Harm Reduction Centers Cost Benefit Analysis

(216-RICR-40-10-25)

Rhode Island Department of Health

November 15, 2021

This report was prepared by the Rhode Island Department of Health (RIDOH) in partnership with the Institute for Clinical and Economic Review (ICER); the University of Washington Comparative Health Outcomes, Policy, and Economics (CHOICE) Institute; and the People, Place, and Health Collective (PPHC) at Brown University.

RIDOH staff	ICER staff
Laura C. Chambers, PhD, MPH Benjamin D. Hallowell, PhD, MPH Rachel P. Scagos, MPH Nathaniel Fuchs, MPH	David M. Rind, MD, MSc David Whitrap
CHOICE Institute staff	**PPHC staff**
Ryan N. Hansen, PharmD, PhD Greg F. Guzauskas, MSPH, PhD	Brandon D.L. Marshall, PhD, MSc Xiao Zang, PhD, MSc

Background

Since 1999, overdose deaths have been increasing in the United States,[1] including Rhode Island. In response, the Rhode Island Department of Health (RIDOH), in collaboration with state and community partners, has implemented numerous interventions to prevent overdose deaths and other drug-related harms. From 2016 to 2019, overdose deaths began to decline in Rhode Island; however, in 2020, Rhode Island experienced its highest number of accidental overdose deaths ever recorded.[2] In this context, new overdose prevention approaches are urgently needed.

In July 2021, Governor Daniel McKee signed a bill into law authorizing a two-year pilot program of harm reduction centers (HRCs) to prevent drug overdoses in Rhode Island (RI Gen. Laws Chapter 23-12.10).[3] An HRC is a community-based resource for health screening, disease prevention, and recovery assistance where persons may safely consume pre-obtained controlled substances in a non-judgmental environment without legal repercussions. HRCs have health care and/or harm reduction professionals on-site, as well as supplies and equipment, to prevent overdose, reduce drug-related harms, and provide resources and referrals for additional services that may be appropriate for persons utilizing the center (e.g., other harm reduction services, social services, counseling, or other medical treatment). HRCs are sometimes referred to as supervised injection, supervised consumption, or safer injection sites or facilities.

Prior evidence suggests that HRCs are cost-effective and reduce fatal overdoses.[4,5] Importantly, to date, no HRC client has experienced a fatal overdose within an HRC.[6] HRCs have also been associated with safer drug use behaviors, such as reduced syringe re-using, syringe sharing, public injection, and rushed injection, as well as uptake of addiction treatment and other health services. Finally, some studies suggest that HRCs have community and public order benefits, such as a decrease in public injection, without an increase in drug-related crime or public nuisance in the community.[4,5]

From a public health perspective, HRCs would complement and/or expand existing syringe service programs in Rhode Island. Syringe service programs provide sterile needles and syringes to people who inject drugs. Often, they also provide or facilitate other harm reduction supplies or services, such as naloxone, fentanyl test strips, and referral to counseling, substance use treatment, or other medical and social services. As of October 2021, AIDS Care Ocean State's statewide Education, Needle Exchange, Counseling, Outreach, and Referral – or ENCORE – program is the only needle exchange program in Rhode Island[7] and includes a satellite site at Project Weber/Renew, mobile van, and street outreach.

As required by the Rhode Island law, the Rhode Island Department of Health (RIDOH) is developing regulations (216-RICR-40-10-25) to establish minimum standards for HRCs that are consistent with acceptable international standards of practices and that will provide services in such a manner as to safeguard the health, safety, and welfare of clients. The objective of this analysis was to estimate the costs and benefits of the implementation of a hypothetical HRC in Rhode Island to inform these regulations.

Methods

Overview

The objective of this analysis was to estimate the incremental costs and benefits of the implementation of an HRC in Rhode Island compared to currently available harm reduction services (i.e., the status quo). Specifically, we compared the addition of a hypothetical HRC to a hypothetical existing syringe services program in Providence, Rhode Island, to syringe services program alone (because many HRCs also provide sterile injecting and other drug-using equipment without requiring that persons consume substances on-site). We selected Providence as the location for the hypothetical HRC because it is the city with the largest population[8] and highest number of fatal overdoses[9] in Rhode Island, although it is important to note that the law allows an HRC in any community with prior municipal-level approval.

Our analysis leveraged a decision analytic mathematical model developed by the Institute for Clinical and Economic Review (ICER) in partnership with the University of Washington Comparative Health Outcomes, Policy, and Economics (CHOICE) Institute.[6,10] ICER and the CHOICE Institute developed this model based on adapted outcome calculations from relevant prior models,[11-17] as well as interviews with key staff and researchers of HRCs. The model estimates costs and outcomes over a one-year time period, utilizing information predominantly from evaluations of the Insite, an HRC in Vancouver, British Columbia.[18] Although the Rhode Island HRC regulations will permit various modes of consumption (e.g., inhalation), the model described herein focuses on the potential impact of HRCs for people who inject drugs due to the limited availability of outcome estimates for other modes of drug use in the scientific literature. ICER and the CHOICE institute have described their model in detail elsewhere;[6] key aspects are summarized below.

Model structure

Our application of the ICER/CHOICE model compares the costs and outcomes for people who inject drugs in Providence under two scenarios: (1) an HRC that includes syringe services provision, and (2) a syringe service program only. In general, the model assumes that an HRC in Providence would provide similar services, have similar cost of living-adjusted operational costs, and have similar protective effects as Insite in Vancouver, but may vary in the number of clients it serves. Insite services include sterile equipment for drug consumption, spectrometer testing of drug contents, immediate response in the event of an overdose, clinical care (e.g., wound management, vaccinations), and connection to addiction, healthcare, and community services.[18] Additionally, the model assumes that transmission probability of new human immunodeficiency virus (HIV) and hepatitis C virus (HCV) infections and rates of initiation and continuation of medications for opioid use disorder (MOUD) would be similar under the two scenarios.

The ICER/CHOICE model was developed from a modified societal perspective (i.e., a perspective that examines some costs and savings outside the health care system)[19] with a one-year time horizon because HRCs are not funded by the health care system or payers of health care. The model was developed in Microsoft Excel for Office 365 (Version 2005).[6]

Model parameters

The ICER/CHOICE model includes input parameters from four broad categories: (1) city characteristics, (2) primary outcomes, (3) costs, and (4) other parameters.

City characteristics. We obtained estimates for Providence for each of the city characteristic input parameters in **Table 1**. For each parameter, we provide our primary estimate, low and high estimates for sensitivity analyses (generally +/-20%), and reference. Of note, we estimated the number of people who inject drugs in Providence based on the average percentage of known people who inject drugs in San Francisco, Baltimore, and Seattle (4.4%).[20-22] Additionally, for the estimated commercial property value, we averaged 2019 estimates for the commercial property value in Philadelphia, Pennsylvania ($319 per square foot), and New Haven, Connecticut ($286 per square foot), due to the lack of Providence-specific estimates.[23] For the commercial mortgage loan rate, we retained the estimate utilized by ICER and the CHOICE Institute across cities.

Table 1. City characteristic input parameter values and sources

Parameter	Primary estimate (low, high)
Number of people who inject drugs	8,700* (6,960, 10,440)[20-22]
Cost of living ratio (compared to Vancouver)	0.93* (0.74, 1.12)[24]
Population density (people per square mile)	9,676* (7,741, 11,611)[25]
Commercial property value (cost per square foot)	$302* ($242, $362)[23]
Commercial mortgage loan rates	7.00% (5.00%, 9.00%)[6]

* Estimate for Providence.

Primary outcomes. We utilized the following estimates for each of the primary outcome input parameters in **Table 2**. Most estimates are consistent with those established by ICER and the CHOICE Institute based on Vancouver Insite studies,[6] except for six that are specific to Providence. First, we utilized 2020 RIDOH Office of the State Medical Examiner data to estimate the number of overdose deaths occurring in Providence per year.[9] Second, we utilized 2020 Office of the State Medical Examiner data to identify locations where the highest percentage of fatal overdoses occur within 0.25 miles (8%).[26] Additionally, compared to the parameter established by ICER and the CHOICE Institute, we decreased the number of unique clients per month expected at the HRC (from 2,100 to 400) due to the smaller population size of Providence. We then used previously published estimates for the monthly number of visits per month per client from Insite to estimate the total annual injections in the HRC among 400 unique clients.[27] Additionally, we used 2021 RIDOH Harm Reduction Surveillance System data to estimate the percentage of non-HRC overdoses resulting in an ambulance run and an ED visit, respectively.[28] Importantly, key assumptions that are built into our primary parameter estimates include: (1) there would be a 35% reduction in fatal overdoses within 0.25 miles of the HRC and 9.3% reduction elsewhere in Providence; (2) prior to the implementation of an HRC, 8% of fatal overdoses in Providence occur within 0.25 miles of the facility; (3) 0.95% of injections result in an overdose; and (4) 46% of overdoses in Providence result in an ambulance run and 43% result in an ED visit.

Table 2. Primary outcome input parameter values and sources

Parameter	Primary estimate (low, high)
Mortality reduction within 0.25 miles of HRC	35% (28%, 42%)[6]
Mortality reduction beyond 0.25 miles of HRC	9.3% (7.4%, 11.2%)[6]
Percentage of Providence overdose deaths within 0.25 miles of HRC	8.0%* (6.4%, 9.6%)[26]
Number of overdose deaths per year in Providence	93* (74, 112)[9]
Total annual injections in HRC	60,840* (48,672, 73,008)[27]
Unique clients per month at HRC	400* (320, 480)
Percentage of injections resulting in an overdose	0.95% (0.50%, 1.20%)[29-32]
Percentage of HRC overdoses resulting in an ambulance run	0.79% (0.63%, 0.95%)[6]
Percentage of HRC overdoses resulting in an ED visit	0.79% (0.63%, 0.95%)[6]
Percentage of non-HRC overdoses resulting in an ambulance run	46%* (37%, 55%)[28]
Percentage of non-HRC overdoses resulting in an ED visit	43%* (34%, 52%)[28]
Percentage of ED visits for overdose resulting in inpatient admission	48% (38%, 58%)[6]

* Estimate for Providence.

Costs. We utilized the following estimates for each of the cost input parameters in **Table 3**. Most estimates were consistent with those used by ICER and the CHOICE Institute, except for three that were specific to Rhode Island or were otherwise adjusted. First, for the cost per ambulance run, we utilized an estimate from the Centers for Medicare and Medicaid Services Ambulance Fee Schedule for Rhode Island, Healthcare Common Procedure Coding System, code A0427, urban base rate.[33] Second, for the cost per inpatient hospitalization, we utilized an adjusted New England average payment to hospitals for opioid-related visits.[34] Finally, we utilized previously published cost estimates for a medium-sized, urban syringe services program in the United States;[35] the estimated cost of naloxone was subtracted and the resulting cost weighted by the model to the estimated cost of living in Providence.

Table 3. Cost input parameter values and sources

Parameter	Primary estimate (low, high)
Insite annual operating costs in Vancouver	$1,687,286 ($1,349,829, $2,024,743)[6]
Term of commercial loan (years)	15[6]
HRC square footage	1,000[6]
Annual syringe service program cost†	$863,861* ($691,089, $1,036,633)[35]
Ambulance run cost	$466* ($372, $559)[33]
ED visit cost	$3,451 ($2,761, $4,141)[6]
Inpatient hospitalization cost	$7,897* ($6,318, $9,476)[34]

* Estimate for Providence.
† Average cost for the United States; weighted by the model to the estimated cost of living in Providence.

Other parameters. We utilized the following estimates for each of the other input parameters in **Table 4**. All estimates are consistent with those used by ICER and the CHOICE Institute.

Table 4. Other input parameter values and sources

Parameter	Primary estimate (low, high)
Odds ratio for HRC reduction in needle/syringe sharing	0.30 (0.11, 0.82)[6]
Probability of HIV infection per injection*	0.67% (0.54%, 0.80%)[6]
Probability of HCV infection per injection*	3.00% (2.40%, 3.60%)[6]
Needle/syringe sharing rate per year	0.011 (0.009, 0.013)[6]
Percentage unbleached needles in shared injections	100% (80%, 100%)[6]
Number of needle/syringe-sharing partners	1.69 (1.35, 2.03)[6]
Percentage of people who inject drugs who are living with HIV	17% (14%, 20%)[6]
Percentage of people who inject drugs who are HCV positive	25% (20%, 30%)[6]
Number of needle/syringes in circulation	827,537 (662,030, 993,045)[6]
Percentage of HRC clients who access MOUD	6% (5%, 7%)[6]
Percentage of non-HRC users who access MOUD	6% (5%, 7%)[6]
MOUD retention factor of HRC	50% (40%, 60%)[6]
MOUD retention factor of non-HRC	50% (40%, 60%)[6]

* Conditional on the needle/syringe sharing rate.

Model outcomes

The outcomes of the model for each scenario included total short-term costs, number of overdose deaths within 0.25 miles of the HRC location, and number of EMS runs, ED visits, inpatient hospitalizations, HIV infections, and HCV infections resulting from the injections that would occur at the HRC, if available. More detailed costs (e.g., annual facility costs and ambulance run, ED visit, and inpatient hospitalization costs for emergency overdose care) were also produced. The primary results of interest were (1) the difference in the total short-term costs between the two scenarios and (2) the difference in the number of overdose deaths within 0.25 miles of the HRC location between the two scenarios. All results were undiscounted values because of the one-year time horizon.

Analyses

Using our primary parameter estimates in **Tables 1-4**, we conducted base-case analyses to estimate the costs and health outcomes in an incremental fashion comparing the two scenarios (i.e., availability of an HRC that includes syringe services vs. availability of a syringe service program only). We also conducted one-way sensitivity analyses, using the low and high estimates provided in **Tables 1-4** for each parameter, to identify critical parameters that have a large impact on costs and health outcomes. Finally, we conducted scenario analyses utilizing our base-case parameters and varying only the number of unique HRC clients per month to understand the impact of client volume on the difference in total short-term costs. Of note, as described above, we calculated the total annual injections within the HRC using the assumed number of unique HRC clients per month and published estimates for the monthly number of visits per month per client from Insite.[27]

Results

In base-case analyses, the annual operating cost for an HRC that includes syringe services provision was $1,602,334, while the cost of operating a syringe service program only was $818,435 (**Table 5**, **Figure 1**). The hypothetical HRC that includes syringe services is estimated to prevent 1.9 deaths per year (equivalent to preventing 19 deaths every 10 years, **Figure 2**). Additionally, each year, the HRC would prevent 261.3 ambulance runs, 244.0 ED visits, and 117.1 inpatient hospitalizations for emergency overdose care, as well as prevent 0.5 HIV infections and 2.8 HCV infections. In total, accounting for the annual operating costs of the HRC as well as short-term medical costs of emergency overdose care (i.e., ambulance runs, ED visits, and inpatient hospitalizations), the HRC would be cost saving; specifically, the total short-term savings would be approximately $1,104,454 annually.

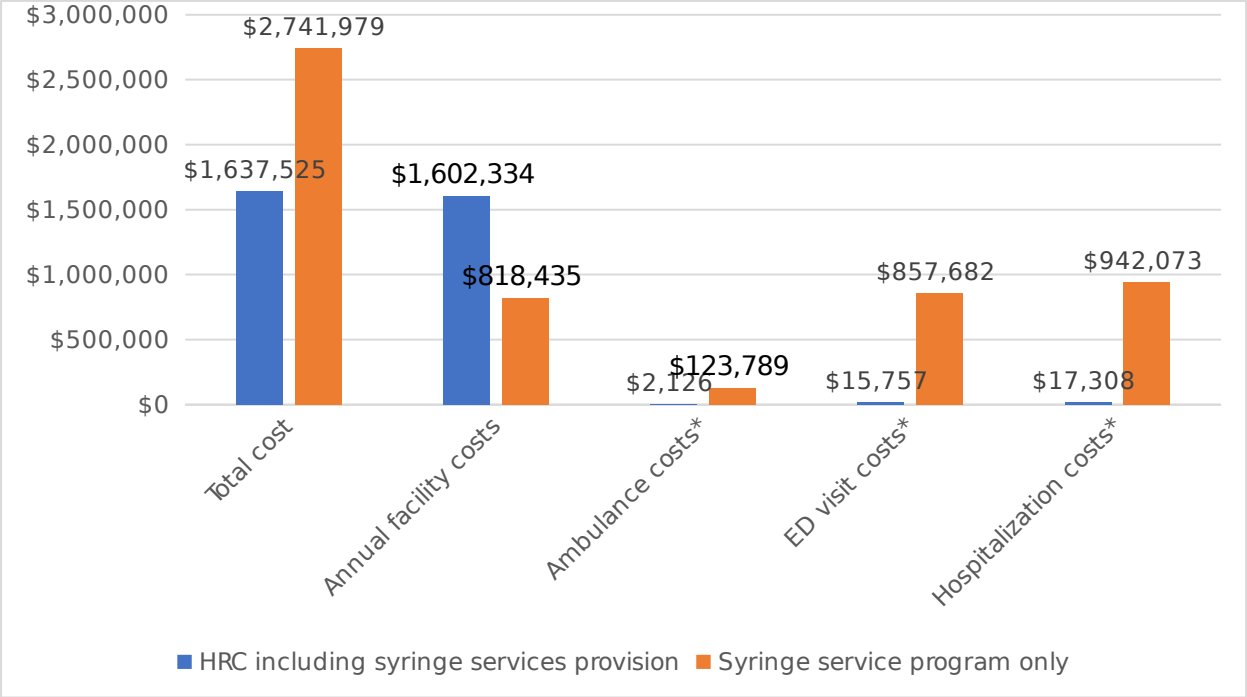
Table 5. Base-case analysis results

Outcome	HRC including syringe services	Syringe service program only	Difference
Total short-term costs	$1,637,525	$2,741,979	-$1,104,454
Annual facility costs	$1,602,334	$818,435	$783,899
Upfront loan	$302,000	--	--
Loan annual payment	$33,158	--	--
Operating cost	$1,569,176	--	--
Ambulance run costs	$2,126	$123,789	-$121,663
ED visit costs	$15,757	$857,682	-$841,924
Inpatient hospitalization costs	$17,308	$942,073	-$924,765
Health outcomes			
Overdoses within 0.25 miles of HRC	578.0	578.0	0.0
Overdose deaths within 0.25 miles of HRC	5.5	7.4	-1.9
Ambulance runs*	4.6	265.9	-261.3
ED visits*	4.6	248.5	-244.0
Inpatient hospitalizations*	2.2	119.3	-117.1
HIV infections	14.1	14.5	-0.5
HCV infections	83.5	86.3	-2.8
MOUD initiations	23.1	23.1	0.0
Sustained MOUD initiations	11.6	11.6	0.0

Abbreviations: ED, emergency department; HCV, hepatitis C virus; HIV, human immunodeficiency virus; HRC, harm reduction center; MOUD, medication for opioid use disorder.

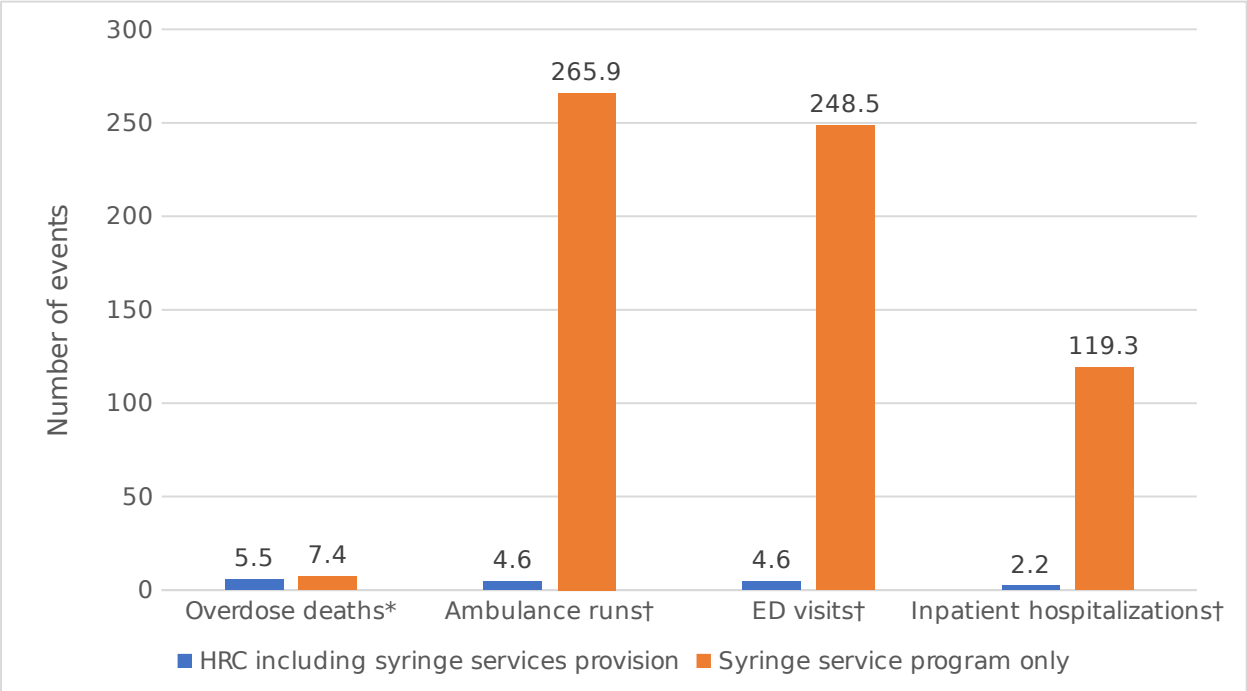
* Resulting from injections that would occur at the HRC, if available.

Figure 1. Base-case analysis short-term cost results



Abbreviations: ED, emergency department; HRC, harm reduction center.
* Resulting from injections that would occur at the HRC, if available.

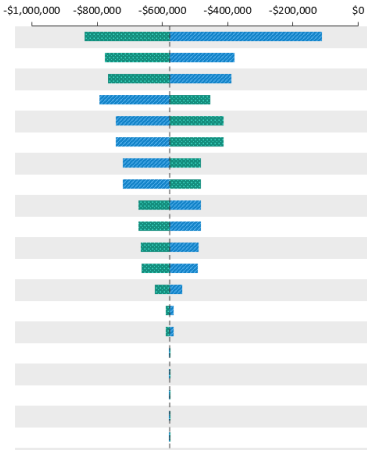
Figure 2. Base-case analysis health outcome results



Abbreviations: ED, emergency department; HRC, harm reduction center.
* Within 0.25 miles of HRC.
† Resulting from injections that would occur at the HRC, if available.

In sensitivity analyses varying input parameters across plausible ranges to evaluate the impact on short-term cost savings per overdose death prevented, we found that the most influential parameters were the percentage of injections resulting in overdose, the total annual injections at the HRC, the percentage of overdoses outside of the HRC that result in an ED visit, the reduction in overdose mortality within 0.25 miles of the HRC, the HRC annual operating costs, and the cost-of-living ratio comparing Providence to Vancouver (**Figure 3**). Across one-way sensitivity analyses, for each overdose death prevented society would save a maximum of $837,512 and a minimum of $109,813 in the short term. The most influential parameters when evaluating the impact on short-term cost savings per ambulance run, ED visit, and inpatient hospitalization prevented are included in the list above (**Appendix, Figures A1-A3**).

Figure 3. Sensitivity analysis results, short-term cost savings per overdose death prevented



Parameter	Low Value	High Value	Low Result	High Result	Spread
Percentage of injections resulting in OD	0.50%	1.20%	-$109,813	-$837,512	$727,699
Total annual injections in the HRC	48,672	73,008	-$380,101	-$775,137	$395,036
Percentage of no HRC ODs resulting in ED visit	34%	52%	-$389,368	-$765,870	$376,502
Overdose mortality: reduction within 0.25 mi of HRC	28.0%	42.0%	-$793,840	-$453,970	$339,870
HRC annual operating cost	$1,349,829	$2,024,743	-$741,752	-$413,486	$328,266
Cost-of-living ratio Providence vs. Vancouver	0.74	1.12	-$741,752	-$413,486	$328,266
Overdose mortality: percentage of OD deaths within 0.25 mi of HRC	6.4%	9.6%	-$722,024	-$481,349	$240,675
Overdose deaths/year in Providence	74	112	-$722,024	-$481,349	$240,675
Hospitalization cost in Providence	$6,318	$9,476	-$480,891	-$674,348	$193,457
Percentage of ED visits resulting in inpatient hospitalization	38%	58%	-$480,891	-$674,348	$193,457
Cost of ED visit in Providence	$2,761	$4,141	-$489,556	-$665,683	$176,127
Annual syringe service program cost	$691,089	$1,036,633	-$492,012	-$663,226	$171,213
Overdose mortality: reduction outside 0.25 mi of HRC	7.4%	11.2%	-$538,636	-$622,685	$84,049
Percentage of no HRC ODs resulting in ambulance run	37%	55%	-$564,671	-$590,567	$25,896
Cost of ambulance run in Providence	$372	$559	-$564,893	-$590,345	$25,452
Cost/sqft commercial property in Providence	$242	$362	-$581,087	-$574,151	$6,937
Percentage of HRC ODs resulting in ED visit	0.63%	0.95%	-$581,078	-$574,161	$6,917
Number of unique HRC clients/month	320	480	-$581,005	-$574,234	$6,771
Commercial mortgage loan interest in Providence	5%	9%	-$579,744	-$575,366	$4,378
Percentage of HRC ODs resulting in ambulance run	0.63%	0.95%	-$577,842	-$577,397	$445

Abbreviations: ED, emergency department; HRC, harm reduction center; OD, overdose.

In scenario analyses utilizing our base-case parameters and varying only the number of unique HRC clients per month, the difference in total short-term cost savings ranged from $176,462 (with 200 unique clients per month) to $8,992,390 (with 2,100 unique clients per month similar to Insite), comparing the scenario with an HRC including syringe services provision to the scenario with a syringe service program only (**Table 6**).

Table 6. Scenario analyses varying only the number of unique HRC clients per month

Number of unique HRC clients per month	Total annual injections in HRC*	Difference in total short-term costs comparing the HRC including syringe services to the syringe service program only
200	30,420	-$176,462
300	45,630	-$640,458
400†	60,840	-$1,104,454
500	76,050	-$1,568,450
750	114,075	-$2,728,441
1,000	152,100	-$3,888,432
1,500	228,150	-$6,208,413
2,000	304,200	-$8,528,394
2,100‡	319,410	-$8,992,390

Abbreviations: HRC, harm reduction center.

* Calculated using the number of unique HRC clients per month and published estimates for the monthly number of visits per month per client from Insite.[27]

† Base-case analysis.

‡ Unique number of HRC clients per month at Insite.[36]

Discussion

In our primary analysis, we found that a hypothetical HRC in Providence that includes syringe services provision and serves 400 clients per month would prevent approximately 1.9 deaths, 261.3 ambulance runs, 244.0 ED visits, and 117.1 inpatient hospitalizations for emergency overdose care, as well as 0.5 HIV infections, and 2.8 HCV infections per year compared to a scenario that includes a syringe service program only (i.e., the status quo). Additionally, when only accounting for annual facility costs and short-term costs of emergency overdose care (i.e., ambulance runs, ED visits, and inpatient hospitalizations), we found that the HRC would be cost saving overall compared to the syringe service program only. Accounting for the annual costs of the HRC as well as short-term costs saved through prevention of costly emergency overdose care, we estimated that $1,104,454 would be saved per year from a modified societal perspective.

Our results are generally consistent with prior studies of the cost-effectiveness of hypothetical HRCs in the United States. In the ICER/CHOICE study of hypothetical HRCs in six cities in the United States, compared to a syringe service program only, adding an HRC (similar to Insite) was estimated to prevent 3 overdose deaths per year in each of Boston and Seattle, 4 overdose deaths per year in San Francisco, 6 overdose deaths per year in Atlanta, 9 overdose deaths per year in Baltimore, and 15 overdose deaths per year in Philadelphia. HRCs were consistently found to be cost-saving for all six cities, with short-term annual savings ranging from $3,623,000 for Atlanta to $4,199,000 for Seattle.[6] Separate studies using different models found similar results for hypothetical HRCs similar to Insite in Denver (2.8 overdose deaths prevented and roughly $6,900,000 saved per year),[37] San Francisco (0.24 overdose deaths prevented and $3,500,000 saved per year),[15] and Baltimore (5.9 overdose deaths prevented and $7,800,000 saved per year).[14] One study of a hypothetical HRC in Seattle considered an estimated budget and smaller volume of clients tailored specifically to their hypothetical pilot site and found that the HRC would prevent 6 overdose deaths and save $3,933,687 per year.[12] Although our analysis for Providence suggests that an HRC would be cost saving relative to a syringe service program only, we estimated that the short-term annual cost savings would be lower than estimates for other cities, likely because we assumed conservatively that the HRC would serve substantially fewer clients (400 vs. 2,100 per month) and that the HRC operating costs would be similar to those of Insite (despite the smaller scale of operations). In our scenario analyses varying the number of unique HRC clients per month but retaining the assumption that HRC operating costs would be similar to Insite, the difference in total short-term cost savings ranged from $176,462 (with 200 unique clients per month) to $8,992,390 (with 2,100 unique clients per month similar to Insite). These results demonstrate that an HRC serving a larger number of clients will result in more adverse health outcomes averted and, thus, greater savings.

Importantly, our analyses incorporated only the annual facility costs and short-term costs of emergency overdose care over a one-year period. There would likely be additional lifetime medical costs saved by society due the HIV and HCV infections prevented during the hypothetical one-year period. For example, if we assumed that people who inject drugs in Providence and acquire HIV have similar care-seeking behavior and life expectancy to others with people living with HIV in the United States, the lifetime medical costs saved by preventing one HIV infection would be approximately $261,675 (in 2020 dollars).[38] Similarly, for each

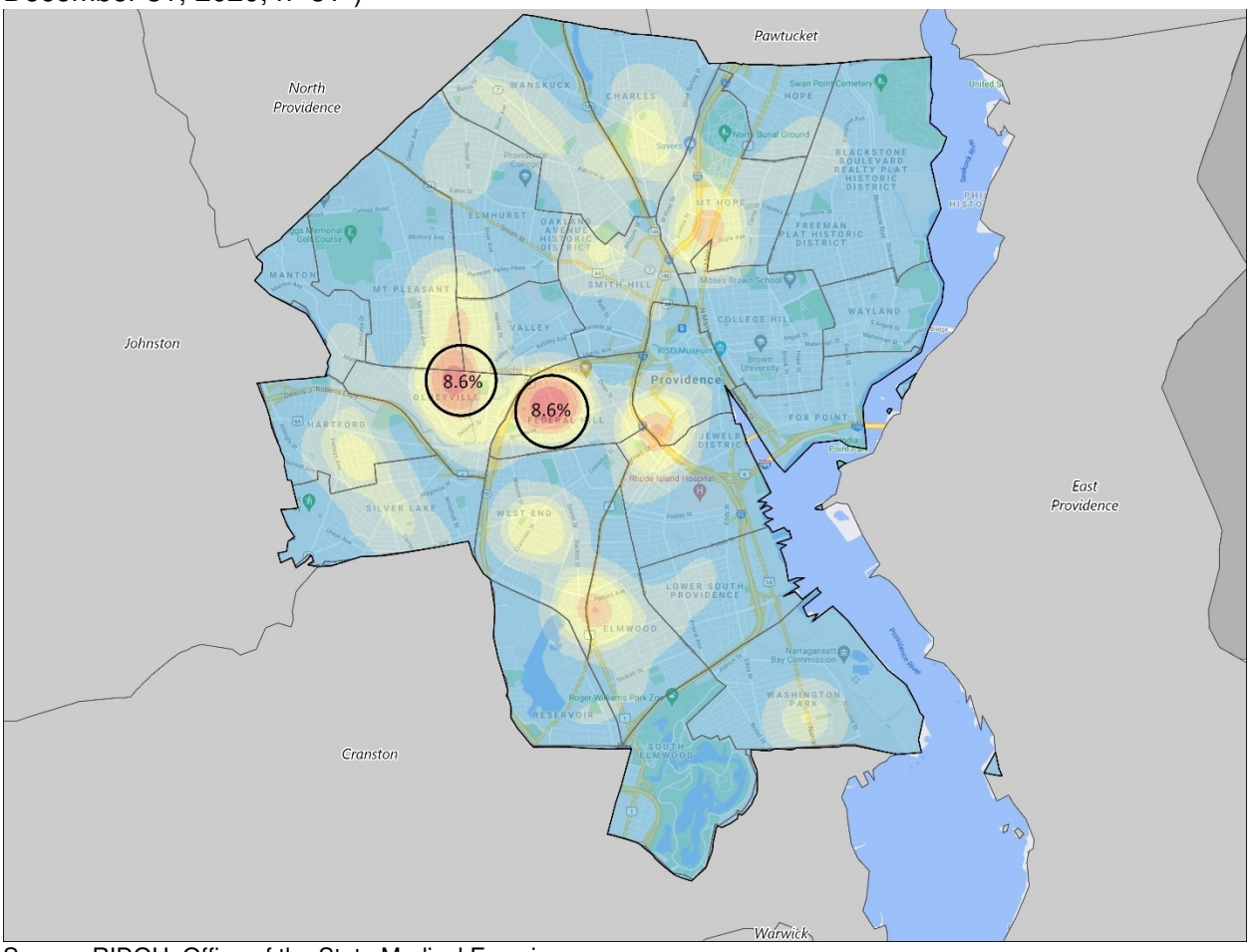
course of HCV treatment potentially avoided by preventing one HCV infection, society would save approximately $38,552 (in 2020 dollars).[17] Applying these rough cost estimates to our base-case analysis results, the prevention of 0.5 HIV infections and 2.8 HCV infections in one year might lead to *additional* long-term savings of approximately $238,783.

Given that the HRC and syringe service program only scenarios considered in our analysis are hypothetical, there may be substantial uncertainty surrounding estimated outcomes due to parameter uncertainty. In sensitivity analyses varying each input parameter across plausible ranges to evaluate the impact on costs per adverse outcome prevented, we found that the most influential parameters were the percentage of injections resulting in overdose, the total annual injections at the HRC, the percentage of overdoses outside of the HRC that result in an ED visit, the reduction in overdose mortality within 0.25 miles of the HRC, the HRC annual operating costs, and the cost-of-living ratio comparing Providence to Vancouver, but none of them were able to alter the conclusion that the HRC would be cost-saving. Across these one-way sensitivity analyses, for each overdose death prevented, society would save a maximum of $837,512 and a minimum of $109,813 in the short term. For context, the Rhode Island Office of Regulatory Reform generally considers it reasonable to spend up to $9,100,000 to prevent one death.[39]

Given the large impact of the estimated annual operating costs of the HRC on our findings, it is important to consider the plausible range of options for HRC implementation in Rhode Island. Herein, we aimed to be conservative in our analysis by basing our modeled HRC costs on the full annual operating costs of Insite in Vancouver, despite expecting that an HRC in Rhode Island would serve fewer clients than Insite (400 vs. 2,100 per month) due to the smaller population of Providence and other municipalities. With similar services but fewer clients, an HRC in Rhode Island would likely have a lower annual operating budget by requiring fewer staff and supplies, as well as a smaller space. Thus, we expect that an actual HRC in Providence would be even *more* cost-saving than the scenario considered in our analysis. Similarly, depending on the service delivery model of potential HRCs in Rhode Island, additional costs may be saved. For example, leveraging existing infrastructure by co-locating an HRC in an existing organization or clinic may decrease annual operating costs for an HRC compared to what was considered in our analysis. Cost and health outcomes for other service delivery models, such as mobile or temporary (e.g., tent) HRCs, are less well understood. These models may be subject to different unit costs per client served, depending on the number of clients served and operational costs. The 2-year pilot program of HRCs in Rhode Island may provide an opportunity to evaluate the actual cost-effectiveness of a variety of service delivery models.

The location of the HRC is also likely to have large impact on the cost-effectiveness of the HRC. Our primary analysis considered a hypothetical location in Providence where 8% of the overdose deaths occur within 0.25 miles of the HRC (prior to the implementation of an HRC). Based on 2020 data, there are two locations in Providence where the greatest percentage (8.6%) of fatal overdoses occur within a 0.25 miles radius: Federal Hill and Olneyville (**Figure 4**). Other things being equal, locating the HRC in one of these areas is likely to be more cost-effective than locating the HRC in other parts of Providence. The Rhode Island Department of Health routinely publishes Municipal Overdose Surveillance Reports, which include similar maps of overdose fatalities and EMS runs for suspected overdoses for each municipality and may be useful for informing potential HRC implementation.[40]

Figure 4. Density of overdose fatalities by incident address in Providence (January 1, 2020 – December 31, 2020, n=81*)



Source: RIDOH, Office of the State Medical Examiner.

* There were 104 overdose deaths that occurred in Providence in 2020; however, due to missing or incomplete address information, only 81 are included.

Our analysis was strengthened using the model developed by ICER and the CHOICE Institute, who are leaders in the field of cost-effectiveness analysis and incorporated feedback from external reviewers and other stakeholders to develop their cost-effectiveness model. We tailored a variety of city, outcome, and cost parameters to Providence using real-world data, likely improving the utility of our results. Nonetheless, our analysis has important limitations. Given that Insite in Vancouver may present the only HRC in North America that has been extensively studied, many of our cost, outcome, and other parameter estimates were based on data from Insite. The findings from Insite/Vancouver may not always be generalizable to the Rhode Island context, particularly due to the different health care and social systems. In particular, our estimate for the total annual injections at the HRC, which was one of the most influential parameter in one-way sensitivity analyses, was based in part on the percentage of Insite clients who attended the center at specific frequencies (e.g., 31.5% of clients attended 2-5 visits per month).[27] Service utilization at an HRC in Rhode Island may be meaningfully different. Additionally, as described above, our estimate of the HRC annual operating cost was based on the operating budget of Insite, which is likely an overestimate of the costs for the smaller facility in Rhode Island that was considered in our analysis. We utilized multiple data sources to inform

our estimate of the probability of overdose per injection, which was another highly influential parameter in our sensitivity analyses. However, risk of overdose is likely to change over time and by location depending on the drug supply and use patterns. There were also important factors that were not included in our analysis. For example, the model did not incorporate the potential for drug checking and other HRC services to reduce the risk of overdose within the HRC, the potential for HRCs to reduce risk of subcutaneous injection-related infections and endocarditis (which can lead to costly hospital stays if left untreated[41]), nor the potential impact of the site on the surrounding community. Although some studies suggest that HRCs may have community and public order benefits, such as a decrease in public injection without an increase in drug-related crime or public nuisance in the community,[4,5] the impact of HRCs on surrounding property values is uncertain and likely depends on the specifics of implementation. For example, a mobile HRC may have less impact (positive or negative) on any one community, or a new HRC co-located within an existing service center may be noticed less by the surrounding community. Finally, we did not account for potential increased initiation of MOUD and other treatment and recovery modalities among HRC clients compared to the syringe services program only scenario. Previous studies have shown that frequent HRC utilization is associated with increased uptake of various treatment services.[42,43] Because engagement in MOUD and other services have numerous health benefits, including a decreased risk of mortality,[44] our cost benefit analysis is likely conservative. Importantly, the 2-year pilot program of HRCs in Rhode Island will provide an opportunity to collect additional cost, outcome, and other data that can improve future analyses and decision-making.

In conclusion, we found that a hypothetical HRC in Providence that includes syringe service provision would be prevent 1.9 deaths, 261.3 ambulance runs, 244.0 ED visits, and 117.1 inpatient hospitalizations for emergency overdose care annually, as well as 0.5 HIV infections, and 2.8 HCV infections per year compared to a scenario that includes a syringe service program only (i.e., the status quo). The HRC would save at least $1,104,454 annually, accounting only for annual facility costs and short-term costs of emergency overdose care (i.e., ambulance runs, ED visits, and inpatient hospitalizations). Especially important factors that will influence the cost-effectiveness of potential HRCs in Rhode Island include the service delivery model, service utilization, actual operational costs, and location of the center. Rigorous collection of detailed operational, cost, and health outcome data at HRCs in Rhode Island can inform quality improvement activities and improve our understanding of HRC impacts.

References

1. Hedegaard H, Miniño AM, Warner M. Drug Overdose Deaths in the United States, 1999-2019. *NCHS Data Brief* 2020; 394:1-8.

2. Rhode Island Department of Health. Accidental Drug Overdose Deaths Occurring in Rhode Island by Month/Year. Accessed: October 4, 2021. Available at: https://ridoh-drug-overdose-surveillance-fatalities-rihealth.hub.arcgis.com/.

3. State of Rhode Island. Rhode Island General Laws 23-12.10. Harm Reduction Center Advisory Committee and Pilot Program. 2021.

4. Kennedy MC, Karamouzian M, Kerr T. Public Health and Public Order Outcomes Associated with Supervised Drug Consumption Facilities: A Systematic Review. *Curr HIV/AIDS Rep* 2017; 14(5):161-183.

5. Levengood TW, Yoon GH, Davoust MJ, et al. Supervised Injection Facilities as Harm Reduction: A Systematic Review. *Am J Prev Med* 2021; 61(5):738-749.

6. Armbrecht E, Guzauskas G, Hansen R, et al. Institute for Clinical and Economic Review. Supervised Injection Facilities and Other Supervised Consumption Sites: Effectiveness and Value; Evidence Report. 2020. Available at: https://d279m997dpfwgl.cloudfront.net/wp/2020/11/ICER_SIF_Evidence-Report_1111320.pdf.

7. AIDS Care Ocean State. ENCORE Needle Exchange. Accessed: October 4, 2021. Available at: https://www.aidscareos.org/Our-Services/Prevention-Center/Needle-Exchange.

8. US Census Bureau. American Community Survey 5-year population estimates. 2018.

9. Rhode Island Department of Health. Municipal Count of All Drug Involved Fatal Overdose by Year (Incident Municipality). Accessed: September 1, 2021. Available at: https://ridoh-overdose-surveillance-rihealth.hub.arcgis.com/datasets/municipal-count-of-all-drug-involved-fatal-overdose-by-year-incident-municipality/explore.

10. University of Washington Comparative Health Outcomes, Policy, and Economics Institute. Cost Effectiveness of Supervised Injection Site Facilities (SIF). Accessed: October 4, 2021. Available at: https://uwchoice.shinyapps.io/SIF-ICER-Dashboard/.

11. Behrends CN, Paone D, Nolan ML, et al. Estimated Impact of Supervised Injection Facilities on Overdose Fatalities and Healthcare Costs in New York City. *J Subst Abuse Treat* 2019; 106:79-88.

12. Hood JE, Behrends CN, Irwin A, et al. The Projected Costs and Benefits of a Supervised Injection Facility in Seattle, WA, USA. *Int J Drug Policy* 2019; 67:9-18.

13. Irvine MA, Kuo M, Buxton JA, et al. Modelling the Combined Impact of Interventions in Averting Deaths During a Synthetic-Opioid Overdose Epidemic. *Addiction* 2019; 114(9):1602-1613.

14. Irwin A, Jozaghi E, Weir BW, Allen ST, Lindsay A, Sherman SG. Mitigating the Heroin Crisis in Baltimore, MD, USA: A Cost-Benefit Analysis of a Hypothetical Supervised Injection Facility. *Harm Reduct J* 2017; 14(1):29.

15. Irwin A, Jozaghi E, Bluthenthal RN, Kral AH. A Cost-Benefit Analysis of a Potential Supervised Injection Facility in San Francisco, California, USA. *J Drug Issues* 2017; 47(2):164-184.

16. Jozaghi E, Vancouver Area Network of Drug Users. Exploring the Role of an Unsanctioned, Supervised Peer Driven Injection Facility in Reducing HIV and Hepatitis C Infections in People that Require Assistance During Injection. *Health Justice* 2015; 3(1):16.

17. Jozaghi E. A Cost-Benefit/Cost-Effectiveness Analysis of an Unsanctioned Supervised Smoking Facility in the Downtown Eastside of Vancouver, Canada. *Harm Reduct J* 2014; 11(1):30.

18. PHS Community Services Society. Insite. Accessed: October 4, 2021. Available at: https://www.phs.ca/program/insite/.

19. Neumann P, Sanders G, Russell L, Siegel J, Ganiats Te. Cost-Effectiveness in Health and Medicine. Oxford University Press; 2016.

20. Chen YH, McFarland W, Raymond HF. Estimated Number of People Who Inject Drugs in San Francisco, 2005, 2009, and 2012. *AIDS Behav* 2016; 20(12):2914-2921.

21. Sherman S, Hunter K, Rouhani S. Safe Consumption Spaces: A Strategy for Baltimore. 2020. Accessed: September 1, 2021. Available at: https://abell.org/sites/default/files/files/Sherman%20Full%20length%20Report%20_final%20(002).pdf.

22. Glick SN. Public Health - Seattle and King County. HIV/AIDS Fact Sheet: People Who Inject Drugs (PWID). 2020. Accessed: September 1, 2021. Available at: https://kingcounty.gov/depts/health/~/media/depts/health/overdose/documents/people-who-inject-drugs-facts.ashx.

23. CommercialCafe. Top 100 Most Expensive US Office Submarkets in 2019. Accessed: September 1, 2021. Available at: https://www.commercialcafe.com/blog/top-100-expensive-office-submarkets-2019/.

24. Expatistan. Cost of Living Comparison. Accessed: September 1, 2021. Available at: https://www.expatistan.com/cost-of-living/comparison/vancouver/providence-rhode-island.

25. US Census Bureau. QuickFacts: Providence city, Rhode Island. Accessed: September 1, 2021. Available at: https://www.census.gov/quickfacts/providencecityrhodeisland.

26. Rhode Island Department of Health. Office of the State Medical Examiner, unpublished data. 2020.

27. Tyndall MW, Kerr T, Zhang R, King E, Montaner JG, Wood E. Attendance, Drug Use Patterns, and Referrals Made From North America's First Supervised Injection Facility. *Drug Alcohol Depend* 2006; 83(3):193-8.

28. Rhode Island Department of Health. Harm Reduction Surveillance System, unpublished data. 2021.

29. Jacka BP, Goldman JE, Yedinak JL, et al. A Randomized Clinical Trial of a Theory-Based Fentanyl Overdose Education and Fentanyl Test Strip Distribution Intervention to Reduce Rates of Opioid Overdose: Study Protocol for a Randomized Controlled Trial. *Trials* 2020; 21(1):976.

30. Notta D, Black B, Chu T, Joe R, Lysyshyn M. Changing Risk and Presentation of Overdose Associated With Consumption of Street Drugs at a Supervised Injection Site in Vancouver, Canada. *Drug Alcohol Depend* 2019; 196:46-50.

31. Colledge S, Leung J, Larney S, et al. Frequency of Injecting Among People Who Inject Drugs: A Systematic Review and Meta-Analysis. *Int J Drug Policy* 2020; 76:102619.

32. Marshall BDL. RAPIDS Clinical Trial, unpublished data. 2021.

33. US Centers for Medicare and Medicaid Services. Ambulance Fee Schedule Public Use Files. Accessed: September 1, 2021. Available at: https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AmbulanceFeeSchedule/afspuf.

34. Mallow PJ, Belk KW, Topmiller M, Strassels SA. Geographic Variation in Hospital Costs, Payments, and Length of Stay for Opioid-Related Hospital Visits in the USA. *J Pain Res* 2018; 11:3079-3088.

35. Teshale EH, Asher A, Aslam MV, et al. Estimated Cost of Comprehensive Syringe Service Program in the United States. *PLoS One* 2019; 14(4):e0216205.

36. Milloy MJ, Kerr T, Tyndall M, Montaner J, Wood E. Estimated Drug Overdose Deaths Averted by North America's First Medically-Supervised Safer Injection Facility. *PLoS One* 2008; 3(10):e3351.

37. Irwin A, Vasan T, Raville L. The costs and benefits of a supervised use site in Denver, Colorado. 2019. Available at: https://drugpolicy.org/sites/default/files/dpa-denver-scs-cost-benefit-analysis_0.pdf.

38. Schackman BR, Fleishman JA, Su AE, et al. The Lifetime Medical Cost Savings From Preventing HIV in the United States. *Med Care* 2015; 53(4):293-301.

39. Rhode Island Office of Management and Budget. Analyzing Regulatory Benefits and Costs: A Guide for Rhode Island Executive Agencies. 2015. Available at: http://omb.ri.gov/documents/reform/regulatory-review/ORR-Review-Analyzing-Regulatory-Benefits-and-Costs.pdf.

40. Rhode Island Department of Health. Drug Overdose Surveillance Data Hub: Municipal-level data reports. Accessed October 1, 2021. Available at: https://ridoh-overdose-surveillance-rihealth.hub.arcgis.com/search?tags=municipality%20report.

41. Fleischauer AT, Ruhl L, Rhea S, Barnes E. Hospitalizations for Endocarditis and Associated Health Care Costs Among Persons with Diagnosed Drug Dependence - North Carolina, 2010-2015. *MMWR Morb Mortal Wkly Rep* 2017; 66(22):569-573.

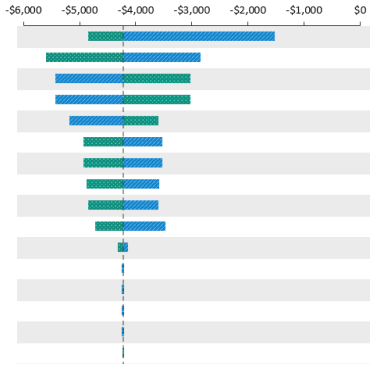
42. Wood E, Tyndall MW, Zhang R, et al. Attendance at Supervised Injecting Facilities and Use of Detoxification Services. *N Engl J Med* 2006; 23:2512-4.

43. DeBeck K, Kerr T, Bird L, et al. Injection Drug Use Cessation and Use of North America's First Medically Supervised Safer Injecting Facility. *Drug Alcohol Depend* 2011; 113(2-3):172-6.

44. Larochelle MR, Bernson D, Land T, et al. Medication for Opioid Use Disorder After Nonfatal Opioid Overdose and Association With Mortality: A Cohort Study. *Ann Intern Med* 2018; 169(3):137-145.

Appendix

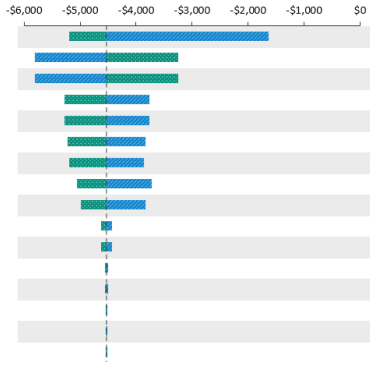
Figure A1. Sensitivity analysis results, short-term cost savings per ambulance run prevented



Parameter	Low Value	High Value	Low Result	High Result	Spread
Percentage of injections resulting in OD	0.50%	1.20%	-$1,527	-$4,852	$3,325
Percentage of no HRC ODs resulting in ED visit	34%	52%	-$2,849	-$5,604	$2,755
HRC annual operating cost	$1,349,829	$2,024,743	-$5,428	-$3,026	$2,402
Cost-of-living ratio Providence vs. Vancouver	0.74	1.12	-$5,428	-$3,026	$2,402
Percentage of no HRC ODs resulting in ambulance run	37%	55%	-$5,188	-$3,591	$1,597
Hospitalization cost in Providence	$6,318	$9,476	-$3,519	-$4,934	$1,416
Percentage of ED visits resulting in inpatient hospitalization	38%	58%	-$3,519	-$4,934	$1,416
Cost of ED visit in Providence	$2,761	$4,141	-$3,582	-$4,871	$1,289
Annual syringe service program cost	$691,089	$1,036,633	-$3,600	-$4,853	$1,253
Total annual injections in the HRC	48,672	73,008	-$3,477	-$4,727	$1,250
Cost of ambulance run in Providence	$372	$559	-$4,134	-$4,320	$186
Cost/sqft commercial property in Providence	$242	$362	-$4,252	-$4,201	$51
Percentage of HRC ODs resulting in ED visit	0.63%	0.95%	-$4,252	-$4,201	$51
Number of unique HRC clients/month	320	480	-$4,251	-$4,202	$50
Commercial mortgage loan interest in Providence	5%	9%	-$4,242	-$4,210	$32
Percentage of HRC ODs resulting in ambulance run	0.63%	0.95%	-$4,214	-$4,240	$26

Abbreviations: ED, emergency department; HRC, harm reduction center; MAT, medication assisted treatment; OD, overdose.

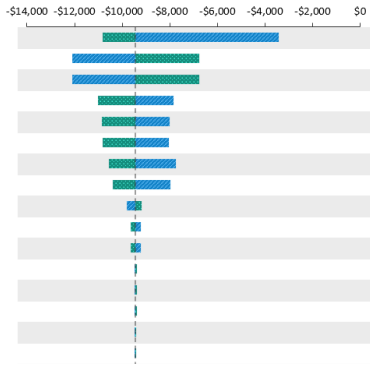
Figure A2. Sensitivity analysis results, short-term cost savings per ED visit prevented



Parameter	Low Value	High Value	Low Result	High Result	Spread
Percentage of injections resulting in OD	0.50%	1.20%	-$1,635	-$5,197	$3,561
HRC annual operating cost	$1,349,829	$2,024,743	-$5,813	-$3,241	$2,573
Cost-of-living ratio Providence vs. Vancouver	0.74	1.12	-$5,813	-$3,241	$2,573
Hospitalization cost in Providence	$6,318	$9,476	-$3,769	-$5,285	$1,516
Percentage of ED visits resulting in inpatient hospitalization	38%	58%	-$3,769	-$5,285	$1,516
Cost of ED visit in Providence	$2,761	$4,141	-$3,837	-$5,217	$1,380
Annual syringe service program cost	$691,089	$1,036,633	-$3,856	-$5,198	$1,342
Total annual injections in the HRC	48,672	73,008	-$3,724	-$5,063	$1,339
Percentage of no HRC ODs resulting in ED visit	34%	52%	-$3,833	-$4,987	$1,154
Percentage of no HRC ODs resulting in ambulance run	37%	55%	-$4,426	-$4,629	$203
Cost of ambulance run in Providence	$372	$559	-$4,427	-$4,627	$199
Cost/sqft commercial property in Providence	$242	$362	-$4,554	-$4,500	$54
Number of unique HRC clients/month	320	480	-$4,554	-$4,501	$53
Commercial mortgage loan interest in Providence	5%	9%	-$4,544	-$4,509	$34
Percentage of HRC ODs resulting in ED visit	0.63%	0.95%	-$4,537	-$4,517	$20
Percentage of HRC ODs resulting in ambulance run	0.63%	0.95%	-$4,529	-$4,525	$3

Abbreviations: ED, emergency department; HRC, harm reduction center; MAT, medication assisted treatment; OD, overdose.

Figure A3. Sensitivity analysis results, short-term cost savings per inpatient hospitalization prevented



Parameter	Low Value	High Value	Low Result	High Result	Spread
Percentage of injections resulting in OD	0.50%	1.20%	-$3,407	-$10,826	$7,419
HRC annual operating cost	$1,349,829	$2,024,743	-$12,111	-$6,751	$5,360
Cost-of-living ratio Providence vs. Vancouver	0.74	1.12	-$12,111	-$6,751	$5,360
Hospitalization cost in Providence	$6,318	$9,476	-$7,852	-$11,011	$3,159
Cost of ED visit in Providence	$2,761	$4,141	-$7,994	-$10,869	$2,876
Annual syringe service program cost	$691,089	$1,036,633	-$8,034	-$10,829	$2,796
Total annual injections in the HRC	48,672	73,008	-$7,758	-$10,547	$2,789
Percentage of no HRC ODs resulting in ED visit	34%	52%	-$7,984	-$10,389	$2,404
Percentage of ED visits resulting in inpatient hospitalization	38%	58%	-$9,815	-$9,176	$639
Percentage of no HRC ODs resulting in ambulance run	37%	55%	-$9,220	-$9,643	$423
Cost of ambulance run in Providence	$372	$559	-$9,224	-$9,639	$416
Cost/sqft commercial property in Providence	$242	$362	-$9,488	-$9,375	$113
Number of unique HRC clients/month	320	480	-$9,487	-$9,376	$111
Commercial mortgage loan interest in Providence	5%	9%	-$9,466	-$9,395	$71
Percentage of HRC ODs resulting in ED visit	0.63%	0.95%	-$9,453	-$9,410	$42
Percentage of HRC ODs resulting in ambulance run	0.63%	0.95%	-$9,435	-$9,428	$7

Abbreviations: ED, emergency department; HRC, harm reduction center; MAT, medication assisted treatment; OD, overdose.