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Systematic Literature Review

Economic Evaluations of Establishing Opioid Overdose Prevention Centers in 12 North American cities: A Systematic Review

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ABSTRACT

Objectives: Overdose prevention centers (OPCs) provide a safe place where people can consume preobtained drugs under supervision so that a life-saving medical response can be provided quickly in the event of an overdose. OPCs are programs that are established in Canada and have recently become legally sanctioned in only a few United States jurisdictions.

Methods: We conducted a systematic review that summarizes and identifies gaps of economic evidence on establishing OPCs in North America to guide future expansion of OPCs.

Results: We included 16 final studies that were evaluated with the Consolidated Health Economic Evaluation Reporting Standards and Drummond checklists. Eight studies reported cost-effectiveness results (eg, cost per overdose avoided or cost per quality-adjusted life-year), with 6 also including cost-benefit; 5 reported only cost-benefit results, and 3 cost offsets. Health outcomes primarily included overdose mortality outcomes or HIV/hepatitis C virus infections averted. Most studies used mathematical modeling and projected OPC outcomes using the experience of a single facility in Vancouver, BC.

Conclusions: OPCs were found to be cost-saving or to have favorable cost-effectiveness or cost-benefit ratios across all studies. Future studies should incorporate the experience of OPCs established in various settings and use a greater diversity of modeling designs.

Keywords: cost-effectiveness analysis, overdose prevention centers, systematic literature review.

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Highlights

- Overdose prevention centers (OPCs) help to provide a safe space for people who use drugs and provide essential public health services that can help reduce opioid overdose fatalities. There is scant health economic evidence on OPCs and no systematic review.
- This systematic review found the optimal number of OPCs varied within the studies, but all suggested opening at least 1 OPC as economically viable.
- The findings from this review suggest that jurisdictions looking for strategies to stem the opioid overdose crisis should establish budgets for supporting OPCs in North America because they are projected to result in favorable economic and health impact.

Introduction

The fentanyl-driven opioid epidemic has fueled increasing overdose fatalities in the United States and Canada.[1] The public health response to overdose deaths includes expanded access to naloxone, a drug that reverses opioid overdoses.[2] Although naloxone saves lives, it requires that a witness is present to administer the medication and/or call emergency services. Fentanyl and other novel opioids, because of their high potency, may need additional units of naloxone or oxygen support to prevent death.[3] Overdose prevention centers (OPCs) provide a safe place where people can consume preobtained drugs under supervision so that, in the event of an overdose, an appropriate medical response can be provided quickly. OPC models include "supervised injection facilities," or broader "supervised consumption sites," which also allow drug inhalation, smoking, and oral ingestion on site.[4] OPCs typically offer harm reduction services beyond naloxone and oxygen administration, such as providing sterile supplies, wound care, and referrals to substance use disorder, HIV, and hepatitis C virus (HCV) treatment programs. OPCs have been operating in Western Europe since the 1980s and Australia since 2001 as part of a comprehensive harm reduction strategy to reduce the risks of overdose and injection-associated infections, such as HIV and HCV.[5,6]

Although OPCs provide essential public health services, they face barriers to initiation and expansion in North America. The first OPC in North America opened in Vancouver in 2003, demonstrating public health benefits, including a 35% reduction in opioid overdose fatalities within the 500 meter area around the OPC.[7] Over 30 OPCs have opened in Canada[8] more recently after overcoming political or community opposition.[9] In the United States, the only 2 legally sanctioned OPCs opened in New York City in November 2021,[10] and Rhode Island is preparing to implement a pilot OPC.[11] Adoption in both countries has been hindered by legal barriers, such as a US federal statute that may be used to prosecute OPC operators and Canadian federal regulations establishing preconditions for approval.[9]

A better understanding of the economic evidence about OPCs in North America can help policymakers weigh benefits and potential downsides of OPCs. This systematic review summarizes the economic evidence to date, including identifying gaps in the literature that can be addressed in future work from newly established North American OPCs.

Methods

Search Strategy

Our search strategy followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses methodology.[12,13] The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42020176033), which details information about the population, interventions comparator control, and other items. Studies were identified by searching PubMed, Embase, Web of Science, EconLit, PsycINFO, and Cost-Effectiveness Analysis Registry. Authors conducted the most recent literature search in February 2023.

Inclusion and Exclusion Criteria

To be included, studies had to be peer reviewed, written in English, and compare 1 or more OPC interventions to at least 1 alternative (eg, no OPC) in North America using an economic approach (eg, cost-offset, cost-effectiveness analysis, and cost-benefit analysis). Commentaries/editorials, theses/dissertations, reviews, and studies without a comparator were excluded.

Selection Process

Study selection, quality appraisal, and data collection were performed by 2 authors independently. Search terms included combinations of terms for "overdose prevention" and "economic" using Boolean operators and key words related to OPC and costs (Appendix Table 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2024.02.004). Studies were included from database inception through December 2022. Records were uploaded to Covidence software (Covidence). In Covidence, studies first underwent title and abstract screening, followed by full-text review. Disagreements between the 2 reviewers' independent assessment during the selection process were reconciled by a third author.

Data Extraction

For each study, we extracted (1) study design, (2) population, (3) outcomes, (4) perspectives and time horizon, (5) design, (6) health economic measures, and (7) findings. Primary outcomes of interest were comparisons of costs (eg, healthcare utilization and cost offsets), cost-effectiveness (eg, cost per overdose avoided and cost per quality-adjusted life-year [QALY]), and cost-benefit (eg, cost to benefit ratios). Modeling techniques were categorized as decision tree, Markov model, microsimulation model, dynamic model, or discrete event simulation, as suggested by Kuntz et al.[14] Results are presented by geographic location in the currency and year in which they were published. We conducted a narrative synthesis of results as studies varied in setting, population, and outcome measure; therefore, combining data across studies was not feasible[1,2]

Reporting and Quality Assessments

We used the Consolidated Health Economic Evaluation Reporting Standards (CHEERS)[15,16] and the Drummond checklists[17] to evaluate the study reporting and quality, respectively. The CHEERS checklist consists of 28 items that were scored using "yes" (met the criteria in total), "no" (not met), or "not applicable." For the Drummond 10-item checklist, we allocated points for each question and categorized articles as poor (1-3), average (4-7), or good (8-10) quality, as was done in a previous study.[18] Two reviewers independently scored each article using both checklists, and discrepancies were resolved by a third reviewer.

Results

Descriptive Characteristics

We identified 6712 references for initial screening and removed 2470 duplicates. Of the 4242 remaining studies, 31 references received full-text screening, and 16 studies were included (Fig. 1). Key characteristics of these studies are reported in Table 1.[19-34] All of the articles, except for 1, were evaluated as "good" quality according to the Drummond checklist (Appendix Table 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2024.02.004), and reporting was generally complete except for 4 studies that failed to report 3 or more items from the CHEERS checklist (Appendix Table 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2024.02.004). The authors of the 16 studies reported no conflicts of interest, and funding sources were predominantly from government or not-for-profit agencies (Appendix Table 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2024.02.004).

Geography and Currency

Eleven studies examined Canadian sites and presented costs in Canadian dollars (CADs).[19-29] Four of these studies examined a single OPC (3 in Vancouver and 1 in Calgary) after the programs had been established. The remaining 7 Canadian studies examined scenarios of expanding OPC services in Vancouver or opening OPCs in other Canadian cities where they had not yet been established. Five studies analyzed the establishment of OPCs in the United States, where, at the time, no legally sanctioned OPCs had been established.[30-34] Six studies failed to report the currency year.[19,22,27,29-31]

Population

All studies focused on a local population of people who use drugs. The population of people who use drugs who were served by an existing OPC or could be served by a hypothetical OPC varied from 1500 to 22 500 (Table 1[19-34]). Fifteen studies considered people who inject drugs.[19-24,26-34] One study assessed supervised smoking facilities (SSFs) and only considered people who smoke crack cocaine.[25]

Perspective

The study's stakeholder perspective informs which costs and savings are included in the analysis. Thirteen articles explicitly reported the stakeholder perspective: 7 reported a healthcare system perspective,[19,24,25,28,33] 1 a payer perspective,[29] and 5 a societal perspective.[20,26,30,31,34] Of the 3 studies that did not explicitly report a perspective, we inferred that 2 adopted a healthcare system perspective[21,22] and 1 a societal perspective[32] based on the cost categories included.

Interventions and Comparators

Six studies considered the health and economic impact of 1 OPC versus 0,[19,21,29-31,34] 9 studies compared the impact of 0, 1, or multiple OPCs,[20,23-28,32,33] and 1 study considered the impact of expanding from the existing OPC up to 15 additional OPCs.[22]

Study Analytic Approaches

Design

Fourteen studies used decision tree-type mathematical modeling,[20-27,29-34] and 2 used dynamic compartmental modeling.[19,28] Nine of the studies that used mathematical modeling estimated HIV outcomes based on previously published HIV infection models, with substantial overlap among the models

Table 1. Summary of health economic evidence on overdose prevention centers.

Study	Population	Outcomes	Perspective, time horizon	Design, number of OPCs	Health economic measures	Key findings
Canada						
Bayoumi and Zaric[19] 2008	People who inject drugs (7000 people) in Vancouver, BC	Prevented HCV and HIV infections, and life-years gained	Healthcare, 10 years	Dynamic compartmental model, 0-1	Cost-effectiveness: $ per LY gained (2008 CAD)	Maintaining 1 OPC is economically preferred to no OPCs and can save nearly CAD $14 million and gain 920 life-years over 10 years. In scenarios with increased safer needle sharing practices off-site or greater methadone uptake, savings and life-years gained grow further
Andresen and Boyd[20] 2010	People who inject drugs (5000 people) in Vancouver, BC	Prevented HIV infections, HIV deaths, and overdose deaths	Healthcare,* 1 year	Mathematical modeling,† 0-6	Cost-effectiveness: $ per HIV infection avoided (2006 CAD) cost-benefit: cost-benefit ratio	The existing OPC provides benefits of more than CAD $6 million per year at a cost-benefit ratio of 4.06:1 and varies between 3.00:1 to 8.04:1 based on HIV model structure assumptions
Pinkerton[21] 2010	People who inject drugs (13 500 people) in Vancouver, BC	Prevented HIV infections	Healthcare,* 1 year	Mathematical modeling,† 0-1	Cost-offset: healthcare costs averted (2008 CAD)	The existing OPC and syringe service facility, prevents 83.5 HIV infections per year, saving CAD $17.6 million, which more than offsets Insite's annual operating cost of CAD $3 million. Without considering decreased off-site syringe sharing, the OPC component of Insite is responsible for 2.8 of the 83.5 averted HIV infections. If syringe sharing among regular clients is reduced by 35% and 70%, 1.4 and 3.8 additional HIV infections would be averted, which correspond to an added savings of CAD $294 777 and CAD $800 109, respectively.

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Table 1. Continued

Study	Population	Outcomes	Perspective, time horizon	Design, number of OPCs	Health economic measures	Key findings
Andresen and Jozaghi[22] 2012	People who inject drugs (4700 people) in Vancouver, BC	Prevented HIV infections	Healthcare,* 1 year	Mathematical modeling,† 1-15	Cost-benefit: Cost-benefit ratio	Implementing additional OPCs is economically beneficial. Assuming one-third, two-thirds, or the entire population of PWID are reached and decreases of off-site needle sharing, implementing up to 2 OPCs, 5 OPCs, and 8 OPCs, respectively, would have economic benefits at least as great as expenses. A decreased initial needle sharing rate lowers the number of economically viable OPCs by 1 to 2 based on proportion of PWID recruited
Jozaghi et al,[23] 2013	People who inject drugs (4300-12 500 people) in Montreal, QC	Prevented HIV and HCV infections	Healthcare,* 1 year	Mathematical modeling, 0-7	Cost-effectiveness: $ per HIV and HCV averted (2012 CAD) cost-benefit: cost-benefit ratio	Implementing up to 3 OPCs would have economic benefits at least as great as expenses when considering averted HCV and HIV infections separately. Lower assumptions of local needle sharing rates suggest as few as 1 OPC may be economically viable
Jozaghi et al,[24] 2014	People who inject drugs (3000-5000 people) in Ottawa, ON	Prevented HIV and HCV infections	Healthcare,* 1 year	Mathematical modeling,† 0-7	cost-effectiveness: $ per HIV infection averted and $ per HCV infection averted (2013 CAD) cost-benefit: cost-benefit ratio	Implementing any number of OPCs would yield economic benefits lesser than expenses when the benefits of averted HCV and HIV infections are considered separately, but when considered together, up to 2 OPCs would have economic benefits greater than expenses. Results are highly sensitive to the local needle sharing rate, with a lower estimate suggesting that no OPCs may be economically favored

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Table 1. Continued

Study	Population	Outcomes	Perspective, time horizon	Design, number of OPCs	Health economic measures	Key findings
Jozaghi and VANDU[25] 2014	People who smoke crack cocaine (4330 people) in Vancouver, BC	Prevented HCV infections	Healthcare,* 1 year	Mathematical modeling, † 0-7	Cost-effectiveness: $ per HCV averted (2012 CAD) cost-benefit: cost-benefit ratio	When considering averted HCV infections, implementing up to 7 SSFs is expected to provide substantial savings when compared with costs. High cost-benefit ratios—from 20.6:1 for 1 SSF to 5.9:1 for 7 SSFs—are driven largely by the low operating costs of SSFs and the high rate of pipe sharing
Jozaghi et al,[26] 2015	People who inject drugs (1500-2000 people) in Victoria, BC	Prevented HIV and HCV infections, prevented overdose deaths	Societal, 1 year	Mathematical modeling,† 0-4	Cost-effectiveness: $ per HIV infection averted and $ per HCV infection averted (2013 CAD) cost-benefit: Cost-benefit ratio	If 2 OPCs were to open in Victoria, BC, it would have a benefit-cost ratio of 1.25:1. The cost-benefit ratios suggest that opening up to 2 OPCs in Victoria may save taxpayers' dollars for the resources that they consume
Jozaghi and Jackson,[27] 2015	People who inject drugs (2000 people) in Saskatoon, SK	Prevented HIV infections	Healthcare, 1 year	Mathematical modeling,† 0-4	Cost-effectiveness: $ per HIV infection averted (CAD, year unknown) cost-benefit: cost-benefit ratio	Implementing up to 4 OPCs would have economic benefits at least as great as expenses when considering averted HIV infections. Results are highly sensitive to the local needle sharing rate, with a lower estimate suggesting that no OPCs may be economically viable
Enns et al,[28] 2016	People who inject drugs in Toronto, ON (10 000 people) and Ottawa, ON	Prevented HCV and HIV infections, and QALYs	Healthcare, 20 years	Dynamic compartmental model, 0-5	Cost-effectiveness: $ per QALY gained (2012 CAD)	In Ottawa and Toronto, up to 2 and 3 OPCs, respectively, would be cost-effective at a $50 000 per QALY threshold when considering the health effects of HIV and HCV. Results were sensitive to variations in facility operating costs, the population of PWID, and changes in syringe sharing

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Table 1. Continued

Study	Population	Outcomes	Perspective, time horizon	Design, number of OPCs	Health economic measures	Key findings
Khair et al,[29] 2022	People who inject drugs (22 425 clients served) in Calgary, AB	Prevented need for ambulance, emergency department services	Payer, 2 years and 3 months	Descriptive statistics	Cost-offset: Ambulance and ED services averted (CAD, year unknown)	The OPC in Calgary was able to save $2 364 876 CAD within 2 years and 3 months of being open. Additionally, within the most recent full year of operation (2019), 698 overdoses were managed at the OPC site
United States						
Irwin et al,[30] 2016	People who inject drugs (22 500 people) in San Francisco, CA	Prevented HIV and HCV infections, overdose deaths, SSTI hospitalizations, and increased methadone uptake	Societal, 1 year	Mathematical modeling,† 0-1	Cost-benefit: Cost-benefit ratio (USD, year unknown)	If an OPC was implemented, a 2.33:1 ratio of total benefits to costs is expected over the first year. Savings from 4 factors, averted HIV and HCV infections, increased MOUD referrals, and reduced skin and soft tissue infections, generated a significant majority of the projected benefits in roughly equal proportions
Irwin et al,[31] 2017	People who inject drugs (20 950 people) in Baltimore, MD	Methadone uptake, prevented HCV and HIV infections, SSTIs, and overdose ambulance calls, ED encounters, hospitalizations, and deaths	Societal, 1 year	Mathematical modeling,† 0-1	Cost-benefit: cost-benefit ratio (USD, year unknown)	If an OPC in Baltimore, MD was implemented, a 4.35:1 ratio of total benefits to costs is expected over the first year. Cost-benefit results were robust but were most affected by variation in the facility's projected operating cost
Hood et al,[32] 2019	People who inject drugs (21 863 people) in King County, WA	Prevented overdose deaths and ambulance calls, increased MOUD uptake, and prevented ED visits, hospitalizations from overdose, and HIV and HCV infections	Societal,* 1 year	Mathematical modeling, 0, 1, or 1 scaled-up	Cost-benefit: cost-benefit ratio (2016 USD)	Implementing 1 OPC is expected to save over $5.1 million with a ratio of total benefits to costs of 4.22:1 over 1 year. If a scaled-up program was implemented, the ratio of benefits to costs would rise to 5.32:1. An increased local overdose rate augments the projected cost-benefit ratio to 7.70:1

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Table 1. Continued

Study	Population	Outcomes	Perspective, time horizon	Design, number of OPCs	Health economic measures	Key findings
Behrends et al,[33] 2019	People who inject drugs in New York, NY	Prevented overdose deaths, ambulance calls, ED visits, and hospitalizations	Healthcare, 1 year	Mathematical modeling, 0, 1, or 4	Cost-offset: healthcare costs averted (2016 USD)	One OPC is expected to save, or offset, at least $700 000 per year in healthcare costs from averted overdoses, whereas 4 OPCs would save at least $2 214 700 per year. Prevented hospitalizations constitute a significant majority of projected savings
Chambers et al,[34] 2022	People who inject drugs in Providence, RI	Prevented overdose related deaths, ambulance runs, ED encounters, and hospitalizations	Modified Societal, 1 year	Decision analytic model, 0, 1	Cost-benefit: cost-benefit ratio (2020 USD)	If an OPC was to open in Providence, RI, it is estimated to save $1 104 454 per year compared with just a syringe service program. Findings were robust under all sensitivity analyses

AB indicates Alberta; BC, British Columbia; CA, California; CAD, Canadian dollar; ED, emergency department; HCV, hepatitis c virus; LY, life-year; MD, Maryland; MOUD, medications for opioid use disorder; NY, New York; ON, Ontario; OPC, overdose prevention center; PWID, people who inject drugs; QALY, quality-adjusted life-year; QC, Quebec; RI. Rhode Island; SSF, supervised smoking facility; SK, Saskatchewan; SSTI, skin and soft tissue infection; USD, United States dollar; VANDU, Vancouver Area Network of Drug Users; WA, Washington.
*Analysis perspective is not explicitly stated in article and inferred by authors based on model valuation.
†Base-case assumes use of Jacobs et al[35] to determine HIV infection rates.

used. Four of these articles used the Jacobs et al[35] model only,[22,23,25,30] 1 used the Kaplan and O'Keefe model only,[21] 3 used both of these models only,[24,26,27] and 1 used these 2 models in combination with 2 others.[20] Similarities in study designs may be partially attributed to the substantial author overlap among the articles (Fig. 2).

Health Economic Approach

Five studies reported cost-benefit results only,[22,30-32,34] 2 reported cost-effectiveness results only,[19,28] 6 reported both,[20,23-27] and the remaining 3 reported cost offsets.[21,29,33] Cost-benefit studies report a ratio of costs avoided to costs incurred, with a ratio of >1 implying a positive return on investment, or net economic benefit results in currency or QALYs. Although reporting results as net benefit is preferred,[36] all cost-benefit results in these studies were reported as ratios. Cost-effectiveness studies report the cost per unit of health improvement achieved (such as infection avoided, life saved, or QALY saved), which can be compared to a threshold value that a decision maker is willing to pay. Cost-offset studies quantify the amount of costs avoided as a result of the program's impact on health outcomes.[17]

Time Horizon and Discounting

Twelve studies used a 1-year time horizon only,[20-22,24-27,30-34] 1 reported results for a 27 month horizon,[29] 1 reported 1-year and 10-year results,[23] 1 used a 10-year horizon,[19] and 1 used a 20-year horizon.[28] Two studies discounted their results at 5% for 10 year and 20 year horizons in accordance with Canadian guidelines,[19,28] and 1 study did not report a discount rate for their 10-year estimate.[23]

Sensitivity and Scenario Analyses

All but 1 study[29] performed sensitivity or scenario analyses to assess the robustness of their results. Of these 15 studies, 11 varied the baseline sharing rate of drug consumption equipment (syringes or pipes),[19-28,30,31] and 5 varied the facility cost.[19,28,30,31,34] Nine studies only included 1 parameter in their sensitivity/scenario analysis and the remaining 6 studies reported multiple sensitivity or scenario analyses by varying 5 to 69 parameters.[19,21,28,30,31,34] Only 1 study reported a probabilistic sensitivity analysis.[28]

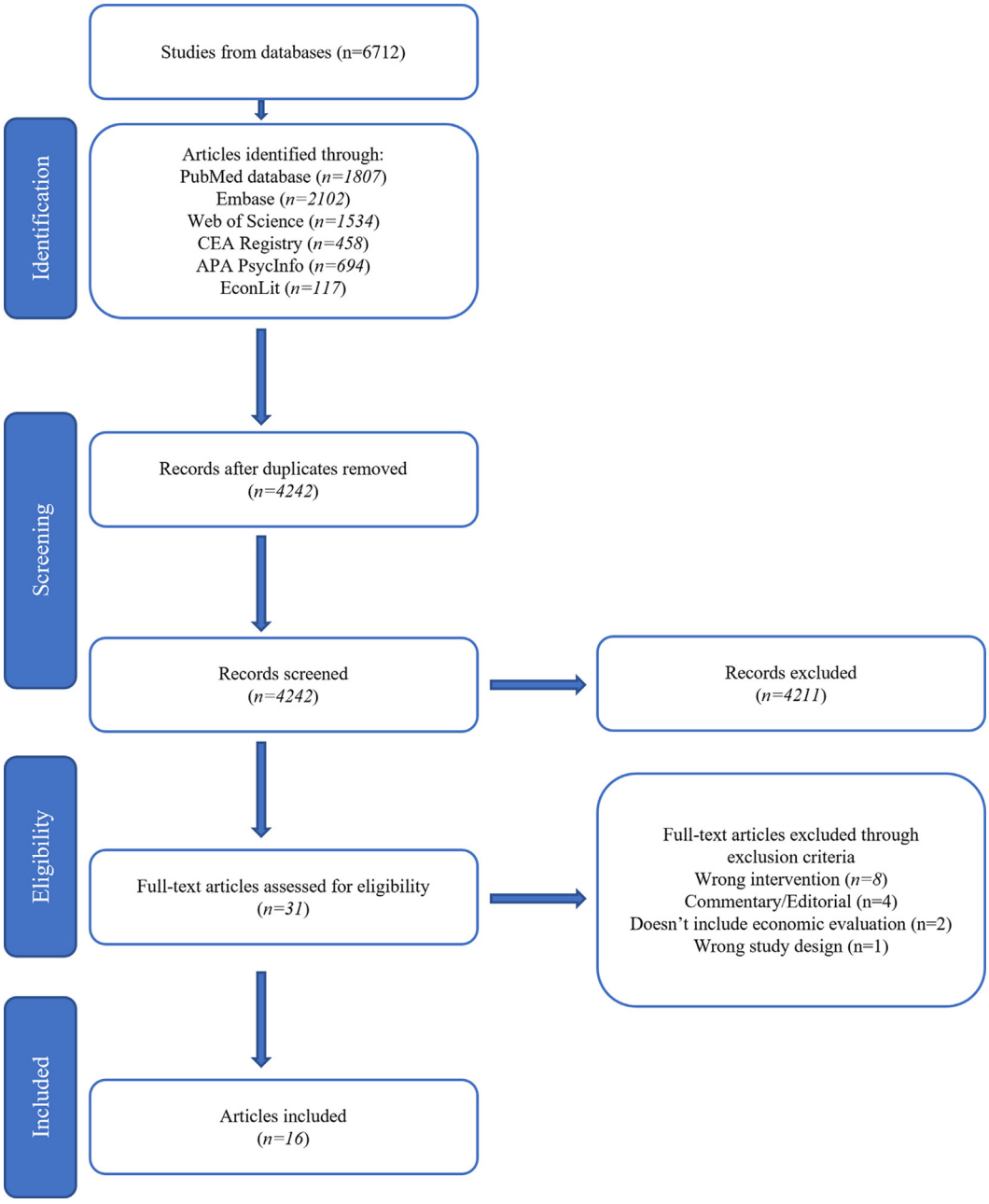
Outcomes and Findings

Summary of health outcomes

The health outcomes considered varied widely (Table 2[19-34,35,37-77]), but the studies can be divided into 2 categories: (1) those focusing primarily on HIV or HCV infections averted and (2) those focusing primarily on opioid overdose fatality outcomes. The first group included 10 studies,[19-28] all examined Canadian cities and were published between 2008 and 2015. Two studies included life-years gained and QALYs as health outcomes, in addition to HCV or HIV cases avoided.[19,28] The second group included 6 studies, assessing 5 cities in the United States[30-34] and 1 city in Canada[29]; all were published between 2016 and 2022. Most of this group also included other health outcomes (eg, HIV and HCV, skin and soft tissue infections [SSTIs], emergency room visits, and uptake of medication for opioid use disorder [MOUD]) (Appendix Table 5 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2024.02.004).

Seven studies included overdose deaths averted as a health outcome.[20,26,30-34] Nine studies reported HIV cases averted

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

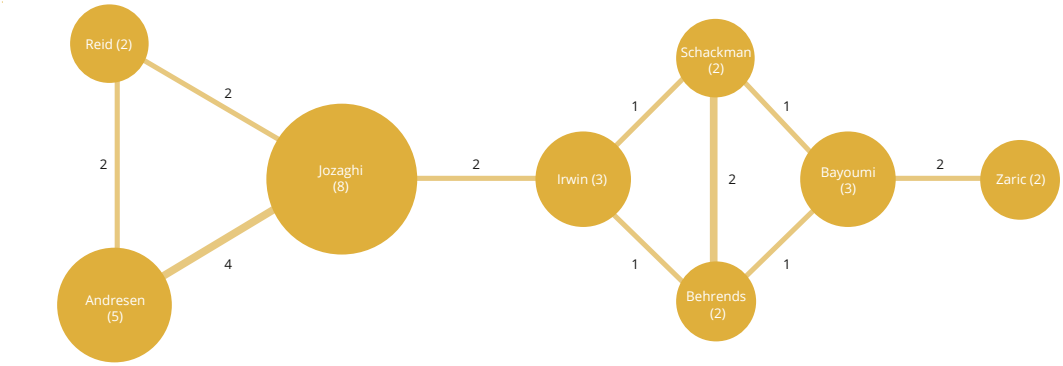


annually based on low, base-case, and high syringe sharing rates, with half of these studies estimating between 1 and 5 cases averted and the other half estimating at least 10 cases averted and upward of 40 (Appendix Fig. 1A in Supplemental Materials found at https://doi.org/10.1016/j.jval.2024.02.004). Five studies reported HCV cases averted annually based on low, base-case, and high syringe sharing rates, with at least 10 cases averted estimated across all sites with 1 OPC and upward of approximately 115 cases averted in the most optimistic scenario (Appendix Fig. 1B in Supplemental Materials found at https://doi.org/10.1016/j.jval.2024.02.004).

Summary of OPC operational costs

All but 1 study included the cost of operating an OPC (Table 2[19-34,35,37-77]). Twelve studies estimated the local cost of an OPC based on the operating budget of the OPC located in Vancouver, Canada,[19-24,26-28,30,31,34] with local cost estimates ranging between $1 500 000 (2006 CAD) and $2 575 336 (USD, year unknown). Three studies estimated the local costs of opening a stand-alone OPC for injection drug use ranging between $1 222 332 (2016 USD) and $3 048 708 (2020 CAD); the estimate for a stand-alone OPC for smoking was $97 203 (2012 CAD).[25,29,32]

Figure 2. Co-authorship diagram for authors of two or more publications. Notes: Co-authorship diagram for authors of two or more publications. The size of each circle is proportional to the number of publications an author is included in. The weight of the lines between authors is proportional to the number of publications both authors appear on. Note: Size of circle is proportional to the number of publications by a given author. Weight of the line between authors is proportional to the number of publications on which both authors appear. For example, Andresen co-authored 5 papers included in this review including 2 with Reid and Jozaghi and another 2 with Jozaghi. Chambers et al. and Khair et al. had no co-authorship with any of the authors in the review and are excluded from the figure.



Healthcare costs avoided

To calculate the monetary impact of establishing or expanding OPCs, all studies included estimates of healthcare costs avoided by the operation of these facilities (Table 2[19-34,35,37-77]). Nine Canadian and 2 US studies incorporated savings from HIV infections averted.[19-24,26-28,30,31] Of the 9 Canadian studies, 2 used the annual cost of HIV treatment per year, $16 947 (2012 CAD),[19,28] to estimate the savings per HIV infection avoided, and 7 used the lifetime cost of medical care for a person living with HIV.[20-24,26,27] The 2 US articles used the lifetime cost of HIV treatment in the United States.[30,31]

Eight articles, 6 from Canada[19,23-26,28] and 2 from the United States,[30,31] considered the savings from averted HCV infections, of which 7 estimated the costs averted over a lifetime.[23-26,28,30,31] One study used $60 000 (2012 CAD)[47,48] representing the cost of a pharmaceutical treatment for HCV,[28] 2 studies used the average lifetime cost of medical care of $68 219 (2014 USD) representing the additional healthcare costs for untreated HCV,[30,31,49] and 4 used the average productivity loss per person with incident HCV of $35 143 (2012 CAD)[45] based on an 2008 Australian report.[23-26] Only 2 studies explicitly included medication costs in their study, with 1 including interferon containing regimens[19] and another including direct-acting antivirals.[28]

Seven studies calculated the savings from each overdose death averted.[20,26,30-34] One study estimated that the value of an overdose death avoided was $660 000 (2006 CAD) based on productivity estimates, and another used the same estimates but in 2013 CAD ($978 924).[20,26] Three US studies used the same productivity method[30-32] and estimated savings from each averted overdose death between $503 869 and $1 170 000 (USD). The remaining US study and Canadian study tabulated only the healthcare costs avoided by averting an overdose, resulting in comparatively small values of $3872 (2016 USD)[33] and $1622 (2020 CAD).[29]

Three studies from the United States incorporated the projected savings from MOUD referrals.[30-32] Two of these estimated that society saves $14 000 per person receiving MOUD per year, based on an annual MOUD cost of $4000.[30,31] The third study estimated that the healthcare system saves $14 651 per person per year, which is the previously reported mean difference in annual healthcare expenditures between patients with OUD enrolled in methadone treatment versus those not enrolled.[32]

Three US studies included the projected savings to the healthcare system from this reduction in SSTIs because of wound care offered by OPCs.[30-32] Two of these studies assumed that 67% of SSTI hospitalizations would be averted among OPC clients. All 3 estimated savings between $15 000 USD[31] and $25 000 USD[30] per hospitalization averted.[30-32]

Economic Outcomes

Cost-benefit results

Ten articles published cost-benefit ratios associated with the operation of 1 or more OPCs.[20,22-27,30-32] Three of these focused on extant OPCs in Vancouver.[20,22,25] Cost-benefit ratios ranged between 2.32 and 5.12 for 1 OPC[20,22] and between 1.07 to 5.90 for 7 OPCs.[22,25]

Four studies examined cost-benefit ratios for hypothetical OPCs in Saskatchewan, Ottawa, Montreal, and Victoria.[23,24,26,27] The cost-benefit ratios were similar across these cities, ranging from 1.26 to 1.40 for 1 OPC. For implementing multiple OPCs, these studies generated cost-benefit ratios >1 for up to 2 OPCs in Ottawa,[22] 3 OPCs in Montreal,[23] and 4 OPCs in Saskatchewan.[27]

Three articles reported cost-benefit ratios in US cities.[30-32] Implementing 1 OPC was reported to have an estimated cost-benefit ratio of 2.33 in San Francisco,[30] 4.35 in Baltimore,[31] and 4.22 in Seattle.[32] Hood et al[32] also found that if overdose rates continued to trend upward, the cost-benefit ratio for 1 OPC in Seattle would increase to 7.70.

Cost-effectiveness results

Eight studies, all Canadian, published cost-effectiveness results.[19,20,23-28] Five studies reported the cost per HIV infection averted,[20,23,24,26,27] and 4 reported the cost per HCV infection averted.[23-26] The cost per HIV infection averted for 1 OPC ranged from $26 316 to $784 447 (2006 CAD)[20] in Vancouver and $436 560 (2013 CAD)[24] in Ottawa. The cost per HCV infection averted for 1 OPC ranged from $1705 (2006 CAD)[25] in Vancouver, to $45 475 in Ottawa.[24] Both HIV and HCV cost-effectiveness ratios increased when more OPCs were considered, reflecting smaller incremental gains as more OPCs were added in the same city.

Two articles reported cost-effectiveness results in terms of life-years or QALYs gained. One article[19] evaluating a Vancouver OPC

Table 2. Summary of key study parameters for overdose prevention centers.

Parameter by Location	Base-Case Estimate	Estimate Source and Rationale
Value of HIV infection averted		
Canada		
Vancouver[19,20]	150 000 over lifetime (2006 CAD)[20]	Authors selected the base-case value as slightly lower than the median of 3 previous estimates from Holtgrave and Pinkerton,[37] 1997 (132 000 2006 CAD), Jacobs et al,[35] 1999 (179 000 2006 CAD) and Gold et al,[38] 1997 (154 000 2006 CAD). HIV treatment costs generally represent the standard of care at the time with either antiretroviral monotherapy or 2-drug combinations.
	15 564 per year (2008 CAD)[19]	Estimate taken from Krentz et al,[39] 2008 and includes costs for all drugs and in-patient and out-patient care from a national Canadian cohort of individuals between 1995 and 2001.
Montreal[23] Ottawa[24] Saskatoon[27] Vancouver[21,22] Victoria[26]	210 555 over lifetime (2008 CAD)	2011 cost estimate of medical care over entire lifetime derived from Canadian Research Network[40] and based on most recent research.[21,41,42]
Toronto[28] Ottawa[28]	16 947 per year (2012 CAD)	Assumes treatment with antiretroviral therapy. Estimate taken from Krentz et al[39] 2008 representing care delivered between 1995 and 2001.
United States[30,31]	402 000 over lifetime (2011 USD)	Estimate of average lifetime treatment costs cites the Centers for Disease Control and Prevention 2015,[43] which likely uses the estimate by Farnham et al[44] of patients who initiate HIV treatment with high CD4 counts representing guidelines of immediate initiation upon diagnosis.
Value of HCV infection averted		
Canada		
Montreal[23] Ottawa[24] Vancouver[25] Victoria[26]	35 143 (2012 CAD)	Undiscounted lifetime productivity loss per person with incident HCV derived from 2010 Australian report estimate of 35 143 (2008 AUD).[45] Does not include cost of HCV treatment.
Vancouver[19]	2650 per year (2008 CAD)	Annual cost based on US lifetime cost of $35 000 to $40 000 for treatment, including labs, medications (including use of interferon containing regimens), and provider visits. Estimated annual cost of HCV derived from Krahn et al,[46] 2005.
Toronto[28] Ottawa[28]	60 000 (2012 CAD)	Cost of 12-week pharmaceutical treatment with direct-acting antivirals derived from 2015 newspaper article[47] and a 2015 Canadian Agency for Drugs and Technologies in Health report.[48]
United States[30,31]	68 219 (2014 USD)	Average lifetime medical cost for a patient with untreated HCV adjusted for inflation, based on $64 490 (2011 USD) estimate from Razavi et al,[49] 2013. The cost of HCV treatment is not included.
Value of death averted		
Canada		
Vancouver[20]	660 000 (2006 CAD)	Includes tangible (ie, value person may add to the economy) only and valued at British Columbia GDP at that time ($33 640 2006 CAD; 35 143 2013 CAD) and an average age of 35 based on epidemiologic data[50] and assumed the age of death as 65.
Victoria[26]	978 924 (2013 CAD)	
United States		
Baltimore City[31]	503 869 (USD, year unknown)	Considers "tangible" costs only and is based on average retirement age of 65,[51,52] median wage for Baltimore City,[53] and 3% discount.[20]

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Table 2. Continued

Parameter by Location	Base-Case Estimate	Estimate Source and Rationale
New York City[33]	3872 (2016 USD)	Calculated by valuing emergency medical services ($392),[54,55] ED ($684),[56] and In-patient ($14 154) and assumed 90% of overdose fatalities included EMS services, 25% of fatalities[57] took place in the ED.
San Francisco[30]	1 170 000 (USD, year unknown)	Followed methods reported in Andresen and Boyd 2010[20] and adjusted for California per capita income.
Seattle[32]	566 539 (2016 USD)	Used a productivity valuation approach based on median per capita income in King County, WA (eg, $41 664 in 2016)[58] weighted by probability of being alive[59,60] from one year to the next assuming average age of 39 based on published King County Syringe Exchange Survey data and assuming retirement age of 65.
Annual per person savings from increase in MOUD uptake		
United States		
Baltimore City[31]	14 000 (USD, year unknown) per person, per year	Assumes average annual cost of MOUD at $4000[61] and a cost-benefit ratio of 4.5 that incorporates savings from reduced crime and health costs, reductions in HIV, HCV, and SSTI infection due to decreases in injection drug use.[42,51,61-65]
San Francisco[30] Seattle[32]	14 651 (2016 USD) per person per year	$11 531 in 2004 USD adjusted to 2016 USD represents healthcare savings per person per year valued at the mean difference in annual healthcare expenditures between OUD-diagnosed patients enrolled in methadone versus not methadone conducted by Kaiser Permanente Northwest.[66]
Value of wound care hospitalization averted		
Baltimore City[31]	15 000 per SSTI hospitalization averted (USD, year unknown)*	Assuming $2500 per day hospitalized[67,68] for 6 days (Hsieh Y-H, Personal Communication).[69-71]
San Francisco[30]	24 000 per SSTI hospitalization averted (USD, year unknown)*	Assuming $4000 per day hospitalized[67,68] for 6 days (Hsieh Y-H, Personal Communication).[69-71]
Seattle[32]	18 568 per hospitalization averted (2016 USD)	$18 568 is the mean cost of hospitalization (including an ED encounter) and $6815 is the mean cost for an ED encounter for drug-related wounds and infections.[72] Proportion of patients with ICD-10 drug-related codes is from unpublished data from local medical centers.
	6815 per ED encounter averted (2016 USD)	
OPC operating cost, $ per year		
Canada		
Vancouver	1 500 000 (2006 CAD)[20]	Annual Insite operation costs for supervised consumption services only.[73]
	3 000 000 (2008 CAD)[21]	Annual Insite operating costs including syringe exchange and supervised consumption services.[63]
	2 948 101 (2008 CAD)[19]	Annual Insite operating costs based on data provided by the Scientific Evaluation of Supervised Injecting investigators.
	97 203 (2012 CAD)[25]	Annual operating cost of existing supervised smoking facility in Vancouver, Canada (50 000 in rent + 47 203 in volunteer stipends).
Montreal	2 182 000 (2012 CAD)[23]	1 530 000 per year estimate (Insite property rental, client provisions, staff salaries, and equipment[41]) adjusted to 2012 CAD and multiplied by 4/3 to account for expanding services from 18-to-24 hours per day.
	1 500 000 + 131 per client (2012 CAD)[27]	Used Insite's $3 million operating cost[21] and assumed ratio of fixed to total costs was similar to Sydney, Australia's OPC.[62]
Ottawa	2 183 000 (2013 CAD)[24]	Authors cite Jozaghi et al,[23] 2013 rationale and estimate for Montreal, as well as a 2008 television interview.[73]
	1 500 000 + 131 per client (2012 CAD)[28]	Used Insite's $3 million operating cost[21] and assumed ratio of fixed to total costs was similar to Sydney, Australia's OPC.[62]
Saskatoon, Saskatchewan[27]	2 182 000 (2013 CAD)	1 530 000 per year estimate (Insite property rental, client provisions, staff salaries, and equipment)[41,74] and other adjustments used in other health economic analyses that have used this estimate.

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Table 2. Continued

Parameter by Location	Base-Case Estimate	Estimate Source and Rationale
Calgary[29]	3048 708 (2020 CAD)	Includes costs of administering oxygen, naloxone, nurses' wages, equipment costs, and emergency medical services for overdoses.
Victoria[26]	2 182 000 (2013 CAD)	1 530 000 per year estimate (Includes the costs of Insite when accounting only for equipment, staff, and property costs)[23] and expanded the hours from 18 to 24.
United States		
Baltimore[31]	1 725 252 per year (USD, year unknown)	4% adjustment to Insite estimate of $1 500 000 to account for Baltimore cost of living.
San Francisco[30]	2 575 336 per year (USD, year unknown)	Also includes 1.5 million in start-up costs amortized over 25 years. 57% adjustment[75] to Insite estimate of $1 500 000 account for San Francisco cost of living as documented by Jozaghi 2015.
		Also includes 2.0 million in start-up costs amortized over 25 years.
Seattle[32]	1 222 332 (2016 USD)	Based upon King County internal estimates[76] for pilot study, including staff salaries, fringe benefits, supplies, training, communications, rent, janitorial services, and indirect rate costs.
Providence[34]	1 602 334 (2020 USD)	Based on upfront loan, operating costs, ambulance run costs, ED visit costs, and inpatient hospitalization costs. Also based on full operating budget of Insite as reported by Institute for Clinical and Economic Review report.[77]

Note. Insite is the first sanctioned supervised drug-injection site in North America that opened in Vancouver, BC in 2003.
AUD indicates Australian Dollar; BC, British Columbia; CAD, Canadian Dollar; ED, emergency department; EMS, emergency medical services; GDP, gross domestic product; HCV, hepatitis c virus; ICD-10: International Classification of Diseases, Tenth Revision; MOUD, medications for opioid use disorder; OPC, overdose prevention center; OUD, opioid use disorder; SSTI, skin and soft tissue infection; USD, United States Dollar; WA, Washington.
*Authors assume 2 out of every 3 SSTIs requiring hospitalizations are averted.[69]

analyzed the cost per life-year gained over 10 years and found that implementing 1 OPC dominates (ie, has a lower cost and results in more life-years gained) compared with having no OPC. The other article[28] reported the cost per QALY gained over 20 years by establishing 1 or more OPCs in 2 Canadian cities, and found that up to 3 OPCs in Toronto and up to 2 OPCs in Ottawa had an incremental cost-effectiveness ratio of <$50 000 (2012 CAD) per QALY gained, and up to 5 OPCs in Toronto and up to 3 OPCs in Ottawa had an incremental cost-effectiveness ratio of <$100 000 (2012 CAD) per QALY gained.

Cost-offset results

Three studies, 2 based in Canada[21,29] and 1 based in the United States,[33] presented cost-offset results. One Canadian article[21] evaluated a Vancouver OPC and found that the $3 million (2008 CAD) facility annual operating costs would be offset by $17.6 million (2008 CAD) in lifetime HIV treatment savings. Another Canadian article[29] reported that the OPC in Calgary produced $2 364 876 (2020 CAD) in savings over 27 months by avoiding the need for ambulance and emergency department services. The US article[33] reported $831 700 in annual averted costs to the New York City healthcare system if 1 OPC was implemented and $2 945 000 (2016 USD) if 4 OPCs were implemented but did not include OPC costs in the offset estimates.

Limitations

The main limitations that were identified by the studies focus on model limitations, with a majority of studies noting a likely underestimation of benefits related to not being able to include all potential health and social benefits of the OPC.[19-29,31,33,34] Several studies also indicated the limitations of using a mathematical modeling approach, including the short time horizon.[20-22,26,27,34] Mathematical models also limit the ability to estimate long-term benefits from HIV and HCV prevention efforts in preventing secondary infections and improved quality of life over time.[19,21,24,26,27,34] Finally, several studies indicated that a major limitation was not being able to use local or recent data for all the inputs.[19-21,25,28,30-33]

Discussion

We identified 16 articles published from 2007 to 2022 that reported economic evaluations of OPCs in North American cities. The studies used a variety of modeling techniques to project economic outcomes; all but 1 had good quality ratings using the Drummond checklist, and most had complete reporting using the CHEERS checklist. Three studies estimated economic and health outcomes for an existing OPC,[19,20,29] whereas the remainder projected the potential impact of implementing 1 or more new OPCs.[21-28,30-34] Regardless of economic analysis performed (cost-benefit, cost-effectiveness, or cost-offset analysis) or the health outcomes considered (HIV, HCV, overdose fatalities, or SSTIs prevented; MOUD initiations; and life-years or QALYs saved), all studies estimated considerable financial and health benefits of opening 1 or more OPCs. For cost-effectiveness studies that reported QALYs saved, the estimated incremental cost-effectiveness ratios for various health outcomes were under

$50 000 and $100 000 per QALY, the willingness to pay thresholds often cited in Canada and the United States.[19,20,23-25,27,28] Cost-benefit studies all reported ratios that were greater than 1 (range = 1.26 to 20.6). Finally, cost-offset studies estimated between $831 700 (2016 USD) and $2 945 000 (2016 USD) of annual cost offsets to the healthcare system after implementing 1 OPC.[21,33]

We identified substantial economic and health benefits in these studies, but this literature has important gaps. The studies identified in this review predominantly used data from 1 OPC in Vancouver, which was identified as a limitation by several studies. Given that there are now over 30 OPCs operating in Canada and 2 legally sanctioned OPCs in the United States, data from other OPCs can provide insights for a variety of operating and substance use environments. For example, they could help distinguish between the operating costs of an OPC opening in a new location versus one that opens within an existing space, such as a harm reduction program. To simulate the impact of different environments, Chambers et al[34] provides an online tool that allows end-users to adjust the reported results to their own local environment based on city characteristics, HIV/HCV infection reduction metrics, population parameters, infection treatment costs, and MOUD utilization by OPC clients. The tool also considers differences in annual costs of stand-alone OPCs versus OPCs implemented alongside syringe service programs. Obtaining data that reflect local conditions for study parameters, as well as for sensitivity analyses, would allow results to be better tailored to each jurisdiction. Although most studies conducted sensitivity analyses to examine the impact of different syringe sharing rates and facility costs, other inputs were not typically varied. For decision makers, understanding what OPC models might be most effective in their local communities, taking into consideration local drug use dynamics and the OPC models they are able to feasibly implement, would help guide adoption and future implementation. For example, 1 study had found that, given the geographical spread of opioid overdose fatalities in New York City, multiple OPCs would need to be implemented to make a considerable impact on reducing opioid overdose fatality rates compared with other cities with more concentrated drug use in 1 area.[33] Nearly all studies utilized decision analytic modeling, with most relying on decision-tree-type mathematical modeling and only 2 using dynamic compartmental modeling.[19,28] There were substantial similarities in mathematical modeling approaches reflecting overlaps in authorship. A greater diversity of modeling approaches and greater use of more advanced modeling methods, such as dynamic compartmental modeling, could provide a more nuanced understanding of the factors that affect economic and health outcomes from OPC implementation. Dynamic compartmental modeling approaches often measure long-term benefits, such as improvements in quality of life over time, unlike the mathematical studies included here that predominantly accounted for only 1 year time horizon. Comparing a variety of modeling approaches could also identify results that are most sensitive to each model's structure and assumptions.[78]

The majority of the studies were from Canada and published between 2008 and 2015 with a primary focus on HIV or HCV health outcomes. Although this work demonstrated the potential impact of OPCs on HIV and HCV outcomes at that time, many of these findings are now outdated in that they either did not include medication costs for HCV or included older medication regimens, such as interferon-based medications for HCV, which had substantially different treatment cure rates and costs than current treatment regimens. Moreover, the increase in opioid overdose fatality rates among people who inject opioids since that time has been unprecedented, whereas the risks of HIV infection among people who inject drugs have declined over this time.[79] The recent studies from 2016 to 2022 (5 from the United States and 1 from Canada) modeled a wider breadth of health outcomes, such as SSTIs avoided, but these studies did not have the opportunity to incorporate either the steep upward trend of opioid-related mortality as a result of fentanyl entering into the drug market or the subsequent impacts of the COVID-19 pandemic. Given these changes, we need new studies that consider the full economic benefits of existing OPCs across a range of contemporary healthcare utilization and health outcome scenarios to provide more current information on how this may affect the magnitude of costs and effects.

Our study and results are subject to several limitations. The language used to describe OPCs is rapidly evolving, and it is possible we may have failed to identify relevant articles. We limited our search to the peer-reviewed published literature and did not include reports not published in peer-reviewed journals (eg, a report published by the Institute for Clinical and Economic Review[77]). Because of the stark differences between the US and Canadian health systems, results are not easily compared between these countries. For instance, Canada's universal health system enables all Canadian citizens access to care, which would increase overall healthcare utilization in comparison with the US multipayer system that results in barriers to healthcare access for some people. It is also important to note that our systematic review did not uncover studies conducted in Mexico, which may have been limited by our search criteria of only including English language studies. We used the CHEERS checklist to evaluate study reporting, as suggested by the Second Panel on Cost-effectiveness in Health and Medicine, but acknowledge that most studies were published before the release of these guidelines.

Conclusion

This systematic review found that the implementation of OPCs is consistently projected to result in greater benefits than costs or to be cost-effective. Future studies should incorporate the experience of OPCs established in various settings, use a greater diversity of modeling designs, and consider both overdose and infectious disease prevention outcomes. However, taken together, these studies make a compelling economic case for the public health benefits of OPCs.

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Links to the disclosure forms provided by the authors are available here.

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