Received: 4 November 2023 | Revised: 4 July 2024 | Accepted: 19 July 2024

DOI: 10.1111/dar.13921

ORIGINAL PAPER

Drug and Alcohol REVIEW APSAD WILEY

The associations of supervised consumption services with the rates of opioid-related mortality and morbidity outcomes at the public health unit level in Ontario (Canada): A controlled interrupted time-series analysis

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Abstract

Introduction: This study aimed to assess the impact of the implementation of legally sanctioned supervised consumption sites (SCS) in the Canadian province of Ontario on opioid-related deaths, emergency department (ED) visits and hospitalisations at the public health unit (PHU) level.

Methods: Monthly rates per 100,000 population of opioid-related deaths, ED visits and hospitalisations for PHUs in Ontario between December 2013 and March 2022 were collected. Aggregated and individual analyses of PHUs with one or more SCS were conducted, with PHUs that instituted an SCS being matched to control units that did not. Autoregressive integrated moving average models were used to estimate the impact of SCS implementation on opioid-related deaths, ED visits and hospitalisations.

Results: Twenty-one legally sanctioned SCS were implemented across nine PHUs in Ontario during the study period. Interrupted time series analyses showed no statistically significant changes in opioid-related death rates in aggregated analyses of intervention PHUs (increase of 0.02 deaths/100,000 population/month; $p = 0.27$). Control PHUs saw a significant increase of 0.38 deaths/100,000 population/month; $p < 0.001$. No statistically significant changes were observed in the rates of opioid-related ED visits in intervention PHUs (decrease of 0.61 visits/100,000 population/month; $p = 0.39$) or controls (increase of 0.403 visits; $p = 0.76$). No statistically significant changes to the rates of opioid-related hospitalisations were observed in intervention PHUs (0 hospitalisations/100,000 population/month; $p = 0.98$) or controls (decrease of 0.05 hospitalisations; $p = 0.95$).

Discussion and Conclusions: This study did not find significant mortality or morbidity effects associated with SCS availability at the population level in Ontario. In the context of a highly toxic drug supply, additional interventions will be required to reduce opioid-related harms.

KEYWORDS
Canada, opioids, public health, supervised consumption services, time series analysis

Key Points

- This study assessed the impact of supervised consumption sites (SCS) in Ontario.
- Analyses were conducted at the level of the public health unit (PHU).
- Interrupted time series analyses were used to compare PHUs with SCS to those without.
- All PHUs in Ontario experienced an increase in opioid-related deaths.
- SCS show no impact on opioid-related death rates at the PHU level.

1 | INTRODUCTION

For the past two decades, Canada has been home to an unprecedented public health crisis of acute drug-related fatalities, mainly from opioids, that is similar in magnitude to that documented for the United States [1]. While there were 2830 opioid-related acute deaths (crude rate: 7.8/100,000 population) in Canada in 2006, this number increased to 7328 deaths (19.1/100,000) in 2022 [2]. In Ontario, Canada's most populous province, the numbers of opioid-related deaths increased almost eightfold, from 366 (3/100,000 population) in 2003 to 2866 (19.1/100,000) in 2021 [3]. This has coincided with corresponding increases in morbidity outcomes, specifically from 1858 (15.2/100,000) to 17,073 (114 /100,00) opioid-related emergency department (ED) visits and from 1185 (9.7/100,000) to 2440 (16.3/100,000) hospitalisations [3]. While earlier in this crisis, the majority of drug-related fatalities were associated with strong prescription opioids in different formulations, by about 2015, illicit, highly potent and toxic synthetic opioids (e.g., fentanyl and analogues) became the predominant driver of opioid-related deaths [4–6].

A number of interventions have been implemented and expanded over time to resolve the drug death crisis in Canada, including supervised consumption services (SCS) [7]. SCS have existed as an intervention in Canada for 20 years, with the general objective of providing a 'safer' environment for individuals to consume pre-obtained drugs under the supervision of trained health professionals with reduced risk (e.g., clean/sterile equipment and a calmer and 'off limits' environment for stressors known to increase overdose) [8, 9]. They also serve as access points for basic health and social supports, emergency care, and referrals to addiction and other health care [8, 10]. There are now dozens of SCS across several of Canada's provinces, including 23 legally sanctioned SCS across Ontario [11].

Although SCS have been implemented and evaluated in several other jurisdictions (e.g., Germany, Switzerland) much of the scientific evaluation efforts have focused on Vancouver, British Columbia (BC) and Sydney, Australia [8]. Based on international, but predominantly Canadian study data, recent systematic reviews have concluded that SCS participation was associated with reductions in opioid overdose morbidity and mortality, reductions in injection risk behaviours, improvements in addiction treatment access or utilisation, and no increases or reductions in crime and public nuisance [8, 10, 12–14]. While, on this basis, existing research quite consistently notes the above-listed benefits for participants in SCS programming, the translation of these associated effect benefits onto population-levels is less evidenced [9, 15].

For example, a controlled interrupted time series analysis evaluated the population-level effects of SCS on health service use and mortality in the province of BC at the level of the local health area between January 2015 and December 2017. Study results were mixed, showing significant declines in reported overdose events, paramedic attendance and ED visits, but no changes to trends in monthly hospitalisation or mortality rates on the population level [9]. Another interrupted time series conducted in Vancouver, however, found that post-SCS expansion, the monthly prevalence of SCS use immediately increased by an estimated 6.4% per month; the monthly prevalence of addiction treatment participation increased by an estimated 4.5% and public injection and syringe sharing decreased by 5.5% and 2.5%, respectively [12].

Only one prior time series analysis has focused on the SCS in the province of Ontario [16]. This study examined the population-level effects of SCS in Ontario between January 2015 and March 2021. Results showed that across the nine health units in the province with an SCS, the number of hours SCS' were open had no effect on rates of opioid-related ED visits, hospitalisations or deaths [16].

As the rates of opioid-related morbidity and mortality continue to increase in Ontario, additional evidence on the effects of SCS is required to confirm and expand

on the results of the one existing time series analysis. The aim of the present study was therefore to determine whether the availability of SCS has been associated with effects on the levels of opioid-related deaths, as well as levels of opioid-related hospitalisations and ED visits, at the public health unit level in the province of Ontario.

2 | METHODS

2.1 | Study design

A controlled interrupted time series (ITS) approach was used for this study. Prior studies have shown high SCS use from the time of site initiation and that impacts of SCS on opioid-related deaths and related morbidity (e.g., needle sharing, public injection) begins within a short period of the site opening [12, 15]. The proposed impact model for this study was therefore a step change, in which a sudden, sustained change either up or down is observed immediately following the intervention [9, 12, 17].

The study setting was the Canadian province of Ontario, with all outcome measures being collected at the level of public health units (PHU) across the province. The primary outcome for this study was the monthly rate of opioid-related deaths per 100,000 individuals. Secondary outcomes were the monthly rate of opioid-related ED visits and opioid-related hospitalisations (both per 100,000 population). Monthly data for all three outcome measures were collected for 100 months (December 2013—March 2022), allowing for a roughly equal distribution of time points before and after the establishment of SCS for most PHUs and to account for potential seasonality of data [18]. The exact distribution of time points pre- and post-intervention differed slightly between PHUs depending on the date of SCS institution.

2.2 | Data sources

Demographic information for Ontario's PHU were obtained from the 2016 census. Information for all legally sanctioned SCS were obtained from Government of Canada and individual SCS websites [19]. All outcome data for this study were obtained from Public Health Ontario's Interactive Opioid Tool, a publicly accessible online tool that reports the number and rate of opioid-related deaths, ED visits and hospitalisations on a monthly basis for each PHU in Ontario [3]. This tool contains data collected from the following sources: (i) the Opioid-Related Death Database; (ii) the National Ambulatory Care Reporting System; and (iii) the Hospital and Discharge Abstract Database [20].

2.3 | Supervised consumption services in Ontario

At the time of data collection, there were 23 government sanctioned SCS offering services across the province of Ontario. These SCS are located within 11 PHUs. The City of Hamilton Public Health Services, Kingston, Frontenac and Lennox and Addington Health Unit, Middlesex-London Health Unit, Niagara Region Public Health, Peterborough Public Health, Region of Waterloo Public Health, Public Health Sudbury and Districts, Thunder Bay District Health Unit and Wellington-Dufferin-Guelph Health Unit each contain 1 SCS whereas Ottawa Public Health has 4 and Toronto Public Health (TPH) 10 SCSs. All 23 (100%) SCS sites are authorised for drug use via injection, with 22 (95.7%) being additionally authorised for intranasal and/or oral consumption, 19 (82.6%) for consumption with peer assistance and 1 (4.4%) for consumption by inhalation. Most offer additional services such as drug checking, safer drug use education and supplies, nursing care and referral to additional services. The Public Health Sudbury and Districts and Peterborough Public Health sites both opened after March 2022. Outcome data for these sites were therefore not available and they were excluded from the time series analyses.

2.4 | Statistical analyses

Basic descriptive statistics were calculated. This included pre- and post-intervention means, the change in respective outcome rates per 100,000 population and the percentage increase in rates.

An autoregressive integrated moving average (ARIMA) approach was utilised to evaluate the impact of SCS on opioid-related deaths, ED visits, and hospitalisations in this study [18, 21]. ARIMA models were fitted for aggregated outcome data across all PHUs with one or more SCS (intervention PHUs) and for across all PHUs with no SCS (control PHUs). A separate model was also fitted for intervention PHUs excluding TPH, as it encompasses a much larger population than other PHUs in the province and could thus bias results. Separate models were also fitted for each PHU with an SCS individually to assess trends in outcomes at the level of the individual PHU. Each intervention PHU was matched to a control PHU using nearest neighbour propensity score matching on PHU demographic characteristics (population size, median age, median income) and a calliper width of 0.15 of the standard deviation of the logit of the propensity score for each PHU [9, 22]. These demographics were chosen for matching because previous research has shown that substance use concerns are greatest in among

those with a low income and is most likely to be reported among those aged 16 to 24 [2, 23, 24]. Population size was chosen due to the differences in service availability in rural versus urban health units, which could affect access to addiction treatment services other than SCS through issues such as longer wait lists, transportation issues, system fragmentation, stigmatisation and lack of services [25, 26]. The rates of opioid-related outcomes pre-SCS implementation were also graphed for each matched pair as a visual inspection of PHU comparability on these outcomes (Figures S2–S9, Supporting Information). This created control matches for each intervention PHU, with the exception of TPH, for which no control was selected.

All ARIMA models were fit initially using the expert modeller function in SPSS and fitted for a step change [27]. Model selection was then confirmed using the Box and Jenkins method [28, 29]. First, data were plotted to understand underlying patterns and determine whether differencing was required to render the series stationary. If stationarity was not clear based on data plots, it was further assessed with an augmented Dickey-Fuller test [30]. Autocorrelation function (ACF) and partial autocorrelation function (PACF) plots of the stationary data were then created to determine the need for autoregressive and/or moving average terms in the ARIMA model. Residual autocorrelation was assessed through visual inspection of model ACF and PACF plots and using the Ljung-Box test for white noise. If residual autocorrelation was present, different autoregressive/moving average orders were selected. The most parsimonious model (smallest possible autoregressive/moving average terms, lowest Bayesian information criterion, highest R squared) was then chosen and the intervention impact estimated [17]. Both nonseasonal and seasonal ARIMA models were considered. All analyses were conducted using SPSS Statistics Version 28.0.1.1 (ARIMA modelling, propensity score matching) and R statistical software (tests of stationarity) [27, 31]. Ethics approval was for this study was granted in the form of an exemption by the Hamilton Integrated Research Ethics Board.

3 | RESULTS

3.1 | Opioid-related deaths

Between January 2014 and December 2021, there were 11,958 opioid-related deaths in Ontario, with a steady increase in the annual number of deaths observed over time. All intervention and control PHUs included in the analyses observed an increase in opioid-related deaths during the study period. The average percentage increase in opioid-related deaths from pre- to post-SCS implementation for the aggregated time series was 96.7% for intervention PHUs and 99% for intervention PHUs excluding TPH. The largest percent increase was observed in aggregation of control PHUs at 177.1% (Table 1). Aggregated analyses showed a non-significant increase in opioid-related death rates in intervention PHUs of 0.02 deaths per 100,000 population per month associated with SCS implementation ($p = 0.27$) (Table 2). Excluding TPH from analyses did not change the results (increase of 0.02 deaths/100,000/month; $p = 0.80$). A significant increase of 0.38 deaths per 100,00 population per months ($p < 0.001$) was observed for control PHUs. Results of analysis showed that Thunder Bay District Health Unit (increase of 1.56 deaths per 100,000 population per month, $p = 0.001$ supervised consumption services [control = 0.56, $p \leq 0.001$]) and Wellington-Dufferin-Guelph Health Unit (6.73, $p < 0.001$ [control = 2.49, $p = 0.23$]) both had statistically significant increases in opioid-related deaths after SCS implementation. The rates of opioid-related deaths, ED visits and hospitalizations over time in both intervention and control PHUs is depicted in (Figure 1).

3.2 | Opioid-related emergency department visits

All intervention and control PHUs showed a trend of increasing opioid-related ED visits during the study period. The mean percentage increase in ED visits in the aggregated time series for intervention PHUs was 83.7% and 79.9% for intervention PHUs excluding TPH (Table 1). The largest percent increase in opioid-related ED visits was observed in aggregation of control PHUs, with a 166.8% increase. The aggregated ARIMA analysis found no statistically significant changes in opioid-related ED visit rates in intervention PHUs associated with SCS implementation (decrease of 0.61 opioid-related ED visits per 100,000 population per month; $p = 0.39$) or control PHUs during the same time-period (increase of 0.403; $p = 0.76$) (Table 2). Excluding TPH from the analysis did not change the results (decrease of 0.01; $p = 0.21$). Only Wellington-Dufferin-Guelph Health Unit had a statistically significant change in ED visits (increase of 37.30 visits/100,000/month) after SCS implementation (control = increase of 0.45; $p = 0.62$). The Hamilton Public Health Services (−0.40) and Region of Waterloo Public Health (−1.03) were the only intervention PHUs with decreases in ED visits associated with SCS implementation, although these were not statistically significant.

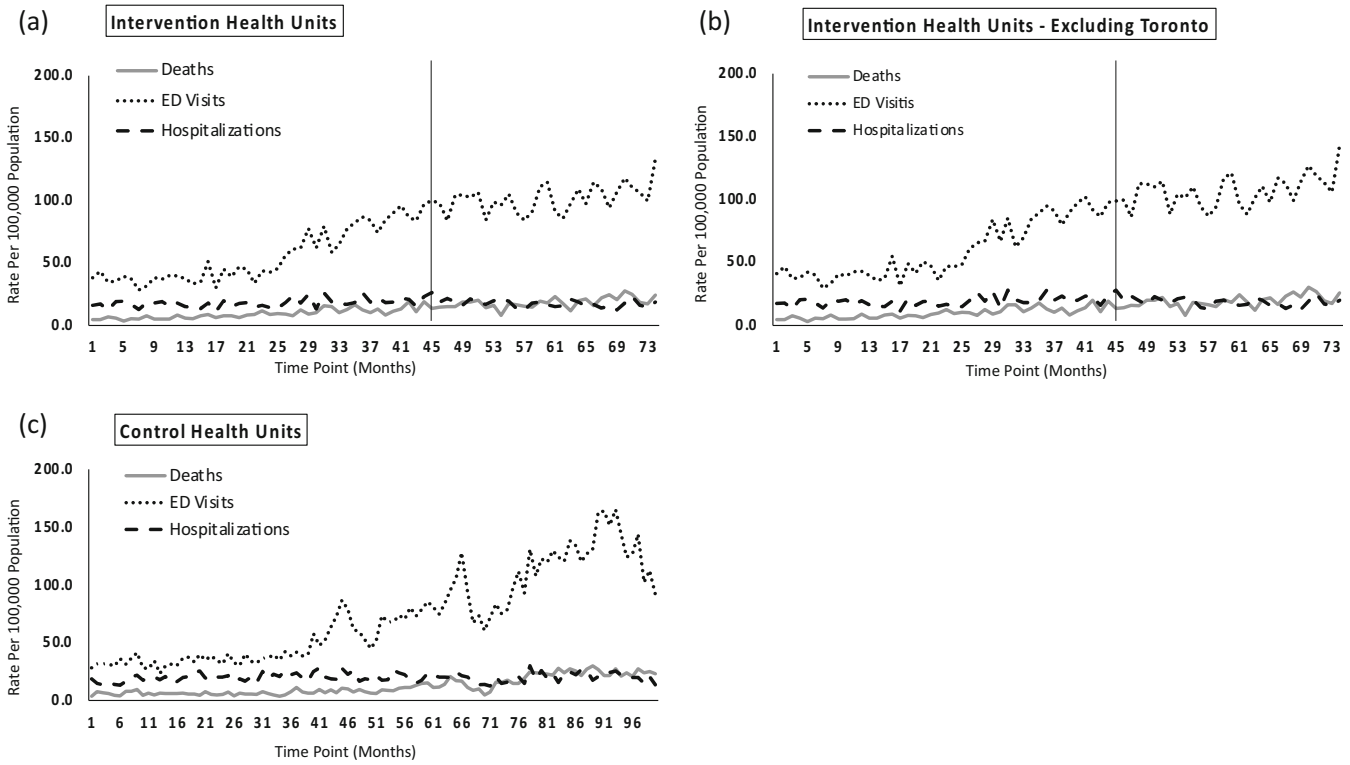

FIGURE 1 (a) Aggregated data for opioid-related deaths, emergency department (ED) visits and hospitalisations for all public health units in Ontario with one or more supervised consumption sites over time; (b) Aggregated data for opioid-related deaths, ED visits and hospitalisation for all public health units in Ontario with one or more supervised consumption sites over time, excluding Toronto Public Health; (c) Aggregated data for opioid-related deaths, ED visits and hospitalisations for all public health units Ontario with no supervised consumption sites. The vertical line in graphs A and B indicate the time point at which SCS were implemented.

3.3 | Opioid-related hospitalisations

Results for opioid-related hospitalisations were mixed. The mean percentage change in the hospitalisation rate for the aggregated time series was −0.6% for intervention PHUs, −1.6% for intervention PHUs excluding TPH and 4.6% for control PHUs from pre- to post-SCS implementation (Table 1). Results of the ARIMA analysis found no changes in opioid-related hospitalisation rates in intervention PHUs (change of 0 hospitalisations per 100,000 population per month, $p = 0.98$). Results were similar when TPH was excluded from the aggregated analysis (−0.27, $p = 0.77$) and control PHUs (−0.05, $p = 0.95$) (Table 2). In the analysis of individual intervention PHUs, no units showed statistically significant changes in hospitalisation rates. For most PHUs (intervention and control), an ARIMA model of (0,0,0) was selected, indicating that the time series results were 'white noise'.

4 | DISCUSSION

This study examined the potential impact of the implementation of SCS on opioid-related mortality and morbidity outcomes at the public health unit level in the province of Ontario, amidst a steadily accelerating public health crisis of opioid-related fatalities.

In this interrupted time-series analysis, the implementation of SCS had no statistically significant impact on the levels of opioid-related deaths, ED visits and hospitalisations at the PHU level in Ontario over the study period (2013–2022). In all PHUs across Ontario, opioid-related death rates and ED visits increased over time, with trends in hospitalisations being mixed. Although the ITS analyses showed that intervention PHUs had no significant changes in opioid-related deaths or ED visits after SCS implementation, there was a statistically significant increase in opioid-related deaths in control units during the same time-period. This suggests that SCS implementation may have had some impact in slowing the increase in deaths rates, but that while SCS are a valuable harm-reduction intervention tool, they alone are not enough to decrease the death toll.

The results are consistent with limited prior time-series analyses on the impacts of SCS on opioid-related mortality. A time series conducted in Ontario found that the number of hours SCS are open in PHUs in Ontario

TABLE 1 Changes in opioid-related deaths, emergency department visits and hospitalisations before and after implementation of supervised consumption services in intervention public health units and matched controls.

	Deaths				ED visits				Hospitalisations			
	Pre-mean[a], *n* (SD)	Post-mean[b], *n* (SD)	Rate change[c]	% change[d]	Pre-mean, *n* (SD)	Post-mean, *n* (SD)	Rate change	% change	Pre-mean, *n* (SD)	Post-mean, *n* (SD)	Rate change	% change
City of Hamilton Public Health Services[e]	**10.9 (6.8)**	**23.3 (8.6)**	**12.4**	**113.8**	**58.3 (27.6)**	**134.5 (44.8)**	**76.2**	**130.7**	**24.6 (8.0)**	**25.4 (9.3)**	**0.8**	**3.3**
Brant County Health Unit	9.0 (9.9)	26.9 (15.3)	17.9	198.9	74.7 (49.6)	153.6 (45.2)	78.9	105.6	25.1 (19.6)	23.9 (12.9)	−1.2	−4.8
Kingston, Frontenac and Lennox and Addington Health Unit	**7.5 (6.7)**	**17.8 (20.4)**	**10.3**	**137.3**	**54.6 (38.0)**	**126.3 (53.9)**	**71.7**	**131.3**	**20.7 (13.2)**	**23.6 (25.7)**	**2.9**	**14.0**
Grey Bruce Public Health Unit	5.0 (5.8)	14.6 (12.3)	9.6	192.0	35.2 (20.3)	65.7 (26.8)	30.5	86.4	17.5 (12.0)	20.9 (13.1)	3.4	19.4
Middlesex-London Health Unit	**5.6 (4.6)**	**17.3 (8.6)**	**11.7**	**208.9**	**39 (22.1)**	**139 (60.1)**	**100**	**256.4**	**19.6 (7.3)**	**19.7 (8.6)**	**0.1**	**0.5**
Peel Public Health	3.8 (2.0)	8.9 (3.7)	5.1	134.2	19.9 (9.6)	41.7 (11.6)	21.8	109.6	7.3 (2.6)	7.8 (2.7)	0.5	6.9
Niagara Region Public Health Department	**11.8 (7.8)**	**28.6 (10.9)**	**16.8**	**142.4**	**87.8 (46.9)**	**164.0 (54.1)**	**76.2**	**86.8**	**21.5 (9.4)**	**20.0 (7.6)**	**−1.5**	**−7.0**
Algoma Public Health Unit	13.7 (13.4)	37.2 (26.8)	23.5	171.5	84.2 (50.4)	169.2 (68.5)	85.0	101.0	37.1 (20.8)	29.0 (18.5)	−8.1	−21.8
Ottawa Public Health	**4.1 (2.7)**	**10.1 (4.9)**	**6.0**	**146.2**	**24.5 (10.0)**	**61.4 (26.6)**	**36.9**	**150.6**	**10.2 (3.4)**	**9.0 (3.8)**	**−1.2**	**−11.8**
Durham Region Health Department	5.8 (3.6)	12.2 (5.4)	6.4	110.3	38.0 (12.8)	88.6 (29.3)	50.6	113.2	12.2 (5.1)	12.3 (5.2)	0.1	0.8
Region of Waterloo Public Health	**8.8 (6.5)**	**17.1 (7.0)**	**8.3**	**93.7**	**53.4 (30.7)**	**89.9 (23.1)**	**36.5**	**68.4**	**13.9 (5.9)**	**14.3 (5.6)**	**0.4**	**2.9**
Northwestern Health Unit	8.2 (10.2)	28.3 (19.6)	20.1	245.1	47.8 (30.8)	148.8 (90.9)	101.0	211.3	18.5 (15.4)	15.6 (15.8)	−2.9	−15.7
Thunder Bay District Health Unit	**17.6 (13.6)**	**51.0 (34.0)**	**33.4**	**189.8**	**67.4 (45)**	**178.5 (79.9)**	**111.1**	**164.8**	**25.8 (14.8)**	**29.9 (14.6)**	**4.1**	**15.9**
Chatham-Kent Health Unit	3.8 (6.2)	15.7 (17.7)	11.9	313.2	44.2 (26.8)	123.4 (65.4)	79.2	179.2	22.8 (15.1)	29.1 (19.5)	6.3	27.8
Wellington-Dufferin-Guelph Health Unit	**4.5 (5.4)**	**11.3 (6.8)**	**6.8**	**151.1**	**38.4 (19.2)**	**72.8 (24.5)**	**34.4**	**89.6**	**14.4 (7.4)**	**13.7 (9.8)**	**−0.7**	**−4.9**

(Continues)

TABLE 1 (Continued)

	Deaths				ED visits				Hospitalisations			
	Pre-mean[a], *n* (SD)	**Post-mean[b], *n* (SD)**	**Rate change[c]**	**% change[d]**	**Pre-mean, *n* (SD)**	**Post-mean, *n* (SD)**	**Rate change**	**% change**	**Pre-mean, *n* (SD)**	**Post-mean, *n* (SD)**	**Rate change**	**% change**
Eastern Ontario Health Unit	3.0 (4.7)	7.5 (8.4)	4.5	150.0	28.0 (15.0)	44.0 (33.3)	16.0	57.1	19.5 (10.1)	20.1 (10.3)	0.6	3.1
Toronto Public Health	**6.1 (2.8)**	**13.7 (5.1)**	**7.6**	**124.6**	**24.5 (14.5)**	**78.4 (29.9)**	**53.9**	**220.0**	**7.6 (2.1)**	**10.6 (2.8)**	**3.0**	**39.5**
Intervention PHUs aggregated	**9.2 (3.9)**	**18.1 (4.3)**	**8.9**	**96.7**	**55.3 (21.3)**	**101.6 (11.3)**	**46.3**	**83.7**	**17.8 (3.5)**	**17.7 (3.2)**	**−0.1**	**−0.6**
Intervention PHUs aggregated—Excluding Toronto	**9.6 (4.1)**	**19.1 (4.9)**	**9.59**	**99.0**	**59.2 (22.7)**	**106.5 (12.9)**	**47.3**	**79.9**	**19.1 (3.9)**	**18.8 (3.6)**	**−0.3**	**−1.6**
Control PHUs aggregated[f]	**6.1 (1.7)**	**16.9 (7.1)**	**10.8**	**177.1**	**37.3 (9.4)**	**99.5 (31.4)**	**62.2**	**166.8**	**19.4 (3.5)**	**20.3 (4.1)**	**0.9**	**4.6**

Abbreviations: ED, emergency department; PHU, public health unit; SD, standard deviation.

[a]Pre-mean refers to the average rate per 100,000 population before the implementation of a supervised consumption site.

[b]Post-mean refers to the average rate per 100,000 population after the implementation of a supervised consumption site.

[c]Rate change = post-mean − pre-mean.

[d]% Change = (rate change/pre-mean) × 100.

[e]Bolded results are those from intervention PHUs with one or more supervised consumption site. Non-bolded results are those from control PHUs with no supervised consumption site(s).

[f]For the aggregated series of control units, August 2017 was used as the pre-post intervention change point as this was the first month that an supervised consumption services was implemented in Ontario.

TABLE 2 Autoregressive integrated moving average analysis on the impact of supervised consumption site (SCS) implementation on rates of opioid-related deaths, ED visits and hospitalisations.

	Deaths				ED visits				Hospitalisations			
	Model	**Estimate**	***t*-value**	***p*-value**	**Model**	**Estimate**	***t*-value**	***p*-value**	**Model**	**Estimate**	***t*-value**	***p*-value**
City of Hamilton Public Health Services[a]	**(0,1,1)**	**0.28**	**1.29**	**0.20**	**(1,1,1)**	**−0.40**	**−0.39**	**0.70**	**(0,0,0)**	**0.78**	**0.46**	**0.65**
Brant County Health Unit	(2,1,0)	0.23	0.24	0.80	(1,1,0)	1.70	0.44	0.66	(1,1,2)	−0.36	−0.93	0.36
Kingston, Frontenac and Lennox and Addington Health Unit	**(0,1,1)**	**0.20**	**1.46**	**0.15**	**(0,1,1)**	**0.01**	**0.38**	**0.70**	**(1,0,0)**	**3.02**	**0.85**	**0.40**
Grey Bruce Public Health Unit	(0,1,1)	0.45	8.04	<0.001	(2,1,0)	−0.56	−0.28	0.78	(0,0,0)	3.37	1.34	0.18
Middlesex-London Health Unit	**(0,1,1)**	**0.15**	**0.65**	**0.52**	**(0,1,1)**	**1.53**	**0.53**	**0.60**	**(0,0,0) (0,0,1)**	**−0.39**	**−0.29**	**0.77**
Peel Public Health	(0,1,4)	0.11	1.28	0.21	(0,1,1)	0.18	0.30	0.76	(0,0,0) (1,0,0)	0.055	1.25	0.21
Niagara Region Public Health Department	**(0,1,1)**	**0.18**	**0.33**	**0.59**	**(1,1,5)**	**0.74**	**0.43**	**0.67**	**(0,0,0)**	**−1.43**	**−9.80**	**0.42**
Algoma Public Health Unit	(0,1,1)	0.89	2.88	0.005	(1,1,1)	2.07	0.84	0.40	(0,0,0)	−8.13	−2.00	0.05
Ottawa Public Health	**(12,1,1)**	**0.13**	**0.14**	**0.95**	**(0,1,1)**	**0.01**	**0.68**	**0.50**	**(0,0,0)**	**−1.15**	**−1.57**	**0.12**
Durham Region Health Department	(3,1,0)	0.01	0.06	0.95	(4,1,0)	0.00	0.22	0.83	(0,0,0)	0.03	0.03	0.97
Region of Waterloo Public Health	**(0,1,1)**	**0.00**	**0.06**	**0.96**	**(0,1,11)**	**−1.03**	**−1.76**	**0.08**	**(0,0,0)**	**−0.47**	**0.37**	**0.71**
Northwestern Health Unit	(0,1,1)	1.11	5.01	<0.001	(0,1,4)	3.31	2.02	0.05	(0,0,0)	−2.87	−0.85	0.40
Thunder Bay District Health Unit	**(0,1,1)**	**1.56**	**3.38**	**0.001**	**(0,1,1)**	**0.69**	**0.18**	**0.86**	**(0,0,0)**	**4.08**	**1.35**	**0.18**
Chatham-Kent Health Unit	(0,1,1)	0.56	4.79	<0.001	(0,1,1)	2.3	2.15	0.03	(0,0,0)	6.31	1.82	0.07
Wellington-Dufferin-Guelph Health Unit	**(0,0,0)**	**6.73**	**5.50**	**<0.001**	**(0,1,5)**	**37.30**	**4.60**	**<0.001**	**(0,0,0)**	**−0.68**	**−0.40**	**0.69**
Eastern Ontario Health Unit	(1,0,8)	2.49	1.21	0.23	(0,1,1)	0.45	0.49	0.62	(0,0,0)	0.69	0.34	0.74
Toronto Public Health	**(1,1,0)**	**0.00**	**0.03**	**0.98**	**(1,1,1)**	**0.00**	**−0.03**	**0.97**	**(0,1,1) (0,0,1)**	**0.00**	**0.56**	**0.58**
Intervention PHUs aggregated	**(0,1,1)**	**0.02**	**1.12**	**0.27**	**(0,1,3)**	**−0.61**	**−0.87**	**0.39**	**(0,0,0)**	**0.00**	**−0.30**	**0.98**
Intervention PHUs aggregated – Excluded Toronto	**(0,1,1)**	**0.02**	**0.25**	**0.80**	**(0,1,1)**	**−0.01**	**−1.28**	**0.21**	**(0,0,0)**	**−0.27**	**−0.30**	**0.77**
Control PHUs aggregated[b]	**(0,1,3)**	**0.38**	**12.0**	**<0.001**	**(1,1,0)**	**0.403**	**0.31**	**0.76**	**(0,0,0)**	**−0.05**	**−0.07**	**0.95**

Abbreviations: ED, emergency department; PHU, public health unit.

[a]Bolded results are those from intervention PHUs with one or more SCS; non-bolded results are those from control PHUs with no SCS.

[b]For the aggregated series of control units, August 2017 was used as the pre-post intervention change point as this was the first month that an SCS was implemented in Ontario.

had no effect on monthly rates of opioid-related deaths, ED visits and hospitalisation [16]. A controlled ITS conducted in BC found no significant changes in monthly rates of opioid-related mortality due to overdose in local health areas with SCS compared to propensity-matched control units [9]. Similarly, an earlier time-series-analysis conducted in Sydney, Australia had found no evidence for the impact of a supervised injecting centre on reducing drug-related deaths in the community [32]. It should be noted however, that this analysis was conducted shortly after Australia experienced a heroin shortage in January 2001 that resulted in a dramatic reduction in overdose deaths [33]. Opioid-related deaths had therefore already began declining before the institution of the SCS and may have influenced the impact of the SCS on reducing opioid overdose-related deaths. Evidence from a modelling study on the impact of major interventions, including SCS, on drug-related mortality in BC estimated that these had averted substantial numbers of deaths, but that the levels of actual deaths remained unchanged [34].

The study results of non-effects of SCS in reducing opioid-related deaths on the population level triggers the crucial question as to why such effects are ostensibly absent, given consistent evidence from participant-level studies showing improvements in acute injection risks, health status and mortality incidents [8, 12, 13]. A primary consideration of SCS in this respect is the limited availability of SCS booths/space in proportion to the number of incidents of use. For concrete illustration: the SCS available during the study period may have provided a total of roughly 150 supervised consumption spaces for individual users, accommodating a crudely estimated 3000–9000 consumption episodes per day. While exact epidemiologic estimates are not available, recent estimates may suggest that Ontario may be home to 300,000–400,000 or more 'at-risk' opioid users which may entail a total as many as 1 million at-risk consumption episodes per day [35]. If these estimates are anywhere near accurate, SCS interventions would merely cover <1% of consumption episodes in this scenario. Even if all consumption episodes that took place within an SCS occurred more safely, the population-level magnitude of these impacts is far too small to produce discernible protective impacts and reductions in overdose deaths on the population level.

There are other possible factors for the limited protective impacts of SCS interventions on opioid-related mortality and morbidity outcomes. For example, there have been an increasing number of drug overdose deaths associated with non-injection use methods, such as inhalation, which the majority of SCS do not currently accommodate [19]. In addition, the vast majority (>80%) of overdose fatalities documented have occurred in private residence or other residential and/or other indoor/shelter-type environments, with many of these incidences involving solitary use [36, 37]. These circumstances point to the importance—but also limitations—of other harm reduction tools aimed at overdose death prevention, including naloxone for acute overdose reversal. Naloxone is an effective overdose response intervention widely distributed and available through community settings; it, however, faces significant limitations in effective application from both increasing opioid toxicity as well as high rates of solitary overdose incidents [34, 37].

Overall, SCS aim to modify select ecological risk conditions for the—proportionally very small—number of consumption episodes that occur within its settings [8]. Even extensive upscaling of SCS availability would likely only produce limited additional benefits for population health [15].

Additionally, SCS interventions do not address the primary cause of excessive drug-related fatalities, which is the extremely toxic/potent drug supply [4, 36]. This has been further aggravated by the increasing contamination of the toxic opioid drug supply with synthetic benzodiazepines and/or psychostimulant elements [2, 38]. Tangible reductions in the overdose risk and death toll will likely be achieved only by reducing toxic drug supply exposure on the population level [39, 40]. For this, 'safer supply' programming providing pharmaceutical-grade opioids for high-risk users may present a first step to achieve effective reversal and reduction effects for opioid deaths [39, 41]. Evidence from Ontario has shown that safer supply programming can lead to decreases in the rate of non-fatal overdoses, deaths, non-prescribed opioid use, ED visits, and hospitalisations [30, 42, 43]. While these programs are in their infancy and will require further evaluation, the evidence thus far supports their use [41].

While the population-level impact of SCS may be hard to quantify, their impact at the individual level remains essential in the context of a highly toxic drug supply. Individual SCS have reported benefits in terms of overdoses being reversed in site, likely preventing deaths in such situations [33]. It has also been argued that individuals who overdose in the presence of trained staff are much more likely to have it reversed than if they had used the same substance without supervision [44]. Additionally, these sites have been identified by individuals who use drugs as a form of safe space and an important point of community connection [45].

This study has some limitations. First, one of the main methodological limitations of ITS analyses is that they are vulnerable to time-varying confounders such as additional interventions or events coinciding with the intervention that may also affect the outcomes of interest [17, 22]. Additional interventions that could potentially affect the rate of opioid-related deaths include the distribution of naloxone kits and expansions of other treatment

options. A control series consisting of data from PHUs in Ontario that did not have an SCS, but were exposed to other interventions not investigated/controlled for in this study, was included in this study to mitigate these time-varying confounds [22, 46]. The impact of differential regulations and restrictions associated with the COVID-19 pandemic in 2020 was however, not assessed in this study. Second, the outcome data used in this study were collected at the public health unit level, the smallest geographic unit available for data collection. This may have led to a decay in possible SCS effects on the outcomes of interest [9]. Prior studies have shown, for example, a decay in the effect of SCS on opioid-related deaths outside of a 500-m radius of the site [44, 47]. Third, this study did not evaluate scenarios in which more than one SCS was introduced in a PHU at different times (Ottawa Public Health and TPH) [48]. While one way to mitigate this limitation would be to estimate the effects of different intervention components by adding multiple interruptions to the time series, this was not deemed feasible for the present study as there were not a sufficient number of time points between the introduction of each subsequent SCS in either PHU with more than one site [49]. There were some intervention units for which the matched control unit varied in terms of population size (e.g., Peel Public Health and Northwestern Health Unit). This pair, however, had similar median ages, incomes and percentages of the population with post-secondary education. Ontario is a very large province geographically and most SCS are located within larger urban centres. Control units without SCS therefore tended to consist of jurisdictions with smaller populations, leading to some differences in population sizes during matching. Finally, the ARIMA models used for intervention and control PHUs were often quite different, which may have impacted the results.

5 | CONCLUSIONS

This study lends further evidence to the fact that while SCS interventions can produce important benefits for consumers that access their services but are insufficient in reducing opioid-related deaths in Ontario. Additional harm reduction measures, such as expansion of naloxone distribution, public health messaging surrounding the risks of consuming drugs alone, and especially safer supply programming, are urgently needed to tackle this public health crisis.

AUTHOR CONTRIBUTIONS

Each author certifies that their contribution to this work meets the standards of the International Committee of Medical Journal Editors.

CONFLICT OF INTEREST STATEMENT

Tessa Robinson and Prof. Farrokhyar have no interests to declare. Prof. Fischer has held research grants and contracts in the areas of substance use, health, interventions and policy from public funding and government organisations (i.e., public-only sources).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Robinson T, Farrokhyar F, Fischer B. The associations of supervised consumption services with the rates of opioid-related mortality and morbidity outcomes at the public health unit level in Ontario (Canada): A controlled interrupted time-series analysis. Drug Alcohol Rev. 2024;43(7):1880–91. https://doi.org/10.1111/dar.13921