusted the approach by weighting the median income by the probability of remaining alive from one year to the next. While the income level of people who use drugs is lower than county average (Glick, Burt, Moreno, Ketchum, & Thiede, 2016), the county median income level was used to represent our county's valuation of its residents. We subtracted the median age of PWID who participated in the King County Syringe Exchange Survey (e.g. 39)[4] from the typical age of retirement (e.g. 65) in order to estimate the average number of years between overdose and retirement (e.g. 26). To calculate the present value of a single prevented overdose, we applied this equation:

$$V = \sum_{i=0}^{n} \frac{S(a+i) + S(a+i+1)}{2} \times \frac{W}{1.03^i}$$

In this equation, n represents average number of years to retirement (e.g. 26 years), S represents the percent of PWID who survive to the middle of the following year, a represents the median age of PWID, W represents the median King County annual per capita income (e.g. $41,664), and 1.03 represents the 3% discount rate. The adjustment for survival was based upon life tables published for the general population (Arias, Heron, & Xu, 2014) and assumes that the standardized mortality rate for PWIDs is 11 times that of the general population (Mathers et al., 2013), but that PWIDs who survive to 55 will have comparable survival rates to the general population after age 55. Ultimately, the value of each averted fatal overdose was estimated to be $566,539; this figure was multiplied by the estimated number of overdoses prevented annually by the hypothetical SIF.

Drug-related infections

We estimated the hospitalization rate for skin and soft tissue infections (SSTI) and systemic infections (including sepsis, bacteremia, and endocarditis) by analyzing CHARS data. We restricted this database to King County hospitals and analyzed the number of hospitalizations and cost of hospitalizations corresponding to patients with an ICD-10 code signifying substance use and a diagnosis code signifying SSTI, sepsis, bacteremia, and/or endocarditis. To estimate hospitalization rates, the number of hospitalizations served as the numerator and the estimated number of PWID (e.g. 21,863) as the denominator (Table 3), as represented by this equation:

$$R_{hospitalization} = \frac{N_{hospitalizations}}{21863}$$

To estimate the annual rate of ED visits for systemic infections and/or SSTI we calculated the percent of 2017 UWMC and HMC ED visits for drug-related systemic infection and/or SSTI that resulted in hospitalization and calculated the ED visits by multiplying the hospitalization rate (from CHARS) by the inverse of this proportion, as represented by this equation:

$$R_{EDvisit} = R_{hospitalization} \times \frac{1}{P}$$

For example, the hospitalization rate for drug-related systemic infection (with or without SSTI) was 5.6 per 100 PWID-year and 80% of UWMC and HMC ED visits for drug-related systemic infection resulted

[4] Unpublished.

Table 2
Values, sources, and equations used to predict non-fatal overdose-related outcomes and savings.

Input Parameters & Assumptions	Source	Pilot, Current OD Rates	Pilot, Elevated OD Rates	Scaled-Up rogram, Current OD Rates	Scaled-Up rogram, Elevated OD Rates
OUTCOMES					
# of overdoses anticipated to occur annually at Seattle SIF					
Current OD rates: 4.8 overdoses will occur per 1000 SIF visits.	Vancouver Coastal Health	= 35,100*.0048			
Elevated OD Rates: 9.5 overdoses will occur per 1000 SIF visits.		= 167 overdoses	333	541	1072
# of overdoses that effectively managed SIF staff without EMS Support					
97.8% of overdoses that occur at SIF will be effectively managed by SIF staff and will not require further clinical care.	MSIC Evaluation Committee (2003)	= 97.8%*167 = 164	326	530	1048
# ofaverted deployments of emergency medical services for non-fatal overdoses that occur at SIF					
911 is called for 56% of overdoses witnessed outside of supervised injection facilities.	Kummer et al. (2015)	= 164 * 56% = 92	182	297	587
# ofaverted emergency department visits for non-fatal overdoses that occur at SIF					
77% of overdoses with EMS response would result in Emergency Department Visit	KC EMS Data	= 92*77% =71	140	228	452
# ofaverted hospitalizations for non-fatal overdoses that occur at SIF					
47% of ED patients presenting for drug overdose will be admitted.	HMC data	= 71 * 47% = 34	66	107	212
SAVINGS					
Value of Averted overdose-related EMS incidents:					
Cost of single EMS incident = $700	KC data	= 92 * $700 = $64,350	$127,664	$207,594	$410,864
Value of Averted overdose-related EDvisits:					
Adjusted Cost of single ED Visit = $6815	HMC data	= 71 * $6,815 =$483,865	$954,100	$1,556,230	$3,080,039
Value of averted overdose-related hospitalizations:					
Mean Charge of OD hospitalization* = $43,802	WADOH	= (34 * $17,083) – (34*$6,815)			
Cost to Charge Ratio : 0.39 Mean *cost* of overdose-related hospitalization = $17,083		= $ 349,112	$677,688	$1,098,676	$2,176,816

Acronyms: EMS = Emergency Medical Services; ED = Emergency Department.
*^The *Comprehensive Hospital Abstract Reporting System* was queried for ICD-10 codes connoting drug overdose: T40, T43.

Table 3
Values, sources, and equations used to predict averted overdose deaths and associated value of lives saved.

Input Parameters & Assumptions	Source	Pilot, Current OD Rates	Pilot, Elevated OD Rates	Scaled-Up Program, Current OD Rates	Scaled-Up Program, Elevated OD Rates
		OUTCOMES			
Total # of overdoses in King County in 2016	WADOH (See Methods Section)	=1,782/0.20 =8,793			
# drug overdose deaths in 2016	King County Medical Examiner Office	337			
Ratio of fatal to non-fatal overdose		= 337/8793 = .0383	.0383	.0383	.0383
# of deaths averted by the SIF		=.0383*167 = 6	13	21	41
		VALUE OF DEATHS AVERTED			
Present Value of Single Life Saved	(See Methods Section)	$566,539	$566,539	$566,539	$566,539
Value of Prevented Overdose Deaths		=6*$566,539 =$3,399,234	$6,798,468	$11,330,780	$23,228,099

in hospitalization; thus, the rate of ED visits for drug-related systemic infection (with or without SSTI) was 1.25 times the hospitalization rate (e.g. 7.0 per 100 PWID-year).

In a cohort of PWID in Vancouver, frequent SIF use was associated with a 42% reduction in cutaneous infection (Lloyd-Smith et al., 2008). We assumed a comparable relationship would exist between SIF utilization and systemic infections (e.g. sepsis, bacteremia, or endocarditis). We also assumed that the influence of SIF utilization on the incidence of SSTI and systemic infections would diminish in proportion to diminished utilization of the SIF, operationalized by multiplying 42% by the frequency of visits relative to the "high utilizer" group (Table 3). For example, to estimate the infection rate reduction among moderate SIF users, we *halved* the infection rate reduction estimate to 21%, because we expected that "moderate" SIF utilizers would visit the SIF half as frequently as the "high" SIF utilizers. To estimate the number of hospitalizations and ED visits prevented by the SIF, we applied the following equation:

$$P = \sum_{i=1}^{4} [(C_i \times R) - (C_i \times R \times (1 - r_i))]$$

In this equation, P represents prevented hospitalizations or ED visits, i represents the four categories of SIF clients, C represents the number of unique SIF clients in each category (i) ; R represents the rate of hospitalization or ED visit (derived from CHARS); and r represents

Table 4
Values, sources, and equations used to predict healthcare utilization for injection-related infections and wounds.

Input Parameters & Assumptions	Source	Estimates for Pilot	Estimates for Scaled-Up Program
	OUTCOMES		
Rate of Hospitalization in Absence of SIF:			
There were 2142 hospitalizations in 2016 for injection-related wounds and infections[a], excluding Hepatitis & HIV.	WADOH	Overall: 2142 / 21863 = 9.8 per 100 PWID-yr	
1,221 hospitalizations for systemic infection (with or without cutaneous complaint)		Systemic Infection : 1221 / 21863 = 5.6 per 100 PWID-yr	
921 for skin and soft tissue infections (SSTI) *without* systemic infection.			
21,863 PWID in King County	Table 1	SSTI (only): 921/21863 = 4.2 per 100 PWID	
The SIF's impact on the rate of hospitalizations and ED visits for injection-related wounds and infections[a] will be proportional to frequency of SIF visits.	Table 1 Lloyd-Smith et al. (2010); see Methods Section.		
# of Hospitalizations Prevented by SIF			
$R_{\text{Hospitalization for Systemic Infection and/or SSTI}}$ = 9.8 per 100 PWID-yr		**11**	**25**
# of ED Visits for Systemic Infections Prevented by SIF			
80% of ED patients presenting with systemic infection will be admitted. The rate of ED visits for systemic infections is 1.25 times the hospitalization rate $R_{\text{ED visits for Systemic Infection}}$ = 7.0 per 100 PWID-yr	UWMC/HMC unpublished data	**8**	**18**
# of ED Visits for Cutaneous Wounds/Infections Prevented by SIF			
44% of ED patients presenting with SSTI will be admitted. The rate of ED visits for systemic infections is 2.3 times that of the hospitalization rate. $R_{\text{ED visits for SSTI}}$ = 9.5 per 100 PWID-yr	UWMC/HMC unpublished data	**11**	**24**
	SAVINGS		
Cost for single ED Visit = $6815	UWMC/HMC unpublished data	= $6,815*(8 + 11) = **$129,485**	**$286,230**
Mean charge of hospitalizations drug-related wounds & infections = $32,220. Cost to Charge Ratio : 0.39 Mean cost of hospitalization = $18,568	WADOH	=($18,568*11)-(11*6815) = **$129,282**	**$293,825**

[a] The *Comprehensive Hospital Abstract Reporting System* was queried for ICD-10 codes connoting drug use (F11, F13-F16, F18-F19) AND abscess (G061, G062, L020, L021, L022, L024, J851), cellulitis (L0300, L0310, L0311, L032, L0335, L038), ulcers (L089, L979), endocarditis (I330, I39, I38), septicaemia (A410, A412, A419), osteomyelitits (M4620, M4625, M4629, M8617, M8618, M8661, M8663, M8666, M8681, M8691, M8695), staphylococcal infection (A490, A499, B956), and septic arthritis (M0000, M0002, M0004, M0005, M0006, M0008, M0009), myositis (M6005, M6008), or necrotizing fasciitis (M726). Acronyms: PWID= Persons who Inject Drugs.

the reduction in infection rate adjusted for the frequency of visits (e.g. high (r = 42%), moderate (r = 21%), low (r = 8%) sporadic (r = 2%) (see Table 4).

To estimate the savings corresponding to prevented hospitalizations, we estimated the mean charge for drug-related infections (derived from CHARS (WADOH)). We applied the same equations as those used to estimate the value of prevented hospitalizations and ED visits for non-fatal overdose.

Referrals to programs that provide medication for opioid use disorder

Among participants in the 2017 King County Needle Exchange Survey, 41% reported that they had "been on" methadone, buprenorphine, or naltrexone in the past 12 months. In cohort of PWID recruited from InSite, regular InSite utilization was associated, in adjusted analyses, with a 33% greater likelihood of initiating addiction treatment programs, including methadone treatment and inpatient programs (DeBeck et al., 2011). Thus, we assumed that 41% of all Seattle SIF users would receive medications for opioid use disorder (MOUD), regardless of their SIF utilization; but that an additional 13.5% of *regular* Seattle SIF clients would enroll into a MOUD program as a result of a SIF-initiated referral, as reflected in this equation:

$$Treatment = (Clients_{High/Moderate} \times .135)$$

Enrollment in drug treatment programs, methadone and buprenorphine in particular, both improves health outcomes and survival, as well as increases monetary savings by reducing healthcare utilization and encounters with the correctional system (Murphy & Polsky, 2016). Studies examining healthcare resource utilization and the costs associated with opioid use disorder treatment programs have shown that despite increased healthcare costs associated with outpatient and prescription use, opioid treatment is associated with lower total healthcare costs because of lower utilization of high-cost services, such as emergency department and inpatient care (Murphy & Polsky, 2016). To estimate savings to the healthcare system for SIF clients referred and retained in a MOUD program, we referred to an analysis conducted by Kaiser Permanente Northwest that compared the mean total annual costs to the health plan for Kaiser beneficiaries diagnosed with opioid use disorder (OUD) who had at least one methadone visit versus no methadone visits and limited interactions with the Addiction Medicine Department (McCarty et al., 2010). This analysis found that the mean difference in annual healthcare expenditures between OUD-diagnosed patients enrolled in methadone and not enrolled in methadone was, on average, $11,531 (in 2004 dollars), equivalent to $14,651 in 2016 dollars. To estimate the value of SIF-referrals to MAT, we multiplied the number of regular SIF clients who are projected to enroll in MOUD as a result of a SIF referral by $14,651.

HIV and hepatitis C infections

We estimated the incidence of HIV and HCV (that would subsequently become chronic) infections using this equation (Box 2):

$$R = \frac{N \times F}{U \times P} \times C$$

We applied the estimated HIV and HCV incidence rates derived to the number of unique SIF clients in order to estimate the expected number of HIV and HCV infections that would occur in this group of PWID in the absence of the SIF. This exercise suggested that the low baseline HIV incidence rate and high baseline HCV prevalence rate (resulting in a small proportion of PWID currently susceptible to HCV), when applied to a small number of PWID, would limit the number of incident HIV and HCV infections that could possibly be averted by the SIF. Therefore, we did not include savings associated with prevention of HIV or HCV infections in our cost analysis.

Box 2
Inputs for Hepatitis C and HIV Projections.

	Hepatitis C	HIV	Source
N = Annual number of acute infections reported to King County	21	11*	King County, 2018 HIV/AIDS Epidemiology Unit (2017) *attributed to injection drug use
F = correction factor for underreporting	12.3	1	Klevens, Liu, Roberts, Jiles, and Holmberg (2014)
U = proportion of PWID uninfected	.33	.95	Glick et al. (2016)
P = number of PWID in King County	21,863	21,863	Thiede and Buskin (2014)
C = proportion of infections that become chronic	.80	1	King County (2018)
R = estimated annual incidence rate among KC PWID	**.029**	**.0005**	**(estimated)**

Results

SIF's influence on non-fatal overdose outcomes and associated costs

If the pilot SIF experienced overdose rates comparable to InSite in 2015, then 167 overdoses would be anticipated to occur and be reversed annually at the pilot SIF (Table 2). If instead the overdoses occurred outside the SIF, they would result in 92 EMS encounters (representing a value of $64,350), 71 ED visits (representing a value of $483,865), and 34 overdose-related hospitalizations (representing a value of $349,112). In total, clinical management of overdoses at the pilot SIF would save the healthcare system $897,327. The outcomes projected for the three other scenarios are presented in Table 2 and ranged in value from $1.8 million to $5.7 million.

SIF's potential to prevent overdose deaths

The pilot SIF, given current overdose rates, is projected to prevent 6 overdose deaths annually (Table 3). The prevention of overdose deaths represents a societal value of $3,399,234. If overdose rates increased to that observed during the overdose crisis that affected Vancouver in 2016, then the pilot SIF is projected to prevent 13 overdose deaths, representing a value of $6,798,468.

If the SIF program were scaled-up, it would have the potential to avert 21 overdose deaths if overdose rates remained constant and 41 deaths if Seattle experienced elevated overdose rates, representing a value of $11.3 million and $23.2 million, respectively.

SIF's influence on infection-related hospitalizations and emergency department visits

We estimated that the rate of hospitalization for SSTI and/or systemic infection is 9.8 per 100 PWID; the rate of ED visits for systemic infections to 7.0 per 100 PWID; and the rate of ED Visits for SSTI to be 9.5 per 100 PWID (Table 4). The pilot SIF is projected to prevent 11 hospitalizations for drug-related systemic infections and/or SSTI (representing a value of $129,282), 8 ED visits for systemic infections, and 11 ED visits for SSTI (representing a value of $129,485). A scaled-up SIF program is projected to prevent 25 hospitalizations for drug-related systemic infections and/or SSTI (representing a value of $293,825), 8 ED visits for systemic infections, and 24 ED visits for SSTI (representing a value of $286,230).

Influence of SIF on enrollment into treatment programs that provide medication for opioid use disorder

For the pilot site, we project that 211 clients will receive MOUD in a given year, of whom 41 will seek MOUD as a result of a SIF-facilitated treatment referral. The monetary value associated with the enrollment of SIF-referred patients into MOUD programs is $600,691 (Table 5). For the scaled-up SIF program, we project 483 clients will receive MOUD in a given year, of whom 94 will seek MOUD as a result of a SIF-facilitated treatment referral; the corresponding value of SIF-facilitated MOUD referrals is $1,377,194 (Table 5).

Influence of SIF on the prevention of viral infection acquisition

In the absence of a SIF, we would expect 0.22 HIV diagnoses and 3.8 incident HCV infections (that would progress to chronic infections) in a group of 414 PWID (e.g. the estimated number of unique clients to Pilot SIF). The number of HIV and HCV infections prevented annually by the SIF would be (considerably) less than 1 and 4, respectively. The potential of the SIF to influence the incidence of HIV and HCV infections would be greater, yet still modest, in the context of a scaled-up SIF program.

Summary

Annually, we estimate that the Pilot SIF in Seattle (given current overdose rates) would reverse 167 overdoses and prevent 6 overdose deaths, 45 hospitalizations, 90 emergency department visits, and 92 emergency medical service deployments; and it would facilitate the enrollment of 41 clients in MOUD (Table 6). These health benefits correspond to a monetary value of $5,156,019 per year. The annual estimated cost of running the SIF is $1,222,332. The corresponding cost-benefit ratio suggests that the Pilot SIF would generate $4.22 in immediate return for every dollar spent on SIF operational costs. The pilot SIF is projected to save the healthcare system $534,453. If the Seattle SIF program were scaled up and Seattle experienced elevated overdose rates, the health benefits and financial value would be considerably greater. In this scenario, the SIF is projected to reverse 1072 overdoses and prevent 41 overdose deaths, 291 hospitalizations, 494 emergency department visits, and 587 emergency medical service deployments and to facilitate the enrollment and retention of 94 clients in medication assisted treatment programs each year. In this scenario, the annual return is projected to be $10.17 for every $1.00 invested (Table 6).

Discussion

Our analysis suggests that the SIF program in Seattle would save lives and result in considerable health benefits and cost savings, especially in the context of elevated overdose rates. The anticipated savings in healthcare expenditures (averted EMS deployments, ED visits, and hospitalizations, and reduced healthcare utilization associated with referral to substance use disorder treatment) from the SIF pilot still exceeds the SIF pilot's operational costs by $534,453. The net savings is projected to grow considerably with scale-up of the SIF program to $1.4 million (given current overdose rates).

In order to be consistent with other cost analyses for U.S. SIFs, we applied a similar approach to valuing lives saved as previous authors (Irwin, Jozaghi, Bluthenthal et al., 2017; Irwin, Jozaghi, Weir et al., 2017). This approach did not place value on life years beyond retirement age and did not use quality-adjusted life years to value life years

Table 5
Values, sources, and equations used to predict the number of SIF referrals to treatment programs that provide medications for opioid use disorder (MOUD) and the corresponding monetary value of the referrals.

Input Parameters, Assumptions, Conclusions	Source	Estimates for Pilot	Estimates for Scaled-Up Program
	OUTCOMES		
41% of KC PWID receive treatment services in a 12-month period.	2017 King County Needle Exchange Survey[a]	# of SIF clients who receive MOUD as a result of their engagement at the SIF	
High and moderate SIF utilizers will be 1.33 times more likely than the general population of KC PWID to seek treatment services.	DeBeck et al. (2011)	=(302*.135) =41	94
The number of high or moderate SIF utilizers of the pilot SIF and scaled up SIF site will be 302 and 807, respectively.	Table 1		
	SAVINGS		
Savings in healthcare expenditures associated with MOUD = $14,651	McCarty et al. (2010)	=41 * $14,651 = $600,691	$1,377,194

[a] Unpublished result.

Table 6
Summary of Anticipated Benefits and Health Savings from Seattle SIF.

	Pilot, current OD rates	Pilot, elevated OD rates	Scaled-up Program, current OD rates	Scaled-up Program, elevated OD rates
Health Outcomes				
# of Overdoses Reversed	167	333	541	1,072
# of Averted:				
Overdose deaths	6	13	21	41
Hospitalizations[d]	45	77	168	291
Emergency department visits[d]	90	159	270	494
Emergency medical service deployments[c]	92	182	297	587
HIV diagnoses	< 0.2	< 0.2	< 0.7	< 0.7
Chronic HCV infections	< 3.2	< 3.2	< 8.8	< 8.8
# of SIF clients who enroll in a treatment program that provides MOUD following SIF-facilitated referral.	41	41	94	94
Value of Health Outcomes				
Valuation of Health Outcomes[a]				
Fatal overdose lives saved	$3,399,234	$6,798,468	$11,330,780	$23,228,099
Hospitalizations	$ 478,394	$ 806,970	$ 1,392,501	$ 2,470,641
Emergency Department visits	$ 613,350	$1,083,585	$ 1,842,460	$ 3,366,270
Emergency Medical Services deployments	$ 64,350	$ 127,664	$ 207,594	$ 410,864
SIF-facilitated enrollment into a treatment program that provides MOUD.	$ 600,691	$ 600,691	$ 1,377,194	$ 1,377,194
Summary Measures				
Annual cost of program	$1,222,332	$1,222,332	$3,033,340	$3,033,340
Value of health outcomes	$5,156,019	$9,417,378	$16,150,529	$30,853,068
Cost-benefit ratio ($1 spent generates):	$4.22	$7.70	$5.32	$10.17
Net savings of healthcare expenditures[b]:	$534,453	$1,396,578	$1,786,409	$4,591,629

Abbreviations: MOUD = medication for opioid use disorder.
[a] Reversed overdoses and prevented HIV and chronic HCV infections not included (see text).
[b] Excludes value of lives saved.
[c] For overdose.
[d] For overdose and drug-related infections.

gained. It should be noted that we used a conservative approach to assigning value to lives saved. In fact, the valuation we applied in our analysis ($566,539) is a fraction of the valuation used by federal agencies (Merrill, 2017). For example, the Environmental Protection Agency sets the value of one life saved at $10 million (Merrill, 2017). Even still, the value assigned to preventing overdose deaths accounted for 66% of the value assigned to all projected health benefits generated from the pilot SIF.

The potential of SIFs to prevent HIV and HCV infections has been explored in several simulation and theoretical models, which have generally suggested a positive impact on infection rates (Andresen & Boyd, 2010; Enns et al., 2016; Irwin, Jozaghi, Bluthenthal et al., 2017; Irwin, Jozaghi, Weir et al., 2017; Jozaghi et al., 2013; Pinkerton, 2011). Although there is evidence that SIF utilization is associated with decreased syringe sharing (Kerr, Tyndall, Li, Montaner, & Wood, 2005), a risk factor for HIV and HCV acquisition, this is unlikely to translate into a large number of averted viral infections in Seattle, given local rates of HIV and chronic HCV infection in PWID. Should HIV infection rates dramatically increase among Seattle-area PWID, as seen in other parts of the United States (Conrad et al., 2015), then the SIF would have a greater potential to avert HIV infections.

There are several limitations to our analysis. The cost-benefit model was based largely upon local data and the program design envisioned by local leaders. As such, our results may not be generalizable to other settings with different overdose rates, drug markets, available services, and programmatic models. Our model only assessed the benefits associated with health outcomes and did not account for the SIF's potential to reduce crime, discarded syringes, public drug use, overcrowding of ED and hospitals, or other community concerns. Our model projected the annual benefits of a SIF using close-to current estimates; should population dynamics, overdose rates, HIV/HCV rates, SIF programmatic design, or other factors substantially change in the future, our findings may need to be revisited. There are also limitations specific to each projected outcome, described here:

- Much of the anticipated health benefit from the SIF is based upon estimated overdose incidence rates, which were calculated using the "InSite User Statistics" listed on the Vancouver Coastal Health website. Any error in the numerator (number of overdoses) or denominator (number of injections at InSite) could distort the overdose rate utilized in our model. Furthermore, our model assumes that the overdose rate estimated for InSite was a reasonable approximation for the overdose rate anticipated for a Seattle SIF, despite differences in drug-related trends observed historically between the two cities.
- There is considerable uncertainty around the estimated number of PWID in King County, the denominator used to estimate the rate of hospitalization and ED visits for drug-related infections and HIV/HCV diagnoses. Although these rates might be over- or underestimated, the influence of this source of error on the model's overall projections would be limited. For example, if the PWID population was 25% larger than we assumed, then the anticipated number of averted hospitalizations would be 43 rather than 45 for the pilot site under current OD rates. In order to estimate the number of averted hospitalizations and ED visits for drug-related infections, we referred to a cohort study that assessed the relationship between InSite utilization and SSTI prevalence (Lloyd-Smith et al., 2008); to our knowledge, the relationship between SIF utilization and systemic infection (e.g. bacteremia, sepsis, endocarditis) has not been assessed in the peer-reviewed literature.
- There is considerable uncertainty around the number of treatment referrals facilitated by the SIF and the valuation of such referrals. The number of referrals is contingent on the number of unique clients and a number of unmeasurable factors that influence treatment engagement. The valuation of treatment referrals may have been underestimated, as it did not account for reduction in incarceration (Nordlund, Estee, Mancuso, & Felver, 2004) or mortality corresponding to long-term retention in treatment programs (Sordo et al., 2017).

A strength of our analysis is that we based many of our estimates on actual program plans for the Pilot SIF in the base model and on locally-sourced data. Furthermore, we demonstrated how the benefits and savings would change if Seattle experienced elevated overdose rates and/or the SIF program was scaled-up. These results will also be useful to other jurisdictions currently considering similar public health interventions throughout North America.

Ultimately, we estimated that the Seattle pilot SIF would annually prevent overdose deaths and costly healthcare encounters and facilitate medication assisted treatment referrals, representing a value of $5.1 million. For every $1 invested, the pilot would generate $4.22 in savings. If taken to scale under a scenario in which fentanyl or other factors result in higher overdose rates, every $1 in investment would yield $10.17 in savings. While SIF creation should not be primarily a financial decision, it is important to recognize the robust returns on investment that this analysis predicts while also keeping in mind the value to individuals and to society that are not possible to measure. These include the social and emotional value of saving lives and improving health status of a marginalized segment of society; long term impact of retaining people in treatment and mortality prevention associated with treatment; redirection of monetary savings to primary care and prevention programs; and value of preparing for the potential of a greater drug crisis (e.g. influx of fentanyl into Seattle market). These broader implications, in combination with the measurable costs and benefits described in our analysis, should both be considered by policymakers who evaluating strategies to respond to the opioid epidemic.

Conflicts of Interest

None.

References

Andresen, M. A., & Boyd, N. (2010). A cost-benefit and cost-effectiveness analysis of Vancouver's supervised injection facility. *The International Journal of Drug Policy, 21*(1), 70–76.

Arias, E., Heron, M., & Xu, J. (2014). *United States life tables. National vital statistics reports*. Retrieved from https://www.cdc.gov/nchs/data/nvsr/nvsr66/nvsr66_04.pdf.

British Columbia Coroners Service (2018). *Illicit drug overdose deaths in BC, January 1, 2008- November 30, 2018.* Retrieved from.

Centers for Disease Control and Prevention (2017). *Annual surveillance report of drug-related risks and outcomes — United States, 2017. Surveillance special report 1. Centers for disease control and prevention*Accessed 7AUG2018 from. U.S. Department of Health and Human Serviceshttps://www.cdc.gov/drugoverdose/pdf/pubs/2017cdc-drug-surveillance-report.pdf.

Conrad, C., Bradley, H. M., Broz, D., Buddha, S., Chapman, E. L., Galang, R. R., et al. (2015). Community outbreak of HIV infection linked to injection drug use of oxymorphone–Indiana, 2015. *MMWR Morbidity and Mortality Weekly Report, 64*(16), 443–444.

Darke, S., Mattick, R. P., & Degenhardt, L. (2003). The ratio of non-fatal to fatal heroin overdose. *Addiction, 98*(8), 1169–1171.

DeBeck, K., Kerr, T., Bird, L., Zhang, R., Marsh, D., Tyndall, M., et al. (2011). Injection drug use cessation and use of North America's first medically supervised safer injecting facility. *Drug and Alcohol Dependence, 113*(2-3), 172–176.

DeBeck, K., Kerr, T., Lai, C., Buxton, J., Montaner, J., & Wood, E. (2012). The validity of reporting willingness to use a supervised injecting facility on subsequent program use among people who use injection drugs. *The American Journal of Drug and Alcohol Abuse, 38*(1), 55–62. https://doi.org/10.3109/00952990.2011.600389.

Department of Commerce (2016). Personal income summary: Personal income, population, per capita personal income, King County. Retrieved from. https://www.bea.gov/itable/index.cfm.

DHHS (2015). *CMS manual: Pub 100-04 medicare claims processing.* Accessed on 6AUG2018 fromhttps://www.cms.gov/Regulations-and-Guidance/Guidance/Transmittals/downloads/R3315CP.pdf.

Ducharme, J. (2018). *The country's first safe injection facility may soon open in Philadelphia. Here's What you need to know.* Accessed on 7AUG2018 from*Time*http://time.com/5128626/safe-injection-facilities-us-philadelphia/.

Enns, E. A., Zaric, G. S., Strike, C. J., Jairam, J. A., Kolla, G., & Bayoumi, A. M. (2016). Potential cost-effectiveness of supervised injection facilities in Toronto and Ottawa, Canada. *Addiction, 111*(3), 475–489.

Glick, S., Burt, R., Moreno, M., Ketchum, J., & Thiede, H. (2016). *Highlights from the 2015 Seattle area national HIV behavioral surveillance survey of injection drug use. HIV/AIDS epidemiology unit, public health – Seattle & King County and the infectious disease assessment unit, Vol, 85*, Washington State Department of Healthp. 51 HIV/AIDS Epidemiology Report 2016. Accessed from:.

Heroin and Prescription Opiate Addiction Task Force Final Report and Recommendations (2016). Retrieved from https://www.kingcounty.gov/~/media/depts/community-human-services/behavioral-health/documents/herointf/Final-Heroin-Opiate-Addiction-Task-_Force-Report.ashx?la=en.

HIV/AIDS Epidemiology Unit (2017). *Public health – Seattle & King County and the infectious disease assessment unit. HIV/AIDS epidemiology report, Vol. 86*Washington State Department of Health Accessed 6AUG2018 from.

HMSA (2016). *Emergency room services – Facility coding guidelines.* Accessed on 6AUG2018 fromhttps://hmsa.com/portal/provider/zav_pel.fh.EME.600.htm.

Irwin, A., Jozaghi, E., Bluthenthal, R., & Kral, A. (2017). A cost-benefit analysis of a potential supervised injection facility in San Francisco, California, USA. *Journal of Drug Issues, 47*(2), 164–184.

Irwin, A., Jozaghi, E., Weir, B. W., Allen, S. T., Lindsay, A., & Sherman, S. G. (2017). Mitigating the heroin crisis in Baltimore, MD, USA: A cost-benefit analysis of a hypothetical supervised injection facility. *Harm Reduction Journal, 14*(1), 29. https://doi.org/10.1186/s12954-017-0153-2.

Jenkins, L. M., Banta-Green, C. J., Maynard, C., Kingston, S., Hanrahan, M., Merrill, J. O., et al. (2011). Risk factors for nonfatal overdose at Seattle-area syringe exchanges. *Journal of Urban Health, 88*(1), 118–128. https://doi.org/10.1007/s11524-010-9525-6.

Jozaghi, E. (2012). A little heaven in hell": The role of a supervised injection facility in transforming place. *Urban Geography, 33*, 1144–1162. https://doi.org/10.2747/0272-3638.33.8.1144.

Jozaghi, E., Reid, A. A., & Andresen, M. A. (2013). A cost-benefit/cost-effectiveness analysis of proposed supervised injection facilities in Montreal, Canada. *Substance Abuse Treatment, Prevention, and Policy, 8*, 25. https://doi.org/10.1186/1747-597X-8-25.

Kerr, T., Tyndall, M., Li, K., Montaner, J., & Wood, E. (2005). Safer injection facility use and syringe sharing in injection drug users. *Lancet, 366*(9482), 316–318. https://doi.org/10.1016/S0140-6736(05)66475-6.

King County (2018). *Hepatitis C.* Accessed on 6AUG2018 fromhttps://www.kingcounty.gov/depts/health/communicable-diseases/disease-control/hepatitis-C.aspx.

King County Medical Examiner Office (2018). *Overdose deaths.* Accessed on 12OCT2018 fromhttps://kingcounty.gov/depts/health/examiner/overdose.aspx.

Klevens, R. M., Liu, S., Roberts, H., Jiles, R. B., & Holmberg, S. D. (2014). Estimating acute viral hepatitis infections from nationally reported cases. *American Journal of Public Health, 104*(3), 482–487. https://doi.org/10.2105/AJPH.2013.301601.

Kummer, K., Thiede, H., & Hanrahan, M. (2015). *Needle Exchange Client Surveys 2011, 2013, and 2015: Drugs used, risk and protective behaviors, overdose, health insurance* *coverage, and health concern* Retrieved from https://www.kingcounty.gov/depts/health/communicable-diseases/hiv-std/patients/epidemiology/~/media/depts/health/communicable-diseases/documents/hivstd/2015-hiv-aids-epidemiology-annual-report.ashx.

Larson, S., Padron, N., Mason, J., & Bogaczyk, T. (2017). *Supervised consumption facilities: Review of the evidence*Retrieved fromhttps://dbhids.org/wp-content/uploads/2018/01/OTF_LarsonS_PHLReportOnSCF_Dec2017.pdf.

Lloyd-Smith, E., Wood, E., Zhang, R., Tyndall, M. W., Montaner, J. S., & Kerr, T. (2008). Risk factors for developing a cutaneous injection-related infection among injection drug users: A cohort study. *BMC Public Health, 8*, 405. https://doi.org/10.1186/1471-2458-8-405.

Lloyd-Smith, E., Wood, E., Zhang, R., Tyndall, M. W., Sheps, S., Montaner, J. S., et al. (2010). Determinants of hospitalization for a cutaneous injection-related infection among injection drug users: A cohort study. *BMC Public Health, 10*, 327. https://doi.org/10.1186/1471-2458-10-327.

Mathers, B. M., Degenhardt, L., Bucello, C., Lemon, J., Wiessing, L., & Hickman, M. (2013). Mortality among people who inject drugs: A systematic review and meta-analysis. *Bulletin of the World Health Organization, 91*(2), 102–123. https://doi.org/10.2471/BLT.12.108282.

May, T., Bennett, T., & Holloway, K. (2018). The impact of medically supervised injection centres on drug-related harms: A meta-analysis. *The International Journal of Drug Policy, 59*, 98–107.

McCarty, D., Perrin, N. A., Green, C. A., Polen, M. R., Leo, M. C., & Lynch, F. (2010). Methadone maintenance and the cost and utilization of health care among individuals dependent on opioids in a commercial health plan. *Drug and Alcohol Dependence, 111*(3), 235–240. https://doi.org/10.1016/j.drugalcdep.2010.04.018.

Merrill, D. (2017). *No one values your life more than the federal government.* Retrieved fromBloomberghttps://www.bloomberg.com/graphics/2017-value-of-life/.

Milloy, M. J., Kerr, T., Mathias, R., Zhang, R., Montaner, J. S., Tyndall, M., et al. (2008). Non-fatal overdose among a cohort of active injection drug users recruited from a supervised injection facility. *The American Journal of Drug and Alcohol Abuse, 34*(4), 499–509. https://doi.org/10.1080/00952990802122457.

MSIC Evaluation Committee (2003). *Final report of the evaluation of the Sydney medically supervised injecting centre*.

Murphy, S. M., & Polsky, D. (2016). Economic evaluations of opioid use disorder interventions. *Pharmacoeconomics, 34*(9), 863–887.

Neale, J. (2003). The ratio of non-fatal to fatal heroin overdose. A response to Darke et al. *Addiction, 98*(8), 1171.

Nordlund, D. J., Estee, S., Mancuso, D., & Felver, B. (2004). *Methadone treatment for opiate addiction lowers health care costs and reduces arrests and convictions.* Retrieved fromhttps://www.dshs.wa.gov/sites/default/files/SESA/rda/documents/research-4-49.pdf.

Office of Financial Management (2017). *Population.* Retrieved fromhttps://www.ofm.wa.gov/washington-data-research/population-demographics/population-estimates/april-1-official-population-estimates.

Pinkerton, S. D. (2011). How many HIV infections are prevented by Vancouver Canada's supervised injection facility? *The International Journal of Drug Policy, 22*(3), 179–183. https://doi.org/10.1016/j.drugpo.2011.03.003.

Pitman, R., Fisman, D., Zaric, G. S., Postma, M., Kretzschmar, M., Edmunds, J., Brisson, M., & ISPOR-SMDM Modeling Good Research Practices Task Force (2012). Dynamic transmission modeling: A report of the ISPOR-SMDM modeling good research practices task force–5. *Value in Health, 15*(6), 828–834.

Potier, C., Laprevote, V., Dubois-Arber, F., Cottencin, O., & Rolland, B. (2014). Supervised injection services: What has been demonstrated? A systematic literature review. *Drug and Alcohol Dependence, 145*, 48–68. https://doi.org/10.1016/j.drugalcdep.2014.10.012.

Sordo, L., Barrio, G., Bravo, M. J., Indave, B. I., Degenhardt, L., Wiessing, L., Ferri, M., & Pastor-Barriuso, R. (2017). Mortality risk during and after opioid substitution treatment: Dystematic review and meta-analysis of cohort studies. *BMJ, 357*, j1550.

Thiede, H., & Buskin, S. E. (2014). *Updated population estimates for men who have sex with men (MSM) and people who inject drugs (PWID) estimates for King County* Retrieved from https://www.kingcounty.gov/depts/health/communicable-diseases/hiv-std/patients/epidemiology/~/media/depts/health/communicable-diseases/documents/hivstd/2014-hiv-aids-epidemiology-annual-report.ashx.

Vancouver Coastal Health (2015). Insite user statistics. Retrieved from. http://www.vch.ca/Documents/Insite-user-statistics-2015.pdf.

Vancouver Coastal Health (2016). Insite user statistics. Retrieved from. http://www.vch.ca/Documents/Insite-user-statistics-2016.pdf.

Vancouver Coastal Health (2017). Insite – Supervised injection site. Retrieved from. http://www.vch.ca/Locations-Services/result?res_id=964.

Vancouver Coastal Health (2018). *Insite – supervised injection site.* Retrieved from http://www.vch.ca/public-health/harm-reduction/supervised-consumption-sites/insite-user-statistics.

Washington Department of Health (2017). *Charity care in Washington hospitals*Retrieved fromhttps://www.doh.wa.gov/Portals/1/Documents/2300/HospPatientData/2015CharityCareReport.pdf.