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Original quantitative research

Trends in cannabis-attributable hospitalizations and emergency department visits: data from the Canadian Substance Use Costs and Harms Study (2007–2020)

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Abstract

Introduction: The prevalence of cannabis use continues to increase among certain populations in Canada. This study focussed on the increase in cannabis-attributable hospitalizations and emergency department (ED) visits from 2007 to 2020.

Methods: To estimate the counts of hospitalizations and ED visits attributable to cannabis use, we acquired record-level hospital discharge data with ICD-10 diagnostic information for all fiscal years 2006/07 to 2020/21. Diagnostic information was used to associate each record to a health condition category for eight substances, including cannabis. The prevalence of cannabis use was estimated for each province or territory, calendar year, sex and age using national survey information. These estimates were used to adjust relative risk estimates derived from cannabis literature to calculate cannabis-attributable fractions, which were in turn used to estimate the proportion of hospitalizations and ED visits that were attributable to cannabis use.

Results: Between 2007 and 2020, the overall rate of cannabis-attributable inpatient hospitalizations increased by 120%, from 6.4 in 2007 to 14.0 per 100 000 in 2020. Cannabis-attributable ED visits increased by 113%, from 52.1 per 100 000 in 2007 to 111.0 per 100 000 in 2019, and then decreased by 12% in 2020. This study found that the increases in hospitalizations and ED visits were partly attributed to neuropsychiatric conditions, particularly hospitalizations due to psychotic disorders and ED visits due to acute intoxication among children and youth.

Conclusion: Ongoing monitoring of cannabis-attributable harms is necessary to understand the harms related to use and the factors that influence the ways in which people use cannabis and seek care. Further research may distinguish the early effects of legalization trends from the early pandemic period data.

Keywords: *cannabis, hospitalizations, emergency department visits, psychotic disorder, acute intoxication, Canada*

Highlights

- In Canada in 2020, cannabis was responsible for an estimated 5318 hospitalizations and 37 341 emergency department visits.
- The rate of cannabis-attributable hospitalizations and emergency department visits increased over the study period (2007–2020) by 120% and 88%, respectively, with notable increases among people with neuropsychiatric conditions and unintentional injuries.
- Rates of hospitalizations for cannabis-attributable psychotic disorders were highest among those aged 15 to 34 years. The crude rate among those aged 35 to 64 years increased by 38% between 2019 and 2020.

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Introduction

Cannabis continues to be one of the most-used psychoactive substances in Canada after alcohol.[1] The prevalence of cannabis use has risen steadily over the past decade, with rates continuing to increase since the legalization of nonmedical cannabis in October 2018.[2] From 2007 to 2020, past-year cannabis use among those aged 15 years and older increased from 11% to 18%.[3] In 2022, past-year cannabis use among the general population (aged 16 years and older) was 27%, an increase from 25% in 2021.[4] Overall, among those who used cannabis in the past year, 23% reported daily or almost daily use of cannabis in 2023, with findings showing that more males than females used cannabis daily (25% vs. 20%, respectively).[5]

Alongside this observed increase in the prevalence of cannabis use over the past several years, there is also some evidence of increases in cannabis-related harms.[6] Cannabis-related harms can include injuries from motor vehicle collisions and other unintentional injuries, an increased risk of psychosis and cannabis use disorder as well as some conditions that arise during pregnancy, such as low birth weight.[7,8] There is more literature on hospitalizations and emergency department (ED) visits due to cannabis-attributable harms, as cannabis has been the most common cause of substance use hospitalizations among youth in Canada since legalization.[9,10]

In addition, increases in age-specific rates of ED visits due to cannabis poisoning have been observed,[11] as has an increased prevalence of injured drivers testing positive for tetrahydrocannabidiol (THC) since legalization.[12] Other research has also explored the increase in cannabis use and associated harms before legalization.[6,13] For example, Maloney-Hall et al. showed that hospitalizations for psychotic disorders due to cannabis use tripled from 2005 to 2015.[13]

In the present study, we built on this existing literature on cannabis use hospitalizations and ED visits to create a 14-year time series.

This study was based on the ongoing Canadian Substance Use Costs and Harms (CSUCH) project, which is the only study in Canada to estimate costs and harms dating back to 2007 across a range of substances and outcomes.[3] CSUCH estimates costs and harms for eight types of psychoactive substances, including cannabis. The study also estimates cannabis-attributable costs and harms across 20 indicators in the domains of health care, economic loss of production and criminal justice, and does so over the 14-year period from 2007 to 2020.[3] During the study period (2007 to 2020), several significant cannabis policy events occurred, any of which may have influenced trends in cannabis-related harms. These include changes to medical cannabis regulations (the enactment of the *Marihuana for Medical Purposes Regulations* in 2013 and the *Access to Cannabis for Medical Purposes Regulations* in 2016), the Government of Canada's 2016 announcement of its intent to legalize and regulate nonmedical cannabis, the enactment of the *Cannabis Act* in October 2018, and the onset of the COVID-19 pandemic in early 2020.

To further assess the trends over the 14-year period, the potential impact of legalization of nonmedical cannabis and the potential impact of the COVID-19 pandemic on cannabis-attributable harms, we examined cannabis-attributable hospitalizations and ED visits from 2007 to 2020 and trends from the early years after legalization (2019–2020) across several cannabis-related health conditions.

Methods

The CSUCH 2007–2020 methodology was originally based on the cost study by Rehm et al.[14] and existing international guidelines and literature for which cost estimates of substance use were developed for other countries.[15,16]

Data sources

Record-level discharge data corresponding to overnight inpatient hospitalizations and ED visits were requested and received from the Canadian Institute for Health Information (CIHI) for health care fiscal years 2006/07 to 2020/21. These data were from CIHI's Discharge Abstract Database (DAD)[17] and National Ambulatory Care Reporting System (NACRS).[18] As part of this request, we also received record-level costing information in the form of CIHI's Case Mix Groups+/Resource Intensity Weights, Comprehensive Ambulatory Classification System (CMG+/RIW, CACS) and cost of a standard hospital stay (CSHS; by province/territory) variables, which allowed us to assign an approximated cost to each discharge record.[19]

Inpatient data are from all provinces and territories except Quebec, for all study years. The use of Quebec data requires special permission; this permission was not received in a timely manner and so data could not be included. Only two provinces (Ontario [for 2006/07–2020/21] and Alberta [for 2010/11–2020/21]) and one territory (Yukon, for years 2014/15–2020/21) reported emergency department data with diagnostic information (known as Level 3 data). NACRS Level 3 is required to group records into substance use–related health condition categories.

Data on the prevalence of cannabis use came from the Canadian Substance Use Exposure Database (CanSUED).[3,20] CanSUED was developed and is maintained for the CSUCH project and is based on estimates from the suite of national substance use surveys, which include the Canadian Alcohol and Drugs Survey (CADS); the Canadian Tobacco, Alcohol and Drugs Survey (CTADS); the Canadian Tobacco Use Monitoring Survey (CTUMS); and the Canadian Alcohol and Drug Use Monitoring Survey (CADUMS). The prevalence estimates were modelled by different age* (0–14, 15–34, 35–64, 65+ years) and sex (male, female) groups and by province/territory and year (2007–2020).

Identifying cannabis-related health conditions and estimating cannabis-attributable fractions and cannabis-attributable hospitalizations and ED visits

To identify health conditions and diseases causally related to cannabis use, we used Rehm et al.[14] and preparatory material from the most recent Global Burden of Disease study estimates.[21] Relative risk information corresponding to each identified partially-attributable health condition was from the literature (see Supplementary

* As part of the comprehensive national cost study (CSUCH), these age groups were selected to maintain consistency across 20 indicators. The underlying cost study also gathers data for several variables (i.e. province/territory, sex, age, substances, years and health conditions, where applicable). Due to disclosure issues for some datasets, further granularity among age groups would present challenges.

Table S1).[22-30] The cannabis-related health conditions[†] identified were mental and behavioural disorders[‡] due to the use of cannabinoids (F12), conditions arising during pregnancy due to cannabis use (O35.5, P04.4, P96.1), motor vehicle collisions (V1, Y85.0), unintentional injuries such as accidental poisoning (T40.7, X41–X44, Y11–Y14) and fires (X00–X09, Y26), intentional poisoning (T40.7, X61–X64) and assault/homicide (X85–Y09, Y87.1).

The F12 category corresponding to mental and behavioural disorders due to the use of cannabinoids is wholly attributable to cannabis; that is, a condition of this type could not occur in the absence of cannabis use. Epidemiologically, it therefore has a cannabis-attributable fraction of 1.00. Other health conditions, however, are partially attributable to cannabis use (e.g. motor vehicle collisions, nonviolent crime), meaning cannabis use increases the risk of these conditions, but the condition can also occur in the absence of cannabis use. The proportion of each health condition, by year, province/territory, sex and age group, was estimated by calculating cannabis-attributable fractions (CAFs) using Formula 1:

$$CAF_{y,p,s,a,hc} = \frac{P_{y,p,s,a} \times (RR_{hc} - 1)}{1 + P_{y,p,s,a} \times (RR_{hc} - 1)}$$

(Formula 1)

where $P_{y,p,s,a}$ is the prevalence of past-year cannabis use, by each year, province/territory, sex and age group and RR_{hc} is the relative risk of each partially attributable cannabis-related health condition.

Cannabis-attributable events (hospitalizations and ED visits) were then estimated using the following methodology. First, discharges were enumerated into as many as one cannabis-related health condition using the ICD-10 code present as the most responsible diagnosis, except for a differential methodology for injuries and poisoning. Discharges relating to injuries and poisonings are also assigned an external cause code, which describes how the injury (e.g. a broken arm) came about (e.g. a motor vehicle collision). In this case, the external cause code is used to group the discharge into as many as one cannabis-related health condition. The CAFs calculated using Formula 1 are then applied by year, province/territory, sex, age group and health condition to arrive at an estimated number of cannabis-attributable hospitalizations and ED visits.

Estimating cannabis-attributable rates and associated health care costs

Population-based rates were calculated by dividing the count in each population subgroup by the corresponding population on 01 July of the year in question, as reported by Statistics Canada.[31] Record-level cost estimates were generated by multiplying the CMG + /RIW (for inpatient) or CACS RIW (for ED visits) by the CSHS, as opposed to counting the record as 1.0. Cost calculations were then estimated by summing record-level cost estimates.

From 2016 to 2020, a focussed analysis was completed for health conditions in the F12 category–collectively, mental and behavioural disorders due to the use of cannabinoids. These F12 conditions were grouped into five subcategories, namely, acute intoxication (F12.0), dependence and withdrawal (F12.2, F12.3, F12.4), harmful use (F12.1), psychotic disorder (F12.5, F12.7) and all other (F12.6, F12.8, F12.9). Rates were calculated using the same population figures as described earlier.

Emergency department imputation methods

Reporting information for ED visits at the provincial/territorial level was incomplete. Only Ontario (for fiscal years 2006/07–2020/21), Alberta (2010/11–2020/21) and Yukon (2014/15–2020/21) reported complete diagnostic information (corresponding to NACRS Level 3). Therefore, these three jurisdictions were used in the primary ED cost analysis, and the costs and number of visits for all other provinces and territories were imputed from this basis. To impute the costs for all other provinces, summary tables for Ontario and Alberta were created with ED visit costs for province/territory, year, sex, age group and condition for each substance. These summary tables were rolled up across health conditions, resulting in a table with costs for each province/territory, year, sex and age group.

With information from Alberta and Ontario from 2007 to 2020 and Yukon from 2015 to 2020, the ED costs for other provinces were imputed based on Formula 2:

$$Cost_{y,p,s,a} = Cost_{y,PT,s,a} \times \frac{CSHS_p}{CSHS_{PT}} \times \frac{population_{y,p,s,a} \times prevalence_{y,p,s,a}}{population_{y,PT,s,a} \times prevalence_{y,PT,s,a}}$$

(Formula 2)

where y is year, p is the province/territory being imputed, PT is the province/territory with full information (Ontario, Alberta or Yukon) used to do the imputation, s is sex, a is age group and $CSHS$ is the provincial-level cost of a standard hospital stay variable from the Canadian Institute for Health Information. The costs were adjusted by a "health care cost difference" factor. This factor was based on the ratio of the CSHS variables from Ontario and Alberta.

Analysis

Hospitalization and ED visits data were presented in costs and crude rates (per 100 000) for the age groups 0 to 14 years, 15 to 34 years, 35 to 64 years and 65 + years, and grouped by male and female. Further, we calculated the percent change from 2019 (the first complete year of data after Canada legalized cannabis) to 2020 for cannabis-attributable hospitalizations for unintentional injuries to examine the trend during the first two years after legalization among males and females. Throughout this paper, we calculated the percent change from 2007 to 2020 in order to understand the general trends over the entire study period. Lastly, we examined hospitalizations and ED visits for mental and behavioural disorders due to cannabis, analyzing the F12 condition category from 2016 to 2020 (shown in the Results section). All analyses were performed in R statistical software version 4.3.3 (R Foundation for Statistical Computing, Vienna, AT) and Excel (Microsoft Corp., Redmond, WA, US).

[†] When discharged from Canadian hospitals, patients are assigned a code that indicates the main reason for their hospital stay. Different databases use different coding systems; however, the Discharge Abstract Database uses the Canadian modification of the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10-CA), which is reflected in our methodology.

[‡] Conditions included in this diagnosis (ICD-10-CA code F12.0–12.9) were acute intoxication, harmful use, dependence syndrome, withdrawal state, withdrawal state with delirium, psychotic disorder, amnesic syndrome, residual and late-onset psychotic disorder, other mental and behavioural disorders and unspecified mental and behavioural disorder.

Results

Inpatient hospitalizations

Overall trends

In 2020, cannabis was responsible for an estimated 5318 hospitalizations. The overall crude rate of cannabis-attributable inpatient hospitalizations increased by 120% between 2007 and 2020, with the majority of this increase occurring prior to legalization (2007–2016; Table 1). Examining the first years after legalization, hospitalizations increased from a rate of 12.8 per 100 000 in 2019 to 14.0 per 100 000 in 2020 (a 9% increase). The largest percentage increase in crude rates of cannabis-attributable hospitalizations over the study period occurred among youth: females under 15 years of age experienced a 247% increase and males under 15 experienced a 226% increase. Also, in the 15 to 34 age group, the difference between the rates for males and females increased the most compared to the other age groups.

Trends by health condition category

Between the first two years after legalization (2019–2020), the largest increase in crude rates of hospitalizations was observed for unintentional injuries (41%). However, comparatively, between the two years before legalization (2016–2018), the crude rate of hospitalizations for unintentional injuries increased by 72% (see Supplementary Figure S1). Also, from 2019 to 2020, the increase among those aged 0 to 14 years was 124% (Figure 1), and while the crude rate was higher among males than females for most of the years, the rate of change of hospitalizations for unintentional injuries between 2019 and 2020 was higher among females (60%) than males (24%; Supplementary Table S2).

Per person costs for neuropsychiatric conditions (mental and behavioural disorders due to cannabis) increased the most from 2007 to 2020 (160%), followed by per person costs for unintentional injuries (150%; Supplementary Figure S2). Neuropsychiatric conditions also accounted for an increasing proportion of all cannabis-attributable hospitalizations over the study period from 2007 to 2020 (Supplementary Table S3), and rates were highest among the 15 to 34 age group (Figure 1). The rate of hospitalizations for neuropsychiatric conditions remained relatively stable from 2016 to 2019, and increased between 2019 and 2020 (13%; Supplementary Table S3). From 2019 to 2020, the largest increase occurred among the 0 to 14 age group (51%), followed by the 35 to 64 age group (22%; Figure 1). Also, briefly analyzing the hospitalizations for cannabis-attributable motor vehicle collisions, we see that the rates peaked in 2018, representing a 37% increase from 2007 (Figure 1). This rate decreased slightly (6%) after 2018.

Trends by F12 condition category for mental and behavioural disorder due to cannabis use

Age

Further analyses of the neuropsychiatric conditions, in particular the F12 condition category (Table 2), showed that between 2019 and 2020, the crude rate of cannabis-attributable hospitalizations for psychotic disorder (F12.5) increased by 38%, from 2.0 to 2.8 per 100 000, among those aged 35 to 64 years. Over the same period, rates of hospitalizations for psychotic disorder among those aged 15 to 34 years also increased, by 21% from 8.7 to 10.6 per 100 000. In comparison, leading up to legalization, between 2016 and 2018, rates increased by 22% and 10% among those aged 35 to 64 years and 15 to 34 years, respectively. Moreover, cannabis-attributable hospitalizations for acute intoxication nearly tripled from 2019 to 2020 among those aged 0 to 14 years. Overall rates of dependence and withdrawal remained stable from 2019 to 2020; however, they decreased among those aged 15 to 34 (19%) and 35 to 64 years (16%).

Sex

The crude rate for cannabis-attributable hospitalizations due to psychotic disorder for males was higher compared to females (Supplementary Table S4), both leading up to legalization (2016–2018) and during the first two years after legalization (2019–2020); however, females had a greater percentage increase from 2019 to 2020 (34%) compared to males (22%).

Emergency department visits

Overall trends

In 2020, cannabis was responsible for an estimated 37 341 ED visits. From 2007 to 2019, per person costs for ED visits for cannabis increased by 95%, subsequently

TABLE 1
Overall crude rate (per 100 000) of cannabis-attributable hospitalizations, by sex and age, Canada,[a] 2007 to 2020

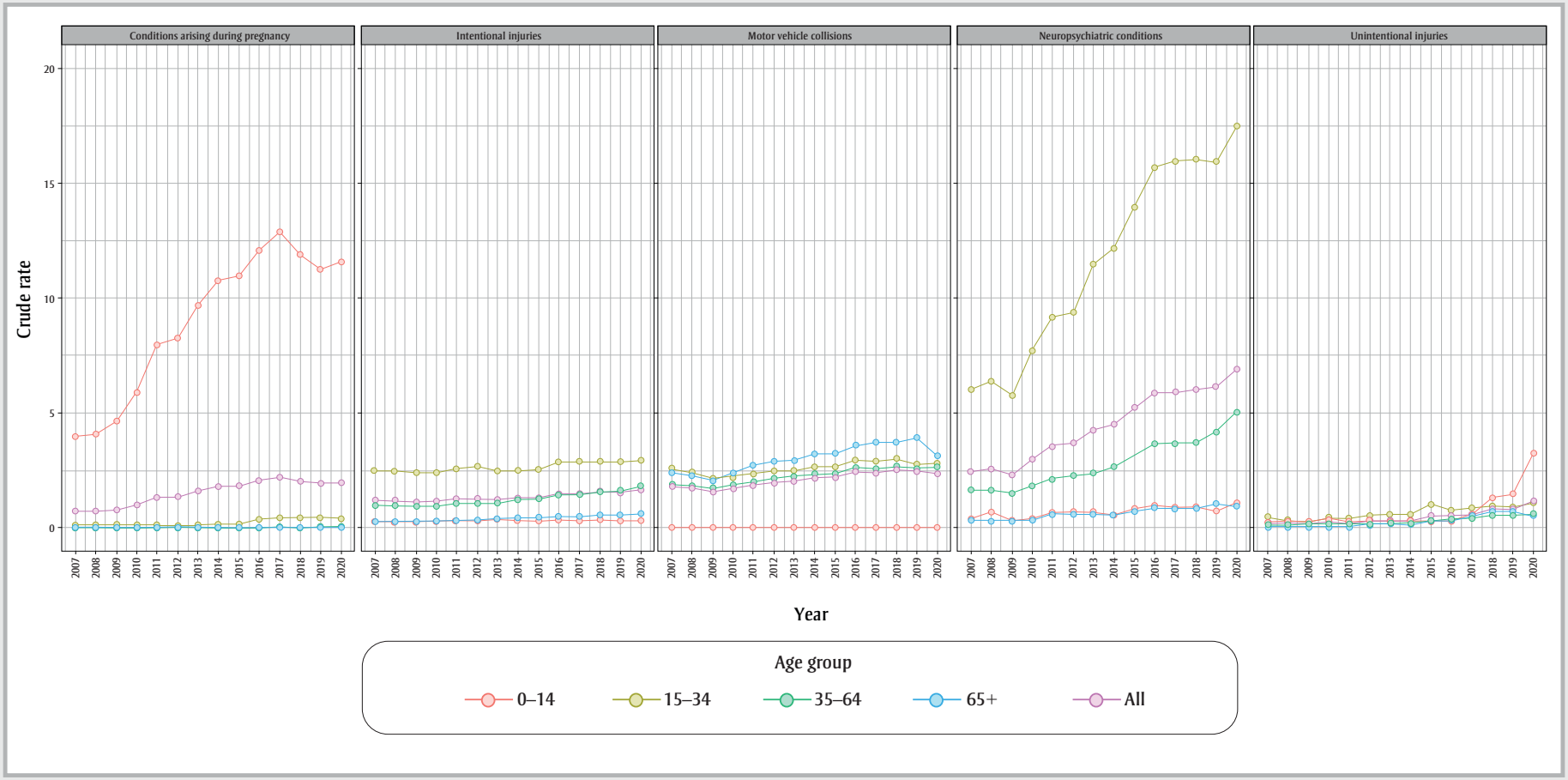
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	% change between 2007 and 2020
Female	4.1	4.2	3.7	4.4	5.0	5.2	6.2	6.3	7.6	8.2	8.3	9.0	8.8	9.5	134
0–14 y	4.1	4.3	4.5	5.9	7.6	7.9	9.3	9.7	10.9	11.8	11.1	13.7	11.6	14.1	247
15–34 y	6.5	6.9	5.7	6.7	7.5	7.4	10.0	9.6	13.0	13.9	15.1	14.8	14.8	15.9	146
35–64 y	3.0	3.1	2.7	3.0	3.2	3.5	3.7	4.1	4.6	5.0	4.8	5.4	5.5	6.4	111
65+ y	2.7	2.7	2.3	2.5	3.2	3.2	3.5	3.6	4.0	4.4	4.5	5.1	5.4	4.0	48
Male	8.7	8.6	8.3	9.8	11.5	12.0	12.7	13.9	14.5	16.5	16.9	16.8	16.9	18.5	113
0–14 y	5.6	6.2	6.3	7.9	10.6	11.3	12.6	14.0	13.9	15.6	18.1	15.3	15.7	18.2	226
15–34 y	16.8	16.5	15.5	18.7	21.5	22.6	23.9	26.1	27.2	30.9	30.6	31.6	30.4	33.0	97
35–64 y	6.2	6.1	5.9	6.6	7.5	7.7	8.1	8.7	9.6	11.2	11.3	11.5	12.3	13.9	123
65+ y	3.2	3.1	3.0	3.7	4.3	4.7	4.7	5.4	5.5	6.5	6.7	6.8	7.3	6.7	107
Total	6.4	6.4	6.0	7.1	8.2	8.6	9.4	10.1	11.0	12.3	12.6	12.9	12.8	14.0	120

Data source: Canadian Institute for Health Information Discharge Abstract Database, 2006/07 to 2020/21, and National Ambulatory Care Reporting System, 2006/07 to 2020/21.

Abbreviation: y, years.

[a] Excluding Quebec.

FIGURE 1
Crude rate (per 100 000) of cannabis-attributable hospitalizations, by health condition and age group, Canada,[a] 2007 to 2020



Note: Unintentional injuries include unintentional poisonings and fires.

[a] Excludes hospitalizations in Quebec.

TABLE 2
Crude rate of cannabis-attributable hospitalizations (per 100 000) by F12 condition category[a] for mental and behavioural disorder due to cannabis use, by age, Canada,[b] 2016 to 2020

F12 condition	2016	2017	2018	2019	2020
Acute intoxication	0.3	0.2	0.4	0.3	0.3
0–14 y	0.1	0.1	0.2	0.1	0.3
15–34 y	0.5	0.6	0.6	0.5	0.4
35–64 y	0.2	0.1	0.3	0.3	0.2
65+ y	0.3	0.1	0.4	0.4	0.3
Dependence and withdrawal	0.5	0.4	0.4	0.4	0.4
0–14 y	0.1	0.0	0.0	0.0	0.1
15–34 y	1.1	1.1	1.0	1.1	0.9
35–64 y	0.3	0.3	0.2	0.3	0.2
65+ y	0.1	0.1	0.0	0.1	0.1
Harmful use	1.1	1.2	1.1	1.1	1.0
0–14 y	0.3	0.5	0.3	0.2	0.3
15–34 y	3.2	3.3	3.1	3.1	2.5
35–64 y	0.5	0.4	0.5	0.6	0.6
65+ y	0.0	0.1	0.1	0.1	0.0
Psychotic disorder	2.6	2.6	2.8	3.2	4.0
0–14 y	0.3	0.2	0.2	0.2	0.3
15–34 y	7.3	7.1	8.1	8.7	10.6
35–64 y	1.3	1.6	1.6	2.0	2.8
65+ y	0.2	0.2	0.0	0.2	0.3
All other	0.6	0.7	0.7	0.7	0.7
0–14 y	0.2	0.1	0.2	0.1	0.1
15–34 y	1.7	2.0	2.2	1.8	2.0
35–64 y	0.3	0.3	0.3	0.4	0.5
65+ y	0.1	0.0	0.0	0.1	0.0
Total	5.0	5.1	5.4	5.7	6.4

Abbreviation: y, years.

[a] International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada (ICD-10-CA) code category.

[b] Excludes hospitalizations in Quebec.

decreasing slightly in 2020 (Supplementary Table S5). Similarly, the crude rate of cannabis-attributable ED visits increased from 2007 to 2019 by 113%, and then decreased between 2019 and 2020 by 12%.

Trends by age group and sex

Rates of ED visits due to cannabis use peaked in 2019 among all age groups and subsequently decreased in 2020 (Figure 2). Over the study period (2007–2020), the rates of ED visits were highest for both males and females aged 15 to 34 years. Also, the 0 to 14 age group had the greatest percentage increase (136%) followed by the 15 to 34 (112%), 35 to 64 (91%) and 65 and older (9%) groups. During the first two years after legalization (2019–2020), all age groups experienced a decline in cannabis-attributable ED visits. Additionally, cannabis-attributable ED visits were continuously higher among males than females. From 2007, rates of ED visits among males and females increased by 108% and 120%, respectively, until 2019 and then decreased by 12% and 11% in 2020 (Figure 2).

Trends by F12 condition category for mental and behavioural disorder due to cannabis use

Age

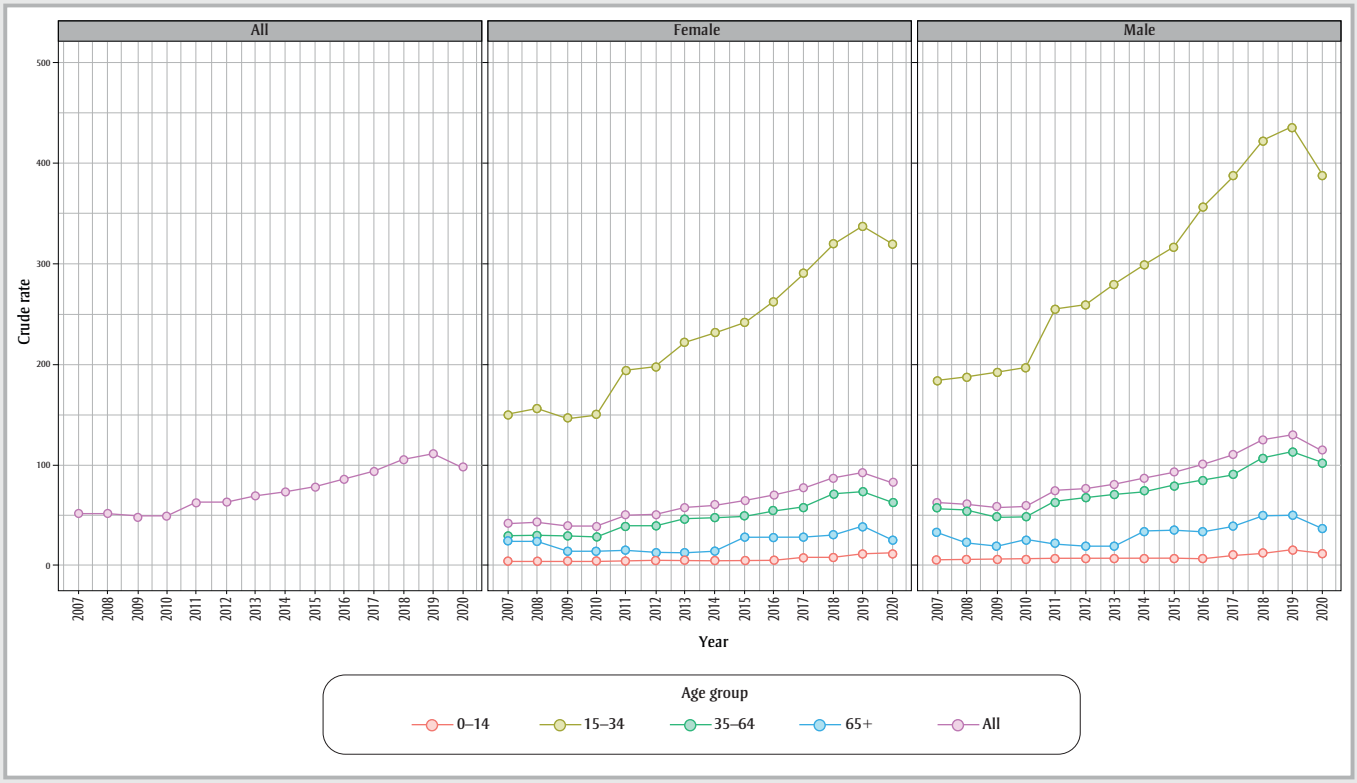
In 2020, among those aged 0 to 14, acute intoxications (F12.0) accounted for most of the ED visits for mental and behavioural disorder due to cannabis use (48%), followed by harmful use (F12.1) (43%; Table 3). Further, in 2020, 42% of all ED visits for mental and behavioural disorders among those aged 15 to 34 years were for harmful use and 27% were for acute intoxication. From 2016 to 2018, acute intoxications among all age groups increased by 135%.

Between 2019 and 2020, the crude rate for psychotic disorder (F12.5) among those aged 15 to 34 years increased the most—by 20%, from 12.9 to 15.5 per 100 000. Over the same period, across the 15 to 34 and 35 to 64 age groups, ED visits for dependence syndrome and withdrawal (F12.2, F12.3, F12.4) increased by 15% and 32%, respectively.

Sex

In 2020, the crude rate for cannabis-attributable ED visits for mental and behavioural disorders among both males and females (Supplementary Table S6) were highest for harmful use, followed by acute intoxication. Between 2019 and 2020, the

FIGURE 2
Crude rate (per 100 000) of cannabis-attributable ED visits, by age group and sex, Canada,[a] 2007 to 2020



Abbreviation: ED, emergency department.

Note: Information on the health conditions associated with the ED visits was not available for all provinces and territories, and is therefore not presented.

[a] Excludes ED visits in Quebec.

crude rate for harmful use among females increased the most, from 10.8 to 11.8 per 100 000 (10%), and decreased for males from 18.7 to 17.7 per 100 000 (5%).

Discussion

Overall, across all age groups and health conditions, inpatient hospitalizations and ED visits increased from 2007 to 2020. Legalization of nonmedical cannabis in 2018 and the COVID-19 pandemic in 2020 may have influenced these trends, particularly impacting hospitalizations due to unintentional injuries and neuropsychiatric conditions; however, cannabis use and related harms have been increasing over time.[6] These findings are consistent with increasing research showing a link between frequent and long-term use of cannabis and psychotic and other mental health disorders.[13,32]

Inpatient hospitalization trends by health condition, age and sex

The crude rate of inpatient hospitalizations due to cannabis use increased by 120% between 2007 and 2020 and 9% during the first two years after legalization of nonmedical cannabis in late 2018 (2019–2020). Increased hospitalizations for neuropsychiatric conditions, cannabis-attributable motor vehicle collisions and unintentional injuries (including poisonings) contributed to this trend. Per person costs of hospitalizations for neuropsychiatric conditions increased the most over the 14 years, followed by per person costs for unintentional injuries, while the crude rate of hospitalizations for unintentional injuries showed the largest increase (more than 5 times) over the study period (2007–2020). In the two years leading up to legalization (2016–2018) the rate of hospitalization for unintentional injuries increased by 72%. From 2019 to 2020, these rates continued to increase, though to a lesser extent (41%) than prior to legalization. Those aged 0 to 14 and females had the largest increases in crude rates of unintentional injury hospitalizations after 2018 (124% and 60%, respectively).

It is important to note that for the first year of legalization (October 2018 to October 2019), cannabis edibles were not yet legal for sale in Canada. Research suggests that edible products (e.g. gummies, candies, chocolate, baked goods) have been associated with more accidental poisonings than other forms of cannabis.[33] While this report presents the national trend, other studies have found that the rates of hospitalizations for cannabis poisoning among children were higher in jurisdictions that did not restrict certain types of edible products, specifically products that are appealing to children and youth.[34,35] Continued education concerning the safe storage of edible products and future monitoring both of trends since edible products became widely available on the legal market and of products considered to be appealing to children and youth will be necessary to determine whether further policy on the sale, packaging, storage or labelling of such products is needed to prevent cannabis-related harms, such as poisoning, especially among those aged 0 to 14 years.[36-38]

Most cannabis-attributable hospitalizations across the study period were for

TABLE 3
Crude rate of cannabis-attributable ED visits (per 100 000) by F12 condition category[a] for mental and behavioural disorder due to cannabis use, by age, Canada,[b] 2016 to 2020

F12 condition	2016	2017	2018	2019	2020
Acute intoxication	4.5	6.7	10.6	12.7	11.1
0–14 y	1.0	2.0	2.8	4.4	2.9
15–34 y	12.2	17.6	26.1	28.2	24.9
35–64 y	2.2	3.4	6.4	9.2	8.1
65+ y	1.0	1.6	3.0	3.8	3.5
Dependence and withdrawal	1.7	2.0	2.0	2.3	2.6
0–14 y	0.2	0.3	0.1	0.2	0.2
15–34 y	4.9	5.5	6.0	6.6	7.6
35–64 y	0.9	1.0	0.9	1.0	1.3
65+ y	0.0	0.2	0.1	0.2	0.0
Harmful use	8.1	10.6	12.6	14.7	14.7
0–14 y	1.8	2.7	2.9	3.7	2.6
15–34 y	23.2	30.5	34.7	37.5	38.7
35–64 y	3.5	4.2	6.1	8.8	8.8
65+ y	0.6	0.9	1.4	1.9	1.6
Psychotic disorder	2.4	3.3	3.9	4.5	5.4
0–14 y	0.1	0.1	0.1	0.2	0.1
15–34 y	7.5	9.8	11.5	12.9	15.5
35–64 y	0.9	1.4	1.9	2.2	3.0
65+ y	0.1	0.1	0.0	0.2	0.1
All other	1.1	1.3	1.6	2.1	1.9
0–14 y	0.2	0.2	0.2	0.3	0.3
15–34 y	3.4	3.7	4.8	5.5	5.3
35–64 y	0.4	0.5	0.7	1.2	1.0
65+ y	0.1	0.0	0.2	0.3	0.2
Total	17.9	23.8	30.8	36.2	35.8

Abbreviations: ED, emergency department; y, years.

[a] International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada (ICD-10-CA) code category.

[b] Excludes ED visits in Quebec.

neuropsychiatric conditions, and these continued to increase after 2018, particularly among the 0 to 14 age group. These conditions include a range of diagnoses, including psychoses. Hospitalizations for psychotic disorder among those aged 35 to 64 increased by 38% from 2019 to 2020. Other studies have also reported an increase in hospitalizations and ED visits for cannabis-related psychosis after legalization.[10,39] This increase may be in part due to improved and broadened health care provider knowledge on cannabis use and related conditions in Canada.[40] However, other studies have found inconclusive evidence of an increase in psychiatric presentations after legalization.[40]

There is evidence that higher levels of cannabis use increases the risk of psychotic outcomes.[41] Higher potency cannabis has been linked to an increased risk of psychosis[42] and some studies show that cannabis use frequency is associated with increased risk of neuropsychiatric disorders, particularly among young people.[43-45] Research shows that there are gender-specific risks and harms associated with cannabis use, specifically with frequency and patterns of use.[46] For example, young men used more frequently, in larger amounts, and were more likely to use alone, increasing their risk of dependency and mental illnesses compared to that of young women.[46]

Accordingly, close monitoring of trends related to cannabis-attributable neuropsychiatric conditions and cannabis indicators (including frequency of use, potency of products used and overall level of cannabis exposure) will be needed to further establish the patterns of potential harm. The current literature highlights the need for making access to mental health and addiction services more equitable, and for public education,[47] especially for youth and young adults, as current education is inadequate.[48]

ED visit trends by health condition, age and sex

The overall per person costs of cannabis-attributable ED visits increased by 95% from 2007 to 2019, and slightly decreased (by 2%) between 2019 and 2020.[3] The overall crude rate of ED visits also increased (113%) between 2007 and 2019 and decreased (12%) from 2019 to 2020. These harms increased the most in the 0 to 14

and 15 to 34 age groups from 2007 to legalization in 2018. Myran and colleagues also found that cannabis-attributable ED visits increased prior to legalization in late 2018.[35]

Moreover, in 2020, almost half (48%) of cannabis-attributable ED visits due to mental and behavioural disorders among the 0 to 14 age group were for acute intoxications. Though research has found that following legalization, there was no difference in the overall rate of ED visits due to acute intoxication, visits among adults aged 18 to 29 increased by more than 50%.[49] We also found that ED visits for dependence syndrome and withdrawal increased from 2019 to 2020, among those aged 15 to 34 and 35 to 64 years. Additionally, researchers have concluded that overall, harmful use, acute intoxication and dependency were the most common causes for cannabis-involved traffic ED visits from 2010 to 2021.[50]

In general, rates of ED visits in all age groups were likely impacted by the pandemic-related reduction in health care services usage, such as ED utilization, and disrupted daily patterns of life.[3,51,52] Research finds that evolving stringency of cannabis retail restrictions in some provinces also impacted the trends observed within the pandemic period.[35] Therefore, to determine post-legalization trends for ED visits due to cannabis use, continued monitoring is required. Future research may explore how jurisdictional cannabis regulations have impacted cannabis-attributable harms in the pandemic-recovery period.

Strengths and limitations

One main strength of our study is that we estimated substance use harms that are wholly and partially attributable to cannabis use from 2007 to 2020, allowing for data analysis over time. However, there are some limitations. The Ontario Mental Health Recording System (OMHRS) was excluded from the calculation of inpatient hospitalizations due to the incompliance of the database with the ICD-10 classification system. Thus, for Ontario and Manitoba, there is likely an underestimation of hospitalization counts and costs.

An additional limitation of this study, and of the underlying cost study, is the large amount of data imputation that is required for the ED visits analysis. NACRS Level 3 data were only available for three provinces/territories (Ontario for fiscal years 2006/07–2020/21, Alberta for fiscal years 2010/11–2020/21 and Yukon for 2015–2020). Therefore, ED visits costs and counts were imputed for the other provinces using the standard provincial groups, to report at a national level. Also, estimates were available only up until 2020. This makes it difficult to tease apart the early effects of legalization from those of the pandemic. Other evidence demonstrates that hospitalizations and ED visits for cannabis poisonings and mental and behavioural disorders continued to increase between 2020 and 2021.[53] In addition to an increase in the rate of cannabis-attributable ED visits and hospitalizations among children, other studies have found an increased severity of ED visits, especially among children aged 12 years and younger.[35,54-56]

Conclusion

This paper presents indicators of cannabis-attributable harms and associated costs over a 14-year period. Our findings show an increasing trend of cannabis-attributable hospitalizations and ED visits for neuropsychiatric conditions and poisonings, particularly among children and youth. Therefore, comprehensive monitoring of cannabis harms is needed, as well as adequate services and education to ensure the health and safety of those at risk.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

EB, RMS: conceptualization.

RM, AS, RMS: formal analysis.

PK, TS, EB, AG, AS, RM, JZ, AZ (Canadian Substance Use Costs and Harms Working Group): methodology (underlying study).

AS: methodology (current study).

RM: project administration.

RM: visualization.

RM, RMS: writing—original draft.

RM, AS, RG, CS, SW, MY: writing—review and editing.

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References

1. Canadian Centre on Substance Use and Addiction. Cannabis. Ottawa (ON): Canadian Centre on Substance Use and Addiction; 2020. 16 p. Available from: https://www.ccsa.ca/sites/default/files/2021-12/CCSA-Canadian-Drug-Summary-Cannabis-2020-en.pdf

2. Statistics Canada. Research to insights: cannabis in Canada [Internet]. Ottawa (ON): Statistics Canada; 2023 [modified 2023 Oct 16; cited 2024 Apr 04]. Available from: https://www150.statcan.gc.ca/n1/pub/11-631-x/11-631-x2023006-eng.htm

3. Canadian Substance Use Costs and Harms Scientific Working Group. Canadian substance use costs and harms 2007–2020 [Internet]. Ottawa (ON): Canadian Centre on Substance Use and Addiction; 2023 [cited 2024 Apr 04]. Available from: https://csuch.ca/documents/reports/english/Canadian-Substance-Use-Costs-and-Harms-Report-2023-en.pdf

4. Health Canada. Canadian Cannabis Survey 2022: summary [Internet]. [Survey]. Ottawa (ON): Government of Canada; 2022 [modified 2022 Dec 16; cited 2024 Apr 04]. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2022-summary.html

5. Health Canada. Canadian Cannabis Survey 2023: summary [Internet]. [Survey]. Ottawa (ON): Government of Canada; 2023 [modified 2024 Jan 18; cited 2024 Apr 04]. Available from: https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2023-summary.html

6. Imtiaz S, Nigatu YT, Ali F, et al. Cannabis legalization and cannabis use, daily cannabis use and cannabis-related problems among adults in Ontario, Canada (2001-2019). Drug Alcohol Depend. 2023;244:109765. https://doi.org/10.1016/j.drugalcdep.2023.109765

7. Fischer B, Hall W, Fidalgo TM, et al. Recommendations for reducing the risk of cannabis use-related adverse psychosis outcomes: a public mental health-oriented evidence review. J Dual Diagn. 2023;19(2-3):71-96. https://doi.org/10.1080/15504263.2023.2226588

8. Memedovich KA, Dowsett LE, Spackman E, Noseworthy T, Clement F. The adverse health effects and harms related to marijuana use: an overview review. CMAJ Open. 2018;6(3):E339-46. https://doi.org/10.9778/cmajo.20180023

9. Canadian Institute for Health Information (CIHI). Fewer young people being hospitalized for substance use, but overall rates still higher than before the pandemic [Internet]. Ottawa (ON): CIHI; 2023 [cited 2024 Apr 04]. Available from: https://www.cihi.ca/en/news/fewer-young-people-being-hospitalized-for-substance-use-but-overall-rates-still-higher-than#

10. Myran DT, Gaudreault A, Konikoff L, Talarico R, Liccardo Pacula R. Changes in cannabis-attributable hospitalizations following nonmedical cannabis legalization in Canada. JAMA Netw Open. 2023;6(10):e2336113. https://doi.org/10.1001/jamanetworkopen.2023.36113

11. Varin M, Champagne A, Venugopal J, et al. Trends in cannabis-related emergency department visits and hospitalizations among children aged 0–11 years in Canada from 2015 to 2021: spotlight on cannabis edibles. BMC Public Health. 2023;23(1):2067. https://doi.org/10.1186/s12889-023-16987-9

12. Brubacher JR, Chan H, Erdelyi S, Staples JA, Asbridge M, Mann RE. Cannabis legalization and detection of tetrahydrocannabinol in injured drivers. N Engl J Med. 2022;386(2):148-56. https://doi.org/10.1056/NEJMsa2109371

13. Maloney-Hall B, Wallingford SC, Konefal S, Young MM. Psychotic disorder and cannabis use: Canadian hospitalization trends, 2006-2015. Health Promot Chronic Dis Prev Can. 2020;40(5-6):176-83. https://doi.org/10.24095/hpcdp.40.5/6.06

14. Rehm J, Baliunas D, Brochu S, et al. The costs of substance abuse in Canada 2002. Ottawa (ON): Canadian Centre on Substance Abuse; 2006. 132 p.

15. Collins DJ, Lapsley HM. The costs of tobacco, alcohol and illicit drug abuse to Australian society in 2004/05. Canberra (AU): Australian Government Department of Health and Ageing; 2008. 143 p. Available from: https://nadk.flinders.edu.au/application/files/3013/8551/1279/Collins__Lapsley_Report.pdf

16. Single E, Collins D, Easton B, et al. International guidelines for estimating the costs of substance abuse. Geneva (CH): World Health Organization; 2003. 81 p. Available from: https://iris.who.int/handle/10665/42603

17. Canadian Institute for Health Information (CIHI). Discharge Abstract Database, 2006/07 to 2020/21. Ottawa (ON): CIHI; 2022.

18. Canadian Institute for Health Information (CIHI). National Ambulatory Care Reporting System (NACRS), 2006/07 to 2020/2021. Ottawa (ON): CIHI; 2022.

19. Canadian Institute for Health Information (CIHI). Cost of a standard hospital stay, 2020/21 Methodology. Ottawa (ON): CIHI; 2022.

20. Zhao J, Stockwell T, Sorge J, et al. Development of the Canadian Substance Use Exposure Database (CanSUED): Modeling the prevalence of substance use in Canadian jurisdictions, 2006 to 2017. Research Square [Preprint]. 2020 [cited 2024 Apr 04]. https://doi.org/10.21203/rs.3.rs-15494/v1

21. Degenhardt L, Charlson F, Stanaway J, et al. Estimating the burden of disease attributable to injecting drug use as a risk factor for HIV, hepatitis C, and hepatitis B: findings from the Global Burden of Disease Study 2013. Lancet Infect Dis. 2016;16(12):1385-98. https://doi.org/10.1016/S1473-3099(16)30325-5

22. Brown SW, Vanlaar WG, Robertson RD. The alcohol and drug-crash problem in Canada: 2014 report. Ottawa (ON): Canadian Council of Motor Transport Administrators; 2017. 242 p. Available from: https://www.ccmta.ca/web/default/files/PDF/2014_Alcohol_and_Drug_Crash_Problem_Report.pdf

23. Brown SW, Vanlaar WG, Robertson RD. The alcohol and drug-crash problem in Canada: 2013 report. Ottawa (ON): Canadian Council of Motor Transport Administrators; 2017. 220 p. Available from: https://www.ccmta.ca/web/default/files/PDF/2013_Alcohol_and_Drug_Crash_Problem_Report.pdf

24. Brown SW, Vanlaar WG, Robertson RD. The alcohol and drug-crash problem in Canada: 2012 report. Ottawa (ON): Canadian Council of Motor Transport Administrators; 2015. 232 p. Available from: https://www.ccmta.ca/web/default/files/PDF/2012_Alcohol__Drug_Crash_Problem_Report_ENG.pdf

25. Traffic Injury Research Foundation of Canada. Alcohol-crash problem in Canada: 2010. Ottawa (ON): Canadian Council of Motor Transport Administrators; 2013. 234 p. Available from: https://tirf.ca/wp-content/uploads/2017/01/2010_Alcohol_Crash_Problem_Report_4_FINAL.pdf

26. Traffic Injury Research Foundation of Canada. Alcohol-crash problem in Canada: 2007. Ottawa (ON): Canadian Council of Motor Transport Administrators; 2010. 232 p. Available from: https://rosap.ntl.bts.gov/view/dot/6377

27. Traffic Injury Research Foundation of Canada. Alcohol-crash problem in Canada: 2009. Ottawa (ON): Canadian Council of Motor Transport Administrators; 2011.

28. Traffic Injury Research Foundation of Canada. Alcohol-crash problem in Canada: 2008. Ottawa (ON): Canadian Council of Motor Transport Administrators; 2010. 234 p. Available from: https://rosap.ntl.bts.gov/view/dot/6376

29. Evarts B. Fire loss in the United States during 2018. Quincy (MA): National Fire Protection Association; 2019. 20 p. Available from: https://www.maine.gov/dps/fmo/sites/maine.gov.dps.fmo/files/inline-files/nfpa_firelossinus_2018.pdf

30. National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health. The health consequences of smoking—50 years of progress: a report of the Surgeon General. Atlanta (GA): Centers for Disease Control and Prevention (US); 2014. Available from: https://www.ncbi.nlm.nih.gov/books/NBK179276/

31. Statistics Canada. Table 17-10-0005-01: Population estimates on July 1, by age and gender [Internet]. Ottawa (ON): Statistics Canada; 2022 [cited 2022 Dec 15]. Available from: https://doi.org/10.25318/1710000501-eng

32. Myran DT, Harrison LD, Pugliese M, et al. Transition to schizophrenia spectrum disorder following emergency department visits due to substance use with and without psychosis. JAMA Psychiatry. 2023;80(11):1169-74. https://doi.org/10.1001/jamapsychiatry.2023.3582

33. Coret A, Rowan-Legg A. Unintentional cannabis exposures in children pre- and post-legalization: a retrospective review from a Canadian paediatric hospital. Paediatr Child Health. 2022; 27(5):265-71. https://doi.org/10.1093/pch/pxab090

34. Myran DT, Tanuseputro P, Auger N, Konikoff L, Talarico R, Finkelstein Y. Pediatric hospitalizations for unintentional cannabis poisonings and all-cause poisonings associated with edible cannabis product legalization and sales in Canada. JAMA Health Forum. 2023;4(1):e225041. https://doi.org/10.1001/jamahealthforum.2022.5041

35. Myran DT, Pugliese M, Tanuseputro P, Cantor N, Rhodes E, Taljaard M. The association between recreational cannabis legalization, commercialization and cannabis-attributable emergency department visits in Ontario, Canada: an interrupted time-series analysis. Addiction. 2022;117(7):1952-60. https://doi.org/10.1111/add.15834

36. Hammond D. Communicating THC levels and "dose" to consumers: implications for product labelling and packaging of cannabis products in regulated markets. Int J Drug Policy. 2021;91:102509. https://doi.org/10.1016/j.drugpo.2019.07.004

37. Matheson J, Le Foll B. Cannabis legalization and acute harm from high potency cannabis products: a narrative review and recommendations for public health. Front Psychiatry. 2020; 11:591979. https://doi.org/10.3389/fpsyt.2020.591979

38. Myran DT, Tanuseputro P, Auger N, Konikoff L, Talarico R, Finkelstein Y. Edible cannabis legalization and unintentional poisonings in children. N Engl J Med. 2022;387(8):757-9. https://doi.org/10.1056/NEJMc2207661

39. Myran DT, Pugliese M, Roberts RL, et al. Association between non-medical cannabis legalization and emergency department visits for cannabis-induced psychosis. Mol Psychiatry. 2023; 28(10):4251-60. https://doi.org/10.1038/s41380-023-02185-x

40. Hall W, Stjepanović D, Dawson D, Leung J. The implementation and public health impacts of cannabis legalization in Canada: a systematic review. Addiction. 2023;118(11):2062-72. https://doi.org/10.1111/add.16274

41. Marconi A, Di Forti M, Lewis CM, Murray RM, Vassos E. Meta-analysis of the association between the level of cannabis use and risk of psychosis. Schizophr Bull. 2016;42(5):1262-9. https://doi.org/10.1093/schbul/sbw003

42. Petrilli K, Ofori S, Hines L, Taylor G, Adams S, Freeman TP. Association of cannabis potency with mental ill health and addiction: a systematic review. Lancet Psychiatry. 2022;9(9): 736-50. https://doi.org/10.1016/S2215-0366(22)00161-4

43. Freeman TP, Winstock AR. Examining the profile of high-potency cannabis and its association with severity of cannabis dependence. Psychol Med. 2015;45(15):3181-9. https://doi.org/10.1017/S0033291715001178

44. Robinson T, Ali MU, Easterbrook B, et al. Identifying risk-thresholds for the association between frequency of cannabis use and development of cannabis use disorder: a systematic review and meta-analysis. Drug Alcohol Depend. 2022;238:109582. https://doi.org/10.1016/j.drugalcdep.2022.109582

45. Robinson T, Ali MU, Easterbrook B, Hall W, Jutras-Aswad D, Fischer B. Risk-thresholds for the association between frequency of cannabis use and the development of psychosis: a systematic review and meta-analysis. Psychol Med. 2023;53(9):3858-68. https://doi.org/10.1017/S0033291722000502

46. Goodman A. Differences in cannabis perceptions among Canadian adolescent boys and girls. Ottawa (ON): Canadian Centre on Substance Use and Addiction; 2021. 14 p. Available from: https://www.ccsa.ca/sites/default/files/2021-07/CCSA-Cannabis-Perceptions-Canadian-Adolescent-Report-2021-en.pdf

47. Kourgiantakis T, Lee E, Kosar AK, et al. Youth cannabis use in Canada post-legalization: service providers' perceptions, practices, and recommendations. Subst Abuse Treat Prev Policy. 2023;18(1):36. https://doi.org/10.1186/s13011-023-00550-1

48. Canadian Centre on Substance Use and Addiction. A public health perspective on cannabis legalization and regulation in Canada. Ottawa (ON): Canadian Centre on Substance Use and Addiction; 2023. 18 p. https://www.ccsa.ca/sites/default/files/2023-01/CCSA_Cannabis_Act_Legislative_review_update_1_en.pdf

49. Baraniecki R, Panchal P, Malhotra DD, Aliferis A, Zia Z. Acute cannabis intoxication in the emergency department: the effect of legalization. BMC Emerg Med. 2021;21(1):32. https://doi.org/10.1186/s12873-021-00428-0

50. Myran DT, Gaudreault A, Pugliese M, Manuel DG, Tanuseputro P. Cannabis-involved traffic injury emergency department visits after cannabis legalization and commercialization. JAMA Netw Open. 2023;6(9):e2331551. https://doi.org/10.1001/jamanetworkopen.2023.31551

51. Finkelstein Y, Maguire B, Zemek R, et al. Effect of the COVID-19 pandemic on patient volumes, acuity, and outcomes in pediatric emergency departments: a nationwide study. Pediatr Emerg Care. 2021;37(8):427-34. https://doi.org/10.1097/PEC.0000000000002484

52. Kim S, Rajack N, Mondoux SE, Tardelli VS, Kolla NJ, Le Foll B. The COVID-19 impact and characterization on substance use-related emergency department visits for adolescents and young adults in Canada: practical implications. J Eval Clin Pract. 2023;29(3):447-58. https://doi.org/10.1111/jep.13817

53. Canadian Institute for Health Information (CIHI). Unintended consequences of COVID-19: impact on harms caused by substance use, self-harm and accidental falls [Internet]. Ottawa (ON): CIHI; 2021 [cited 2024 Apr 04]. Available from: https://www.cihi.ca/en/covid-19-resources/impact-of-covid-19-on-canadas-health-care-systems/unintended-consequences

54. Callaghan RC, Sanches M, Vander Heiden J, Kish SJ. Impact of Canada's cannabis legalisation on youth emergency department visits for cannabis-related disorders and poisoning in Ontario and Alberta, 2015-2019. Drug Alcohol Rev. 2023;42(5):1104-13. https://doi.org/10.1111/dar.13637

55. Cohen N, Galvis Blanco L, Davis A, et al. Pediatric cannabis intoxication trends in the pre and post-legalization era. Clin Toxicol (Phila). 2022;60(1):53-8. https://doi.org/10.1080/15563650.2021.1939881

56. Yeung ME, Weaver CG, Hartmann R, Haines-Saah R, Lang E. Emergency department pediatric visits in Alberta for cannabis after legalization. Pediatrics. 2021;148(4):e2020045922. https://doi.org/10.1542/peds.2020-045922

https://doi.org/10.24095/hpcdp.45.6.02

Original quantitative research

Sex-specific estimates of positive mental health among youth before and during the COVID-19 pandemic in Canada

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This article has been peer reviewed.

Abstract

Introduction: Positive mental health (PMH) is an essential component of mental health and well-being. While population-level data show a decrease in youth PMH during the COVID-19 pandemic, there are sex differences that have not been examined.

Methods: Data from the 2017, 2019 and 2021 Canadian Community Health Survey were used to examine youth (12–17 years) PMH before and during the COVID-19 pandemic. Sex-specific prevalence of high self-rated mental health (SRMH) and average life satisfaction (LS) for each year were calculated and disaggregated by sociodemographic characteristics. Differences between years were quantified, and statistical significance was determined using *t* tests (p value < 0.004 after Bonferroni correction).

Results: From 2019 to 2021, there were significant decreases in the prevalence of high SRMH (from 66.4% to 52.3%) and average LS (8.7 to 8.2) among female youth, at the overall level and across the majority of sociodemographic groups. As for males, no significant decreases were seen at the overall level. After disaggregation, a significant decrease in prevalence of high SRMH was observed from 2019 to 2021 among male youth living in Quebec and nonimmigrant male youth. There were no significant changes in the prevalence of high SRMH or average LS from 2017 to 2019. The sex-specific differences in PMH varied across sociodemographic characteristics.

Conclusion: The PMH of female youth appears to have been affected during the COVID-19 pandemic more than that of male youth. There were sex-specific differences in PMH across sociodemographic groups, suggesting that not all youth were equally affected. Ongoing surveillance with an intersectional lens is needed to better inform public health strategies.

Keywords: *self-rated mental health, life satisfaction, youth, sex differences, COVID-19, Canada*

Highlights

- Overall, significant decreases in high self-rated mental health (66.4% to 52.3%) and average life satisfaction (8.7 to 8.2) were seen among female youth from 2019 to 2021, but not among male youth.
- There were no changes in high self-rated mental health or average life satisfaction from 2017 to 2019, suggesting that the COVID-19 pandemic and its wider impacts could have contributed to the decrease seen in 2021.
- Significant decreases in high self-rated mental health were seen among males who identified as nonimmigrants, or who lived in Quebec.
- For females, significant decreases in high self-rated mental health and/or mean life satisfaction were seen across every sociodemographic characteristic except ethnic/cultural groups.

Introduction

Positive mental health (PMH) has been defined by the Public Health Agency of Canada (PHAC) as "the capacity of each and all of us to feel, think, act in ways that enhance our ability to enjoy life and deal with the challenges we face."[1] PMH is a priority for Canada,[2] is a key component of mental health[3] and can affect physical health.[4]

In 2016, PHAC released the Positive Mental Health Surveillance Indicator Framework (PMHSIF) to monitor PMH and its associated risk and protective factors.[5] The PMHSIF is a tool that provides a snapshot of the state of PMH among adults (aged 18+ years) and youth (aged 12–17 years) in Canada to inform public health promotion initiatives and policies.[5,6] Monitoring PMH is important from a public health perspective because the skills and attributes associated with PMH can lead to improvement in a range of factors including physical health, preventing the onset of mental health problems, strengthening communities and improving quality of life.[1]

Most of the published literature on PMH has focussed on adults. However, adolescence presents a unique developmental period during which to explore PMH and

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its determinants. Considerable cognitive, physical, social and emotional changes occur during adolescence,[7] and youth are often faced with contexts and challenges that differ from those of adults. Although this can make adolescence a period of increased vulnerability to mental health problems,[8] it can also offer opportunities to establish competencies and experiences that can contribute to well-being.[9] For example, evidence from a US study shows that youth with PMH were significantly more likely to have stronger psychosocial functioning such as closeness to others and school integration, as well as fewer conduct problems.[10] Moreover, youth mental health can predict better perceived health and fewer risky health behaviours.[11] Therefore, surveillance of PMH among youth is important to inform public health guidance, especially in the context of crises such as the COVID-19 pandemic.

To prevent the spread of COVID-19, public health measures (such as physical distancing and school closures) were implemented in Canada, starting in March of 2020. Those measures, along with other challenges stemming from the global pandemic (including health concerns, unemployment, isolation, long COVID, etc.), have affected the Canadian population's mental health.[12-17] Indeed, PMH outcomes (e.g. high self-rated mental health [SRMH], mean life satisfaction [LS] and high community belonging) decreased from 2020 to 2021 among Canadian adults.[15,16]

Similar population-level impacts were seen for youth PMH. In Canada, school closures affected 5.7 million children and youth and resulted in the loss of structure, routine and social connection.[18-20] Those changes may have led to increased worry, helplessness, depression and loneliness.[18-20] Social isolation and reduced protective activities, such as physical activity and seeing friends, could have had numerous detrimental impacts on youths' mental health.[20] Indeed, smaller proportions of youth in Canada reported high SRMH in 2021 (62%) compared to 2019 (72%) and 2017 (76%).[6] In a rapid review, researchers reported that six longitudinal studies indicated a statistically significant decrease in youth well-being and LS during the pandemic compared to the prepandemic period.[21] Taken together, the COVID-19 pandemic and resulting public health measures appear to have impacted the PMH of youth.

While national-level data indicate that, overall, the PMH of Canadian youth had been decreasing since even before the pandemic,[6] there are sex differences that should also be taken into account. Specifically, females had a lower prevalence of high SRMH than males both before and during the pandemic.[6] Additionally, some disparities in mental health outcomes for certain youth populations were seen before the COVID-19 pandemic. For example, students in Grades 6 to 10 with a higher socioeconomic status reported lower LS than students with a lower socioeconomic status.[22] However, to our knowledge, no study has examined sex differences in youth PMH by sociodemographic subgroup. Filling this data gap is necessary to have a better understanding of possible sex differences in PMH of Canadian youth. Furthermore, understanding how inequities may affect youths' PMH is crucial for tailoring mental health promotion efforts and developing targeted public education and messaging.

Accordingly, the objectives of this study were to (1) provide nationally representative, sex-specific estimates of the prevalence of high SRMH and mean LS before (i.e. 2017 and 2019) and during (i.e. 2021) the pandemic; (2) present sex-specific estimates by sociodemographic characteristics to capture intersectional identities; and (3) assess whether the PMH outcomes for males and females, at the national level and across groups, significantly changed across the study period.

Methods

Data and participants

Data were from the 2017, 2019 and 2021 Canadian Community Health Survey (CCHS).[23-25] The CCHS is an annual, national, cross-sectional survey of individuals aged 12 or older in the 10 Canadian provinces and three territories.[23-25] Individuals living on reserves or in other Indigenous settlements in the provinces, full-time members of the Canadian Armed Forces, individuals in institutions and people living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James were excluded from this survey's target population.[23-25] These exclusions represent less than 3% of the population in Canada.[23-25] Survey respondents were selected using a stratified multistage sampling technique.[23-25] Respondents completed the CCHS voluntarily via computer-assisted telephone interview or personal interview.[23-25] In the current study, data were restricted to those aged 12 to 17 years, and limited to those living in the 10 provinces due to the use of single survey years, resulting in a final sample size of 4207 in 2017, 3609 in 2019 and 3283 in 2021.[23-25]

Measures

PMH outcomes

To measure SRMH, participants were asked how they would describe their mental health. Five response options were offered: "excellent," "very good," "good," "fair" and "poor." Those who answered "excellent" and "very good" were categorized as having high SRMH. To measure LS, participants were asked how they feel about their life right now. Participants answered using a scale from 0 ("very dissatisfied") to 10 ("very satisfied"). LS was examined as a continuous variable. Both PMH outcomes were based on how they are defined and measured in the youth PMHSIF.[6]

Sociodemographic variables

The sociodemographic variables examined in this study were sex (female, male); household income adequacy quintile; region of residence (British Columbia, the Prairies [Alberta, Saskatchewan, Manitoba], the Atlantic provinces [New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador], Ontario, Quebec); immigration status (yes, no); place of residence (population centre, rural area); and ethnic/cultural group (Indigenous, Black, East and Southeast Asian, South Asian, Arab/West Asian, Latin American, White). The derived household income quintile variable (INCDVRCA) created by Statistics Canada was modified to report on household income adequacy quintile.[23-25] Place of residence was derived from the participant's postal code.[23-25] Individuals living in continuously built-up areas with populations of at least 1000 and population densities of at least 400 per km^2 were classified as living in population centres.[23-25]

Analysis

Descriptive statistics were calculated using the Statistical Analysis System (SAS EG) version 7.1 (SAS Institute Inc., Cary, NC, US). Sex-specific prevalence of high SRMH and estimates of mean LS were calculated, overall and disaggregated by sociodemographic characteristics. Estimates were weighted using sampling weights provided

by Statistics Canada. We estimated coefficients of variation and 95% confidence intervals (CIs) using bootstrap weights (1000 replicates). Sex-specific estimates of average LS and prevalence of high SRMH in 2017, 2019 and 2021 were compared, with significant differences established using *t* tests. Sex-specific differences within sociodemographic subgroups were established using unadjusted linear or logistic regression. A Bonferroni correction was used to adjust for type 1 error when multiple models were run (e.g. by sex and age group). *P* values were considered stat3istically significant if they were less than 0.004 (0.05/2 × 6; we multiplied 2 by 6 because we had 2 sex groups and 6 disaggregates [including overall estimates]).

Results

Sample characteristics

Sex-specific descriptive statistics are outlined in Table 1. For all three years examined, the majority of the study population lived in Ontario and Quebec, lived in a population centre, were nonimmigrants and identified as White. Across all three years, there were no statistically significant differences across sample characteristics between the male and female populations.

Sex-specific prevalence estimates of high SRMH before and during the pandemic

Sex-specific prevalence estimates of high SRMH can be found in Table 2. (The absolute changes for sex-specific prevalence estimates of high self-rated mental health can be found later on, in Table 4.)

Sex differences

In 2017, 2019 and 2021, females had a significantly lower prevalence of high SRMH compared to males. Across all three years, females living in a population centre and who identified as nonimmigrants had significantly lower prevalences of high SRMH compared to males. In 2019 and 2021, females who were living in the fourth income quintile and who identified as White had significantly lower prevalences of high SRMH compared to males. In 2019, females living in Quebec or the Atlantic provinces had significantly lower prevalences of high SRMH compared to males. In 2021, females in the second, third and fifth income quintiles; females living in British Columbia, Ontario, the Prairies or a rural area; and females who were immigrants reported lower prevalences of high SRMH compared to males.

Male youth

In 2021, prevalence of high SRMH was significantly higher among males who were immigrants (82.2%) compared to those who did not identify as immigrants (69.8%). There were no significant differences in the prevalence of high SRMH by income quintile, region, place of residence, or ethnic/cultural group in either 2017, 2019 or 2021.

Changes in prevalence of high SRMH across 2017, 2019 and 2021

From 2019 to 2021, no significant change in prevalence of high SRMH was observed at the overall level for male youth. However, significant decreases were seen for males living in Quebec (69.2% vs. 84.6%) and those who were nonimmigrants (69.8% vs. 78.2%). There were no significant changes in prevalence of high SRMH from 2017 to 2019.

Female youth

In 2019, prevalence of high SRMH was significantly lower among females who identified as Indigenous (45.3%) compared to those who identified as White (66.5%). In 2021, females who lived in British Columbia had a significantly lower prevalence of high SRMH (39.9%) compared to those who lived in Quebec (58.5%).

Changes in prevalence of high SRMH across 2017, 2019 and 2021

For female youth, prevalence of high SRMH was significantly lower in 2021 (52.3%) compared to 2019 (66.4%). In 2021, compared to 2019, there were significant decreases in the prevalence of high SRMH among females in the highest income quintile (51.0% vs. 74.5%); living in British Columbia (39.9% vs. 71.4%); living in a population centre (52.0% vs. 65.2%) or in a rural area (54.5% vs. 72.2%); who were nonimmigrants (52.4% vs. 64.7%) or immigrants (52.2% vs. 76.4%); and who identified as White (49.7% vs. 66.5%). In 2019, prevalence of high SRMH was significantly lower among females who were nonimmigrants (64.7% vs. 72.3%) compared to 2017.

Sex-specific mean life satisfaction estimates before and during the pandemic

Sex-specific mean LS estimates can be found in Table 3. The absolute changes for sex-specific average LS estimates can be found in Table 4.

Sex differences

Although there were no significant differences in average LS between males and females in 2017 or 2019 (overall or across subgroups), average LS was overall significantly lower among females (8.2) compared to males (8.7) in 2021. In 2021, average LS was significantly lower among females compared to males in the third (8.2 vs. 8.7) and fifth (8.0 vs. 8.7) income quintiles; females living in British Columbia or Ontario (8.1 vs. 8.7); females living in a population centre (8.2 vs. 8.6); females living in a rural area (8.3 vs. 8.8); nonimmigrant females (8.2 vs. 8.6); females who identified as White (8.1 vs. 8.6); and females who identified as Indigenous (7.8 vs. 8.8).

Male youth

In 2017, males who were in the third income quintile (8.5) had significantly lower mean LS compared to those in the first income quintile (8.9). Across all three years, there were no significant differences in average LS by region, place of residence, immigration status or ethnic/cultural group.

Female youth

For female youth in 2019, mean LS was significantly higher in the two highest income quintiles (Q4: 8.8, Q5: 8.9) than those in the lowest income quintile (8.4). In 2019 and 2021, mean LS was significantly higher among females who identified as South Asian (9.1 and 8.9, respectively) than those who identified as White (8.6 and 8.1, respectively). In 2021, mean LS was significantly higher among females who identified as Arab and West Asian (9.0) compared to those who identified as White (8.1). Across all three years, there were no significant differences by region, place of residence or immigration status.

Changes in mean life satisfaction across 2017, 2019 and 2021

For both male and female youth, mean LS remained stable from 2017 to 2019 overall and across all sociodemographic groups. There were no significant changes in mean LS from 2019 to 2021 for male youth, overall and across all sociodemographic groups. On the other hand, for female youth, mean LS was significantly lower in 2021 (8.2) compared to 2019 (8.7). From 2019 to 2021, there were significant decreases in mean LS among females in income

TABLE 1
Descriptive characteristics, stratified by sex, CCHS 2017, 2019 and 2021

Variables		2017 % (95% CI)		2019 % (95% CI)		2021 % (95% CI)	
		Males	Females	Males	Females	Males	Females
Total unweighted		2156	2051	1836	1773	1703	1580
Total weighted		1 147 311	1 087 876	1 171 489	1 115 051	1 224 882	1 179 889
Household income quintile adequacy	Q1 (lowest)	24.5 (21.4–27.5)	27.7 (24.6–30.8)	18.2 (15.4–21.1)	21.9 (18.9–24.9)	23.6 (20.2–26.9)	21.3 (18.6–24.0)
	Q2	21.4 (18.9–23.9)	18.3 (16.0–20.6)	21.7 (18.9–24.6)	22.0 (19.0–25.0)	19.7 (16.4–23.0)	21.6 (18.5–24.8)
	Q3	18.3 (16.1–20.5)	18.2 (16.1–20.4)	23.9 (20.9–26.9)	20.0 (17.3–22.8)	22.3 (19.2–25.4)	22.0 (18.8–25.2)
	Q4	20.2 (18.0–22.5)	20.1 (17.6–22.6)	20.5 (17.8–23.2)	21.6 (18.8–24.4)	18.2 (15.5–21.0)	17.9 (15.0–20.7)
	Q5 (highest)	15.6 (13.6–17.7)	15.7 (13.5–17.9)	15.6 (13.4–17.8)	14.5 (12.0–17.0)	16.2 (13.7–18.7)	17.2 (14.5–19.8)
Region	British Columbia	12.7 (12.7–12.7)	12.7 (12.7–12.7)	12.6 (12.6–12.6)	12.5 (12.5–12.5)	12.4 (12.4–12.4)	12.4 (12.4–12.4)
	Prairies	19.6 (19.6–19.6)	19.5 (19.5–19.5)	19.8 (19.8–19.8)	19.7 (19.7–19.7)	20.1 (20.0–20.2)	20.2 (20.2–20.3)
	Ontario	40.5 (40.5–40.5)	40.5 (40.5–40.5)	40.3 (40.3–40.3)	40.3 (40.3–40.3)	39.8 (39.7–39.8)	39.7 (39.6–39.8)
	Quebec	20.9 (20.9–20.9)	21.0 (21.0–21.0)	21.2 (21.2–21.2)	21.3 (21.3–21.3)	21.6 (21.5–21.6)	21.6 (21.6–21.6)
	Atlantic	6.3 (6.3–6.3)	6.3 (6.3–6.3)	6.2 (6.2–6.2)	6.2 (6.2–6.2)	6.2 (6.1–6.3)	6.0 (5.9–6.1)
Place of residence	Population centre	80.6 (78.9–82.3)	81.6 (79.9–83.4)	80.8 (78.9–82.7)	82.1 (80.2–84.0)	80.1 (78.1–82.1)	84.6 (82.9–86.2)
	Rural	19.4 (17.7–21.1)	18.4 (16.6–20.1)	19.2 (17.3–21.1)	17.9 (16.0–19.8)	19.9 (17.9–21.9)	15.4 (13.8–17.1)
Immigration status	Yes	15.4 (13.1–17.8)	15.1 (12.9–17.4)	16.5 (13.8–19.2)	14.3 (11.8–16.9)	16.3 (13.5–19.1)	14.1 (11.3–16.9)
	No	84.6 (82.2–86.9)	84.9 (82.6–87.1)	83.5 (80.8–86.2)	85.7 (83.1–88.2)	83.7 (80.9–86.5)	85.9 (83.1–88.7)
Ethnic/cultural background	White	62.9 (60.2–65.6)	63.3 (60.4–66.3)	63.2 (60.1–66.3)	61.5 (58.3–64.7)	61.2 (57.7–64.7)	61.3 (58.1–64.6)
	South Asian	6.8 (5.0–8.5)	7.4 (5.4–9.3)	7.3 (5.2–9.4)	6.9 (5.2–8.6)	6.4[E] (4.5–8.4)	7.5[E] (5.2–9.8)
	East and Southeast Asian	6.9 (5.4–8.4)	6.3 (4.8–7.7)	12.1 (9.6–14.6)	11.3 (9.0–13.7)	11.1 (8.7–13.5)	9.6 (7.5–11.8)
	Black	5.0[E] (3.2–6.7)	4.7[E] (2.9–6.5)	5.4 (3.9–6.9)	6.2[E] (4.2–8.3)	5.2[E] (3.5–7.0)	6.1[E] (4.0–8.1)
	Arab and West Asian	4.4[E] (2.7–6.0)	3.6[E] (2.3–4.8)	2.8[E] (1.6–4.0)	3.2[E] (1.9–4.5)	4.4[E] (2.8–6.1)	5.2[E] (3.4–6.9)
	Latin American	2.2[E] (1.0–3.4)	1.2[E] (0.6–1.9)	1.4[E] (0.7–2.1)	1.6[E] (0.6–2.6)	3.1[E] (1.4–4.9)	1.1[E] (0.4–1.9)
	Indigenous	5.9 (4.6–7.3)	5.3 (4.3–6.4)	5.6 (4.3–7.0)	6.5 (5.0–7.9)	5.1 (4.0–6.2)	7.0 (5.3–8.7)

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval.

[E] Estimate should be interpreted with caution due to high sampling variability (coefficient of variation between 15.0 and 35.0).

quintiles Q3 (8.2 vs. 8.7), Q4 (8.2 vs. 8.8) and Q5 (8.0 vs. 8.9); females living in British Columbia (8.1 vs. 8.8), the Atlantic provinces (8.4 vs. 8.8) and Ontario (8.1 vs. 8.6); females living in a population centre (8.2 vs. 8.7); nonimmigrant females (8.2 vs. 8.7); and females who identified as White (8.1 vs. 8.6).

Discussion

This study examined the sex-specific prevalence of high SRMH and mean LS in Canadian youth across various sociodemographic characteristics in 2017, 2019 and 2021. Consistent with national data,[6] our findings show that prevalence of high SRMH and mean LS estimates were significantly lower among female youth during the COVID-19 pandemic compared to before. This overall decrease was not seen among male youth. However, there were distinctions in the results after disaggregation. This highlights the importance of (1) incorporating a sex-specific lens, (2) disaggregating the data when possible and (3) exploring different PMH outcomes to better capture the nuanced and potential differential impact of the pandemic on different facets of youths' PMH. Interestingly, there was no significant change in the two PMH outcomes in 2019 compared to 2017 for either male or female youth overall and across all sociodemographic characteristics. This provides additional evidence for the wider negative impact of the COVID-19 pandemic on youth PMH. Ongoing surveillance is needed to assess whether PMH outcomes return to prepandemic levels.

Among females, there were significant decreases in the prevalence of high SRMH and mean LS across the majority of sociodemographic characteristics. After quantifying the decrease, it was apparent that some populations experienced a larger decrease in PMH than others. For example, the largest decrease in prevalence of high SRMH was seen among females living in British Columbia and the largest decrease in mean LS was among females in the highest income quintile. Among males, the only significant decreases in prevalence of high SRMH were seen among those living in Quebec and nonimmigrants. Targeted mental health promotion activities within these populations may be beneficial. Since this study was descriptive in nature, we cannot identify the reasons for the observed decreases.

TABLE 2
Sex-specific prevalence estimates of high self-rated mental health among youth aged 12 to 17, disaggregated by sociodemographic characteristic, CCHS 2017, 2019 and 2021

Variables		High self-rated mental health					
		Males % (95% CI)			Females % (95% CI)		
		2017	2019	2021	2017	2019	2021
Overall		79.4 (76.9–81.9)	78.0 (75.0–81.0)	71.8 (68.4–75.2)	72.3[a] (69.3–75.2)	66.4[a] (63.0–69.8)	52.3[a] (48.4–56.3)
Household income quintile adequacy	Q1 (lowest; ref.)	76.4 (70.4–82.3)	80.2 (74.0–86.5)	66.8 (58.8–74.8)	71.6 (65.2–78.1)	68.5 (61.3–75.7)	55.6 (48.0–63.1)
	Q2	81.9 (77.0–86.8)	73.9 (67.0–80.8)	71.4 (62.7–80.1)	75.4 (69.7–81.1)	67.3 (60.0–74.6)	50.5[a] (41.3–59.6)
	Q3	73.8 (67.7–79.8)	75.9 (69.6–82.3)	71.4 (64.4–78.4)	72.3 (66.3–78.2)	62.0 (54.4–69.7)	53.2[a] (43.7–62.7)
	Q4	82.0 (76.8–87.2)	82.0 (75.7–88.4)	74.0 (66.8–81.2)	69.7 (62.9–76.5)	63.3[a] (56.1–70.5)	52.7[a] (44.3–61.1)
	Q5 (highest)	83.9 (77.8–89.9)	78.8 (72.1–85.6)	77.8 (70.2–85.5)	71.2 (62.7–79.7)	74.5 (67.6–81.3)	51.0[a] (42.4–59.7)
Region	British Columbia	80.9 (74.7–87.1)	75.7 (68.5–82.8)	76.9 (69.7–84.1)	72.8 (66.3–79.3)	71.4 (63.6–79.1)	39.9[a,b] (31.0–48.9)
	Prairies	81.8 (77.2–86.4)	75.1 (68.7–81.5)	72.7 (66.3–79.1)	73.1 (67.9–78.3)	64.8 (58.1–71.4)	53.2[a] (45.9–60.4)
	Ontario	79.0 (74.3–83.7)	76.1 (70.4–81.7)	71.3 (64.9–77.8)	68.8 (63.1–74.4)	64.0 (57.6–70.4)	52.1[a] (44.7–59.4)
	Quebec (ref.)	78.6 (73.5–83.6)	84.6 (80.5–88.7)	69.2 (62.0–76.4)	76.7 (71.4–81.9)	69.9[a] (64.2–75.6)	58.5 (51.1–65.8)
	Atlantic	73.5 (66.9–80.2)	81.7 (76.1–87.3)	70.6 (62.3–78.9)	75.6 (69.6–81.6)	65.1[a] (57.3–73.0)	55.4 (45.9–64.8)
Place of residence	Population centre	79.7 (76.8–82.6)	77.5 (74.0–81.1)	70.6 (66.6–74.7)	72.0[a] (68.6–75.4)	65.2[a] (61.2–69.1)	52.0[a] (47.5–56.5)
	Rural (ref.)	78.1 (73.3–82.9)	79.9 (75.5–84.3)	76.6 (71.8–81.3)	73.5 (68.6–78.5)	72.2 (66.8–77.6)	54.5[a] (47.5–61.4)
Immigration status	Yes	80.9 (74.0–87.8)	77.9 (70.2–85.6)	82.2[b] (74.4–90.0)	72.3 (63.9–80.7)	76.4 (68.6–84.2)	52.2[a] (41.6–62.8)
	No (ref.)	79.1 (76.4–81.8)	78.2 (75.1–81.3)	69.8 (66.1–73.5)	72.3[a] (69.2–75.3)	64.7[a] (61.1–68.3)	52.4[a] (48.3–56.5)
Ethnic/cultural background	White (ref.)	78.8 (75.6–82.0)	77.0 (73.4–80.6)	72.3 (68.0–76.5)	72.2 (68.7–75.6)	66.5[a] (62.5–70.5)	49.7[a] (45.1–54.4)
	South Asian	82.6 (72.0–93.3)	95.5 (91.3–99.8)	83.7 (72.3–95.1)	67.4 (53.4–81.5)	85.0 (76.2–93.8)	68.0 (52.0–84.0)
	East and Southeast Asian	75.5 (65.8–85.1)	74.2 (63.7–84.7)	66.5 (54.7–78.2)	72.8 (61.9–83.6)	68.5 (56.8–80.2)	49.7 (35.3–64.0)
	Black	91.0 (81.5–100.5)	82.8 (69.0–96.5)	85.4 (73.7–97.1)	87.5 (76.9–98.1)	67.0 (49.4–84.7)	59.5[E] (41.1–77.9)
	Arab and West Asian	89.2 (78.3–100.0)	77.5 (57.2–97.9)	76.6 (58.7–94.6)	64.1[E] (43.6–84.5)	79.5 (64.9–94.1)	58.3 (41.8–74.8)
	Latin American	74.9[E] (51.9–97.9)	85.9 (70.5–101.4)	F	95.2 (85.5–104.8)	64.3[E] (33.7–94.9)	57.5[E] (19.8–95.2)
	Indigenous	80.2 (72.5–87.9)	68.7 (56.7–80.7)	59.1 (46.7–71.6)	65.3 (55.1–75.5)	45.3[b] (33.6–57.0)	44.5 (31.8–57.3)

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval; ref., reference group.

[a] Significantly different compared to males at $p < 0.004$.

[b] Significantly different compared to reference group at $p < 0.004$.

[E] Estimate should be interpreted with caution due to high sampling variability (coefficient of variation between 15.0 and 35.0).

F Estimate does not meet Statistics Canada's quality standard for this statistical program, and should not be published (coefficient of variation above 35.0).

From 2019 to 2021, significant decreases in prevalence of high SRMH and mean LS were primarily observed among female youth. In addition, overall and across the majority of sociodemographic groups, female youth tended to report significantly lower PMH than male youth. These findings add to the extensive body of evidence reporting sex and gender disparities in mental health among youth.

While sex disparities in PMH had been documented among youth before the COVID-19 pandemic,[26-28] our findings suggest that these inequalities may have increased during the pandemic, thus widening the gender gap.[29-31] Possible explanations for this have been previously published. For example, as social support is a protective factor for PMH,[6] particularly for women younger than 24 years,[32] some COVID-19 restrictions such as online school and physical distancing could have impacted female youths' ability to get the social support they needed,[29,30] which in turn may have had an impact on their well-being.

Other hypotheses include increased demands placed on females versus males as well as females' higher levels of anxiety, depression and sadness, changes in sleep patterns, reduced opportunities to meet with friends and lower sense of control over their lives.[30,33,34] Future studies examining sex-specific associations between risk or protective factors and PMH are needed to better understand these disparities in the Canadian youth and to tailor targeted public health prevention efforts accordingly.

Unexpectedly, other than among White female youth and nonimmigrants, no other significant changes in PMH were seen across the sociodemographic groups. We suspect that this may be due to smaller sample sizes, which could have reduced the power to detect differences. However, our findings did show Indigenous youth as having the lowest prevalence of high SRMH. This is concerning and highlights

TABLE 3
Sex-specific mean life satisfaction estimates among youth aged 12 to 17, disaggregated by sociodemographic characteristics, CCHS 2017, 2019 and 2021

Variables		Mean life satisfaction					
		Males Mean (95% CI)			Females Mean (95% CI)		
		2017	2019	2021	2017	2019	2021
Overall		8.8 (8.7–8.8)	8.7 (8.6–8.8)	8.7 (8.6–8.8)	8.7 (8.6–8.8)	8.7 (8.6–8.7)	8.2[a] (8.1–8.4)
Household income quintile adequacy	Q1 (lowest; ref.)	8.9 (8.7–9.1)	8.8 (8.6–9.0)	8.6 (8.4–8.8)	8.8 (8.6 –9.0)	8.4 (8.2–8.7)	8.3 (8.0–8.5)
	Q2	8.7 (8.6–8.9)	8.7 (8.5–8.9)	8.8 (8.6–9.0)	8.7 (8.5–8.9)	8.6 (8.4–8.8)	8.4 (8.2–8.7)
	Q3	8.5[b] (8.3–8.7)	8.6 (8.4–8.8)	8.7 (8.5–8.9)	8.8 (8.6–8.9)	8.7 (8.5–8.9)	8.2[a] (7.9–8.4)
	Q4	8.8 (8.6–8.9)	8.8 (8.6–9.0)	8.5 (8.3–8.8)	8.5 (8.3–8.7)	8.8[b] (8.7–9.0)	8.2 (7.9–8.5)
	Q5 (highest)	8.8 (8.7–9.0)	8.8 (8.7–9.0)	8.7 (8.5–8.9)	8.6 (8.4–8.9)	8.9[b] (8.7–9.1)	8.0[a] (7.7–8.3)
Region	British Columbia	8.8 (8.5–9.0)	8.7 (8.4–8.9)	8.7 (8.5–8.9)	8.8 (8.6–8.9)	8.8 (8.5–9.0)	8.1[a] (7.9–8.3)
	Prairies	8.8 (8.7–8.9)	8.7 (8.5–8.8)	8.7 (8.5–8.9)	8.8 (8.6–9.0)	8.6 (8.5–8.8)	8.3 (8.1–8.5)
	Ontario	8.7 (8.6–8.9)	8.7 (8.5–8.8)	8.7 (8.5–8.8)	8.6 (8.4–8.7)	8.6 (8.5–8.8)	8.1[a] (7.9–8.3)
	Quebec (ref.)	8.8 (8.6–8.9)	8.9 (8.8–9.0)	8.6 (8.4–8.8)	8.7 (8.5–8.9)	8.6[a] (8.5–8.8)	8.4 (8.1–8.7)
	Atlantic	8.7 (8.5–8.8)	8.9 (8.7–9.0)	8.8 (8.6–9.0)	8.8 (8.6–8.9)	8.8 (8.6–9.0)	8.4 (8.1–8.6)
Place of residence	Population centre	8.7 (8.7–8.8)	8.7 (8.6–8.8)	8.6 (8.5–8.7)	8.7 (8.6–8.8)	8.7 (8.6–8.8)	8.2[a] (8.1–8.3)
	Rural (ref.)	8.8 (8.7–8.9)	8.9 (8.8–9.1)	8.8 (8.7–9.0)	8.7 (8.6–8.8)	8.6 (8.5–8.8)	8.3[a] (8.1–8.6)
Immigration status	Yes	8.9 (8.7–9.0)	8.8 (8.7–9.0)	8.7 (8.5–9.0)	8.6 (8.3–8.9)	8.6 (8.3–8.9)	8.5 (8.1–8.8)
	No (ref.)	8.7 (8.7–8.8)	8.7 (8.6–8.8)	8.6 (8.5–8.7)	8.7 (8.6–8.8)	8.7 (8.6–8.8)	8.2[a] (8.1–8.3)
Ethnic/cultural group	White (ref.)	8.7 (8.7–8.8)	8.7 (8.6–8.8)	8.6 (8.5–8.7)	8.7 (8.6–8.8)	8.6 (8.5–8.7)	8.1[a] (8.0–8.3)
	South Asian	8.7 (8.4–9.0)	9.0 (8.7–9.2)	9.0 (8.7–9.3)	8.7 (8.2–9.2)	9.1[b] (8.8–9.4)	8.9[b] (8.5–9.3)
	East and Southeast Asian	8.6 (8.4–8.9)	8.5 (8.2–8.8)	8.3 (7.8–8.7)	8.9 (8.7–9.2)	8.8 (8.5–9.1)	8.3 (8.0–8.6)
	Black	9.2 (8.7–9.6)	9.1 (8.8–9.4)	9.0 (8.7–9.4)	8.4 (7.7–9.0)	8.6 (8.1–9.1)	8.1 (7.5–8.7)
	Arab and West Asian	8.8 (8.4–9.1)	8.9 (8.5–9.4)	8.6 (8.1–9.1)	8.4 (7.9–8.9)	9.1 (8.7–9.5)	9.0[b] (8.6–9.4)
	Latin American	8.9 (8.1–9.7)	8.9 (8.3–9.5)	8.8 (8.1–9.6)	9.0 (8.2–9.7)	8.6 (8.0–9.3)	7.2 (5.8–8.7)
	Indigenous	8.7 (8.5–8.9)	8.5 (8.1–8.8)	8.8 (8.5–9.0)	8.8 (8.4–9.1)	8.1 (7.6–8.5)	7.8[a] (7.4–8.2)

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval; ref., reference group.

[a] Significantly different compared to males at $p < 0.004$.

[b] Significantly different compared to reference group at $p < 0.004$.

the need to find culturally appropriate ways to enhance PMH among Indigenous youth.[35] There may be macro-level factors, such as race-based discrimination and harassment, that could explain these findings. Indeed, national data from 2020 demonstrate that around half of people who identified as Indigenous reported an increase in discrimination since the start of the COVID-19 pandemic.[36]

The sex-specific results in our study are more nuanced. For example, in 2021, average LS was significantly lower among Indigenous female youth than Indigenous male youth. Factors such as concerns about the impact of stay-at-home orders and concerns about the impact of COVID-19 restrictions on family stress and violence and a lower reported sense of safety in the neighbourhood could have impacted the PMH of female Indigenous youth.[37] Given that violence, neighbourhood safety and discrimination are risk factors for PMH,[5,6] future studies examining these in more depth along with intersectional identities are needed to form a more comprehensive understanding of PMH among youth.

Strengths and limitations

This study had some noteworthy strengths, including the large sample size in all three years and the national representativeness. This is also the first Canadian study quantifying changes (from 2017 to 2019 and 2019 to 2021) in two PMH outcomes among male and female youth, with an intersectional lens.

However, there are also some limitations to highlight. As the surveys analyzed were cross-sectional and independent from one another, any changes observed across the three years represent changes at the national level and not at the individual level. The descriptive nature of the analysis did not allow for identification of factors that contributed to any changes in PMH over time. Furthermore, estimates for certain groups could not be released, or were limited, due to insufficient sample sizes. Finally, all of the data in the analysis were self-reported and are therefore subject to reporting and social desirability bias.

TABLE 4
Absolute change for sex-specific prevalence estimates of high self-rated mental health and mean life satisfaction estimates among youth aged 12 to 17, disaggregated by sociodemographic characteristics, CCHS 2017, 2019 and 2021

		High self-rated mental health				Mean life satisfaction			
		Males		Females		Males		Females	
		2019 vs. 2017	2021 vs. 2019	2019 vs. 2017	2021 vs. 2019	2019 vs. 2017	2021 vs. 2019	2019 vs. 2017	2021 vs. 2019
Overall		−1.4	−6.2	−5.9	**−14.1**[a]	−0.1	0.0	0.0	**−0.5**[a]
Household income quintile adequacy	Q1 (lowest)	+3.8	−13.4	−3.1	−12.9	−0.1	−0.2	−0.4	−0.1
	Q2	−8.0	−2.5	−8.1	−16.8	0.0	+0.1	−0.1	−0.2
	Q3	+2.1	−4.5	−10.3	−8.8	+0.1	+0.1	−0.1	**−0.5**[a]
	Q4	0.0	−8.0	−6.4	−10.6	0.0	−0.3	+0.3	**−0.6**[a]
	Q5 (highest)	−5.1	−1.0	+3.3	**−23.5**[a]	0.0	−0.1	+0.3	**−0.9**[a]
Region	British Columbia	−5.2	+1.2	−1.4	**−31.5**[a]	−0.1	0.0	0.0	**−0.7**[a]
	Prairies	−6.7	−2.4	−8.3	−11.6	−0.1	0.0	−0.2	−0.3
	Ontario	−2.9	−4.8	−4.8	−11.9	0.0	0.0	0.0	**−0.5**[a]
	Quebec	+6.0	**−15.4**[a]	−6.8	−11.4	+0.1	−0.3	−0.1	−0.2
	Atlantic	+8.2	−11.1	−10.5	−9.7	+0.2	−0.1	0.0	**−0.4**[a]
Place of residence	Population centre	−2.2	−6.9	−6.8	**−13.2**[a]	0.0	−0.1	0.0	**−0.5**[a]
	Rural	+1.8	−3.3	−1.3	**−17.7**[a]	+0.1	−0.1	−0.1	−0.3
Immigration status	Yes	−3.0	+4.3	+4.1	**−24.2**[a]	−0.1	−0.1	0.0	−0.1
	No	−0.9	**−8.4**[a]	**−7.6**[a]	**−12.3**[a]	0.0	−0.1	0.0	**−0.5**[a]
Ethnic/ cultural group	White	−1.8	−4.7	−5.7	**−16.8**[a]	0.0	−0.1	−0.1	**−0.5**[a]
	South Asian	+12.9	−11.8	+17.6	−17.0	+0.3	0.0	+0.4	−0.2
	East and Southeast Asian	−1.3	−7.7	−4.3	−18.8	−0.1	−0.2	−0.1	−0.5
	Black	−8.2	+2.6	−20.5	−7.5	−0.1	−0.1	+0.2	−0.5
	Arab and West Asian	−11.7	−0.9	+15.4	−21.2	+0.1	−0.3	+0.7	−0.1
	Latin American	+11.0	N/A	−30.9	−6.8	0.0	−0.1	−0.4	−1.4
	Indigenous	−11.5	−9.6	−20.0	−0.8	−0.2	+0.3	−0.7	−0.3

Abbreviation: CCHS, Canadian Community Health Survey.

[a] Bolded estimates indicate a statistically significant difference based on a formal *t* test at $p < 0.004$.

Conclusion

The PMH of female youth in Canada worsened during the COVID-19 pandemic. This could indicate that existing sex disparities in PMH were exacerbated during that time. Continued surveillance of sex-specific PMH outcomes across various youth subpopulations is needed to help identify groups that may benefit from increased resources and targeted public health prevention strategies.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

Authors' contributions and statement

FLP, LLO, MV: conceptualization.

FLP, MV: formal analysis.

FLP, LLO, MV: methodology.

FLP, MV: project administration.

FLP, MV: writing—original draft.

FLP, LLO, KCR, MV: writing—review and editing.

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References

1. Public Health Agency of Canada. Mental health promotion: promoting mental health means promoting the best of ourselves [Internet]. Ottawa (ON): PHAC; 2014 [cited 2023 Mar 5]. Available from: https://www.canada.ca/en/public-health/services/health-promotion/mental-health/mental-health-promotion.html

2. Mental Health Commission of Canada (MHCC). Changing directions, changing lives: the mental health strategy for Canada. Calgary (AB): MHCC; 2012 [cited 2023 Mar 5]. 156 p. Available from: https://www.mentalhealthcommission.ca/wp-content/uploads/drupal/MHStrategy_Strategy_ENG.pdf

3. World Health Organization (WHO). Mental health [Internet]. Geneva (CH): WHO; 2022 [cited 2023 Mar 5]. Available from: https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response

4. Shaffer-Hudkins E, Suldo S, Loker T, March A. How adolescents' mental health predicts their physical health: unique contributions of indicators of subjective well-being and psychopathology. Appl Res Qual Life. 2010; 5(3):203-17. https://doi.org/10.1007/s11482-010-9105-7

5. Orpana H, Vachon J, Dykxhoorn J, McRae L, Jayaraman G. Monitoring positive mental health and its determinants in Canada: the development of the Positive Mental Health Surveillance Indicator Framework. Health Promot Chronic Dis Prev Can. 2016; 36(1):1-10. https://doi.org/10.24095/hpcdp.36.1.01

6. Public Health Agency of Canada (PHAC). Positive Mental Health Surveillance Indicator Framework [Internet]. Ottawa (ON): PHAC; 2024 [modified 2024 Nov 21; cited 2025 Feb 14]. Available from: https://health-infobase.canada.ca/positive-mental-health

7. Lerner RM, Steinberg L, editors. Handbook of adolescent psychology [ebook]. Hoboken (NJ): Wiley; 2009. https://doi.org/10.1002/9780470479193

8. MacLeod KB, Brownlie EB. Mental health and transitions from adolescence to emerging adulthood: developmental and diversity considerations. Can J Community Ment Health. 2014; 33(1):77-86. https://doi.org/10.7870/cjcmh-2014-007

9. Ross DA, Hinton R, Melles-Brewer M, et al. Adolescent well-being: a definition and conceptual framework. J Adolesc Health. 2020;67(4):472-6. https://doi.org/10.1016/j.jadohealth.2020.06.042

10. Keyes CL. Mental health in adolescence: is America's youth flourishing? Am J Orthopsychiatry. 2006;76(3):395-402. https://doi.org/10.1037/0002-9432.76.3.395

11. Hoyt LT, Chase-Lansdale PL, McDade TW, Adam EK. Positive youth, healthy adults: does positive well-being in adolescence predict better perceived health and fewer risky health behaviors in young adulthood? J Adolesc Health. 2012;50(1):66-73. https://doi.org/10.1016/j.jadohealth.2011.05.002

12. Public Health Agency of Canada (PHAC). A vision to transform Canada's public health system: the Chief Public Health Officer's report on the state of public health in Canada 2021. Ottawa (ON): PHAC; 2021. 129 p. Available from: https://www.canada.ca/en/public-health/corporate/publications/chief-public-health-officer-reports-state-public-health-canada/state-public-health-canada-2021.html

13. Gadermann AC, Thomson KC, Richardson CG, et al. Examining the impacts of the COVID-19 pandemic on family mental health in Canada: findings from a national cross-sectional study. BMJ Open. 2021;11(1):e042871. https://doi.org/10.1136/bmjopen-2020-042871

14. Shields M, Tonmyr L, Gonzalez A, et al. Symptoms of major depressive disorder during the COVID-19 pandemic: results from a representative sample of the Canadian population. Health Promot Chronic Dis Prev Can. 2021;41(11):340-58. https://doi.org/10.24095/hpcdp.41.11.04

15. Public Health Agency of Canada (PHAC). Map of Canadian mental health during the COVID-19 pandemic [Internet]. Ottawa (ON): PHAC; 2022 [cited 2023 Jul 9]. Available from: https://health-infobase.canada.ca/covid-19/mental-health/

16. Capaldi CA, Liu L, Dopko RL. Positive mental health and perceived change in mental health among adults in Canada during the second wave of the COVID-19 pandemic. Health Promot Chronic Dis Prev Can. 2021;41(11): 359-77. https://doi.org/10.24095/hpcdp.41.11.05

17. Goodman ML, Molldrem S, Elliott A, Robertson D, Keiser P. Long COVID and mental health correlates: a new chronic condition fits existing patterns. Health Psychol Behav Med. 2023;11(1):2164498. https://doi.org/10.1080/21642850.2022.2164498

18. Nearchou F, Flinn C, Niland R, Subramaniam SS, Hennessy E. Exploring the impact of COVID-19 on mental health outcomes in children and adolescents: a systematic review. Int J Environ Res Public Health. 2020; 17(22):8479. https://doi.org/10.3390/ijerph17228479

19. Samji H, Wu J, Ladak A, et al. Review: mental health impacts of the COVID-19 pandemic on children and youth - a systematic review. Child Adolesc Ment Health. 2022;27(2):173-89. https://doi.org/10.1111/camh.12501

20. Chadi N, Ryan NC, Geoffroy MC. COVID-19 and the impacts on youth mental health: emerging evidence from longitudinal studies. Can J Public Health. 2022;113(1):44-52. https://doi.org/10.17269/s41997-021-00567-8

21. Zolopa C, Burack JA, O'Connor RM, et al. Changes in youth mental health, psychological wellbeing, and substance use during the COVID-19 pandemic: a rapid review. Adolesc Res Rev. 2022;7(2):161-77. https://doi.org/10.1007/s40894-022-00185-6

22. Public Health Agency of Canada (PHAC). Trends in health inequalities in Canadian adolescents from 2002 to 2018. Findings from the 2018 Health Behaviour of School-aged Children (HBSC) Study. Ottawa (ON): PHAC; 2022. 13 p. Available from: https://www.canada.ca/en/public-health/services/publications/science-research-data/trends-health-inequalities-canadian-adolescents-2002-2018.html

23. Statistics Canada. Canadian Community Health Survey – Annual Component, 2017 [Internet]. Ottawa (ON): Government of Canada; 2017 [cited 2023 Jul 9]. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=329241

24. Statistics Canada. Canadian Community Health Survey – Annual Component, 2019 [Internet]. Ottawa (ON): Government of Canada; 2019 [cited 2023 Jul 9]. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=1208978

25. Statistics Canada. Canadian Community Health Survey – Annual Component, 2021 [Internet]. Ottawa (ON): Government of Canada; 2021 [cited 2023 Jul 9]. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=1314175

26. Campbell OL, Bann D, Patalay P. The gender gap in adolescent mental health: a cross-national investigation of 566,829 adolescents across 73 countries. SSM Popul Health. 2021;13:100742. https://doi.org/10.1016/j.ssmph.2021.100742

27. Yoon Y, Eisenstadt M, Lereya ST, Deighton J. Gender difference in the change of adolescents' mental health and subjective wellbeing trajectories. Eur Child Adolesc Psychiatry. 2023;32(9):1569-78. https://doi.org/10.1007/s00787-022-01961-4

28. de Looze ME, Huijts T, Stevens GW, Torsheim T, Vollebergh WA. The happiest kids on earth. Gender equality and adolescent life satisfaction in Europe and North America. J Youth Adolesc. 2018;47(5):1073-85. https://doi.org/10.1007/s10964-017-0756-7

29. Halldorsdottir T, Thorisdottir IE, Meyers CC, et al. Adolescent well-being amid the COVID-19 pandemic: are girls struggling more than boys? JCPP Adv. 2021;1(2):e12027. https://doi.org/10.1002/jcv2.12027

30. Ahn SN. The potential impact of COVID-19 on health-related quality of life in children and adolescents: a systematic review. Int J Environ Res Public Health. 2022;19(22):14740. https://doi.org/10.3390/ijerph192214740

31. Engel de Abreu PM, Neumann S, Wealer C, Abreu N, Coutinho Macedo E, Kirsch C. Subjective well-being of adolescents in Luxembourg, Germany, and Brazil during the COVID-19 pandemic. J Adolesc Health. 2021;69(2):211-18. https://doi.org/10.1016/j.jadohealth.2021.04.028

32. Johansen R, Espetvedt MN, Lyshol H, Clench-Aas J, Myklestad I. Mental distress among young adults - gender differences in the role of social support. BMC Public Health. 2021;21(1):2152. https://doi.org/10.1186/s12889-021-12109-5

33. Kerekes N, Bador K, Sfendla A, et al. Changes in adolescents' psychosocial functioning and well-being as a consequence of long-term COVID-19 restrictions. Int J Environ Res Public Health. 2021;18(16):8755. https://doi.org/10.3390/ijerph18168755

34. Landstedt E, Asplund K, Gillander Gådin K. Understanding adolescent mental health: the influence of social processes, doing gender and gendered power relations. Sociol Health Illn. 2009;31(7):962-78. https://doi.org/10.1111/j.1467-9566.2009.01170.x

35. Okpalauwaekwe U, Ballantyne C, Tunison S, Ramsden VR. Enhancing health and wellness by, for and with Indigenous youth in Canada: a scoping review. BMC Public Health. 2022;22(1):1630. https://doi.org/10.1186/s12889-022-14047-2

36. Statistics Canada. The Daily - Experiences of discrimination during the COVID-19 pandemic [Internet]. Ottawa (ON): Government of Canada; 2020 Nov 17 [cited 2023 Oct 10]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/200917/dq200917a-eng.htm

37. Statistics Canada. Perceptions of safety of Indigenous people during the COVID-19 pandemic [Internet]. Ottawa (ON): Government of Canada; 2020 [cited 2024 Oct 16]. Available from: https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00071-eng.htm

https://doi.org/10.24095/hpcdp.45.6.03

Original quantitative research

The epidemiology and deprivation profile of firearm-related injuries and deaths in British Columbia, Canada

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Abstract

Introduction: Firearm-related injuries (FRI) are an important public health issue in Canada. This study aims to determine the incidence of FRI in British Columbia (BC) and examine the distribution according to demographics, intent, urban–rural residence and neighbourhood deprivation.

Methods: De-identified data on deaths and hospitalizations (2010–2019) were retrieved from the BC Vital Statistics and the Discharge Abstract Database obtained from the BC Ministry of Health. We implemented the Canadian Index of Multiple Deprivation for the dissemination area–level marginalization.

Results: A total of 1868 fatal and nonfatal FRI were included in our study, of which 46.4% were due to self-harm. The annual injury rate was 3.93 per 100 000, with the highest rates among men aged 15 to 34 years. Rates were highest in rural and remote areas, in neighbourhoods with the least diverse ethno-cultural composition, and the greatest level of situational vulnerability and economic dependency. We did not observe significantly different rates across residential instability quintiles. The marginalization pattern for intentional self-harm was similar to the aggregated deprivation profile. While assaults were more common in neighbourhoods with higher levels of situational vulnerability and more diverse populations, unintentional injuries were more prevalent in neighbourhoods with higher levels of situational vulnerability.

Conclusion: This study revealed that the burden of FRI was not evenly distributed across demographic determinants, neighbourhood deprivation or urban–rural areas of residence throughout BC. We also observed different deprivation profiles across the various intents of injury and death. Findings highlight the need for addressing FRI at its root causes, by implementing system-level interventions focussed on suicide prevention, poverty reduction, and promoting employment and education.

Keywords: *firearms, Canada, socioeconomic factors, rural, suicide, injuries, gunshot, mortality*

Highlights

- Between 2010 and 2019, a total of 1035 British Columbians lost their lives and another 833 were seriously injured due to firearms.
- Intentional self-harm made up 46.4% of all firearm injuries and deaths in British Columbia.
- The highest rates were among men aged 15 to 34 years, and individuals in rural and remote areas of British Columbia.
- Neighbourhoods with less diverse populations, greater situational vulnerability and higher economic dependency had higher rates of serious or fatal firearm injuries.
- Findings highlight the need for addressing firearm-related injuries at the root causes, through suicide prevention and poverty reduction, and promoting employment and education.

Introduction

Firearm-related injuries (FRI) are a significant public health issue in Canada. According to the Global Burden of Disease study, an estimated 875 fatal FRI occurred among Canadians in 2019, with the death rate being more than three times higher than rates in Australia, England and Ireland.[1] With a disability-adjusted life years (DALYs) rate of 108.9 per 100 000 in 2019, FRI were responsible for 39 789 DALYs among Canadians (3854 years of life lost and 35 935 years lived with disability).[1]

Suicide accounts for more than three-quarters of all firearm-related deaths in Canada, more than double the global rate of 0.68 per 100 000 population.[1] When comparing firearm-related suicide rates in high-income countries with populations greater than 10 million, Canada ranks third, after the US and Chile.[2] At the same time, a Canadian study demonstrated that assault and unintentional injuries were the most common external causes of non-fatal firearm hospitalizations and emergency department (ED) visits, respectively.[3]

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The rate of firearm-related violent crime in Canada began an upward trend in 2014, resulting in an increase of 20% in the six-year period from 2015 to 2020 compared to the previous six years. In 2017, an increase in homicides in two provinces (British Columbia [BC] and Quebec [QC]) was responsible for the national increase in homicides. The increase in BC occurred in both urban and rural areas, which is partly explained by increased numbers of gang- and firearm-related homicides.[4] The rise in firearm-related homicides in BC was due to increases in Vancouver (+7 victims), Abbotsford-Mission (+4) and non-CMAs* (+10); the increase in QC was the result of the January 2017 mass shooting at a Québec City mosque (+6).[4]

In 2020, notable increases in rates of firearm-related violent crime were observed in some Canadian jurisdictions, including southern rural BC, where the rate increased by 34%.[6] The estimated annual cost of violent firearm crime in BC amounts to $294.4 million, with human costs (including health care, productivity and value of statistical life) making up 64% of the total, followed by criminal justice system and programming costs.[7]

While there are estimates that some 26% of Canadian households own at least one firearm, the distribution varies considerably across provinces and territories.[8] According to the International Crime Victim Survey conducted in 1996, the majority of Canadian households that owned firearms possessed at least one long gun; while BC residents reported owning handguns more often than other Canadians (16% of gun owners).[9] Another study on the regional variations in methods of self-protection by Canadians between 1999 and 2004 revealed that British Columbians were two times more likely to own guns for protection and 10% more likely to carry weapons compared to residents of Ontario (ON).[10] That study also demonstrated that Canadians living in rural areas were 2.3 times more likely to own guns, but had lower levels of weapon carrying, suggesting that living in rural areas might be influenced by a culture of firearm ownership used for hunting, protection against wild animals, self-defense against criminals and for entertainment. [10]

Previous studies have demonstrated that neighbourhood deprivation is one of the key determinants of the incidence and severity of injuries, including FRI. For instance, a population-based study in ON demonstrated that young men living in the lowest-income urban neighbourhoods were overrepresented in nonfatal assault FRI.[11] A study of the neighbourhood socioeconomic status of serious injuries in Greater Vancouver, BC, demonstrated higher rates of severe injury in areas with high social and material deprivation, with social deprivation explaining slightly more variation in the injury rates than material deprivation.[12] The urban–rural divide has also been recognized as a determinant of the rate, type and outcome of FRI—due to the differences in the availability of firearms and access to advanced prehospital and hospital trauma care.[13,14]

Despite the notable burden and costs, the epidemiology of FRI and the distribution across deprivation levels and the urban–rural spectrum have not been thoroughly examined in BC. Knowledge of the determinants and patterns of FRI are essential to shape policies and practices in an effort to decrease the burden. Furthermore, much of the epidemiological literature on FRI draws on US studies. Thus, providing evidence on the Canadian context would be beneficial for prevention and policy making. The purpose of this study is to estimate the incidence rate of firearm-related serious injuries and deaths among residents of BC, and to examine the rates across the neighbourhood deprivation spectrum and urban–rural area of residence. The objectives of this study are to determine (1) the crude and standardized rates of FRI in BC; (2) the temporal trend overall and according to intent across the study period; and (3) the distribution of FRI according to sex, age group, intent, firearm type, urban–rural area of residence and neighbourhood deprivation.

Methods

Ethics approval

Ethics approval was granted by The University of British Columbia's Children's and Women's Research Ethics Board, #H22-03453.

Data source and analysis

Following ethics approval, de-identified data on firearm-related deaths of BC residents between the 2010 and 2019 calendar years were retrieved from the BC Vital Statistics obtained from the BC Ministry of Health, through a data sharing agreement with the BC Injury Research and Prevention Unit (BCIRPU; data pulled Aug 2022). De-identified firearm-related hospitalization data were obtained from the Discharge Abstract Database (DAD) obtained from the BC Ministry of Health, retrieved through the BCIRPU, and the records pertaining to in-hospital deaths (n = 51) were removed to avoid the double-counting of fatalities. DAD is a national database, managed by the Canadian Institute for Health Information (CIHI), which contains administrative, demographic and clinical information on hospital separations (also called discharges) from all Canadian provinces and territories, except QC.

The main outcome variable in this study was a fatal or nonfatal injury secondary to firearms during the study period, as identified using the 10th revision of the International Statistical Classification of Diseases and Related Health Problems, Canadian Modification (ICD-10-CA) codes, and examined as counts, proportions and rates per 100 000 population. The explanatory variables included sex, age group, intent (assault, intentional self-harm, unintentional, legal intervention and undetermined), firearm type (rifle, shotgun and larger firearm; handgun; BB gun; airgun; other specified; and unspecified firearm), neighbourhood deprivation quintile and urban–rural area of residence.

We used the Canadian Index of Multiple Deprivation (CIMD), which can be used as a proxy for individual-level deprivation and marginalization.[15] This geography-based index has been developed by Statistics Canada based on 2016 census microdata at the dissemination area (DA) level, the smallest standard geographical area for which all census data are disseminated. CIMD allows for an in-depth understanding of area-level inequality using quintiles across four dimensions: ethno-cultural composition, situational vulnerability, economic dependency and residential instability. For each of the dimensions, the first quintile represents the least deprived area and the fifth quintile represents the most deprived. For the ethno-cultural composition, quintiles 1 and 5 represent

* A CMA (census metropolitan area) is an area consisting or one of more adjacent neighbouring municipalities around a large urban area known as the urban core. A CMA must have a total population of at least 100 000 of which 50 000 or more live in the urban core. A non-CMA refers to a geographical region that does not meet the criteria of a CMA.[5]

neighbourhoods with the least and most diverse population, respectively. In addition to the national level, three provincial and two regional CIMD indexes are available.[15] The BC-specific index was linked to the administrative data, using DA as the common identifier.

Firearm-related injury incidence rates per 100 000 population across the 10-year study period were calculated by summing the total number of fatal and nonfatal injuries and dividing it by the BC population for the same time period. Age- and sex-standardized, population-based, annual incidence rate of firearm-related injuries in BC were calculated using the 2016 Census of Population as the standard population, to enable comparison with other provinces. Ninety-five percent confidence intervals (CIs) for rates were developed at each quintile across dimensions of the CIMD using the Wilson score interval.[16] Simple linear regression was implemented to investigate the temporal trends overall, and according to intent.

The urban–rural area of residence was classified according to the seven-tier Community Health Service Area (CHSA) urban–rural categories (metropolitan, large urban, medium urban, small urban, rural hub, rural and remote), based on the 2016 census.[17] Health services in BC are delivered within five administrative health boundaries (known as health authorities), made up of 89 local health areas. Nested within local health areas, there are 218 CHSAs and 7208 DAs. For the purpose of this study, the DA of the area of residence was used to identify the CHSA urban–rural category, and injury rates were calculated for each category. Frequencies for rural and remote areas were further aggregated to facilitate comparison, as similar rates were observed in these two categories.

Case fatality rate (CFR) was calculated as the proportion of fatal injuries due to firearms, divided by the total number of firearm-related injuries, stratified by the main study variables and reported as percentages.

Data analysis was conducted using SPSS Statistics version 26 (IBM Corp., Armonk, NY, US) and the chi-square test was used to examine differences between the distribution of intent and urban–rural area as well as between the CFR and urban–rural area, with the significance level of $\alpha \leq 0.05$.

Results

A total of 1868 BC residents sustained firearm-related injuries during the study period (55.4% fatal), an annual incidence rate of 3.93 per 100 000 and an age- and sex-standardized rate of 3.90 per 100 000 population. The annual death rate by firearms was 2.18, with a standardized rate of 2.11 per 100 000 population.

The mean (SD) age in years of included individuals was 43.4 (19.3); 34.7 (14.1) among nonfatal and 50.0 (20.0) among fatal cases. Injuries from intentional self-harm accounted for 46.4% of FRI, followed by assault injuries (29.2%) and unintentional injuries (19.1%). Distribution of the frequency and rates of firearm injuries according to demographics, intent and urban–rural area of residence is provided in Table 1. The majority of injured individuals were male (91.8%). Females accounted for 13.0% of assaults and 13.6% of injuries with undetermined intent (vs. 9.3% of unintentional and 4.6% of intentional self-harm injuries).

There were no significant temporal trends in rates over the course of the study period, either overall or according to intent (Figure 1).

The highest rates of FRI (including all intents) were among those aged 15 to 24 and 25 to 34 years: 5.69 (95% CI: 5.11–6.33) and 6.20 (95% CI: 5.63–6.83), respectively (Table 1). The highest rates of unintentional injury and assault FRI were observed in these two age groups, while individuals aged 75 years and older had the greatest intentional self-harm rates by

TABLE 1
Frequency and rates of firearm injuries according to demographics, intent and urban–rural area of residence, British Columbia, 2010 to 2019

Characteristic	Categories	n (%)	Rate[a] (95% CI)	CFR (%)
Sex	Male	1714 (91.8)	7.28 (6.95–7.63)	56.0
	Female	154 (8.2)	0.64 (0.55–0.75)	48.7
Age group (years)	Under 15	23 (1.2)	0.33 (0.22–0.50)	21.7
	15–24	338 (18.1)	5.69 (5.11–6.33)	37.9
	25–34	410 (21.9)	6.20 (5.63–6.83)	37.6
	35–44	267 (14.3)	4.24 (3.76–4.78)	44.6
	45–54	275 (14.7)	3.91 (3.47–4.39)	57.5
	55–64	245 (13.1)	3.68 (3.25–4.17)	77.6
	65–74	162 (8.7)	3.57 (3.06–4.16)	87.0
	75–84	105 (5.6)	4.34 (3.59–5.25)	95.2
	≥ 85	43 (2.3)	4.11 (3.05–5.54)	93.0
Intent	Assault	545 (29.2)	1.15 (1.06–1.35)	36.1
	Intentional self-harm	867 (46.4)	1.83 (1.71–1.95)	92.7
	Unintentional	356 (19.1)	0.75 (0.68–0.83)	4.8
	Legal intervention	41 (2.2)	0.09 (0.06–1.17)	24.4
	Undetermined	59 (3.2)	0.12 (0.09–1.60)	11.9
Urban–rural	Metropolitan	590 (31.6)	2.59 (2.39–2.80)	41.2
	Large urban	162 (8.7)	2.55 (2.19–2.97)	51.9
	Medium urban	352 (18.8)	5.44 (4.90–6.04)	52.6
	Small urban	168 (9.0)	5.07 (4.36–5.89)	61.3
	Rural hub	107 (5.7)	4.86 (4.02–5.87)	69.2
	Rural	398 (21.3)	8.01 (7.27–8.84)	72.4
	Remote	27 (1.4)	7.84 (5.39–10.79)	74.1
	Missing	64 (3.4)	NA	59.4

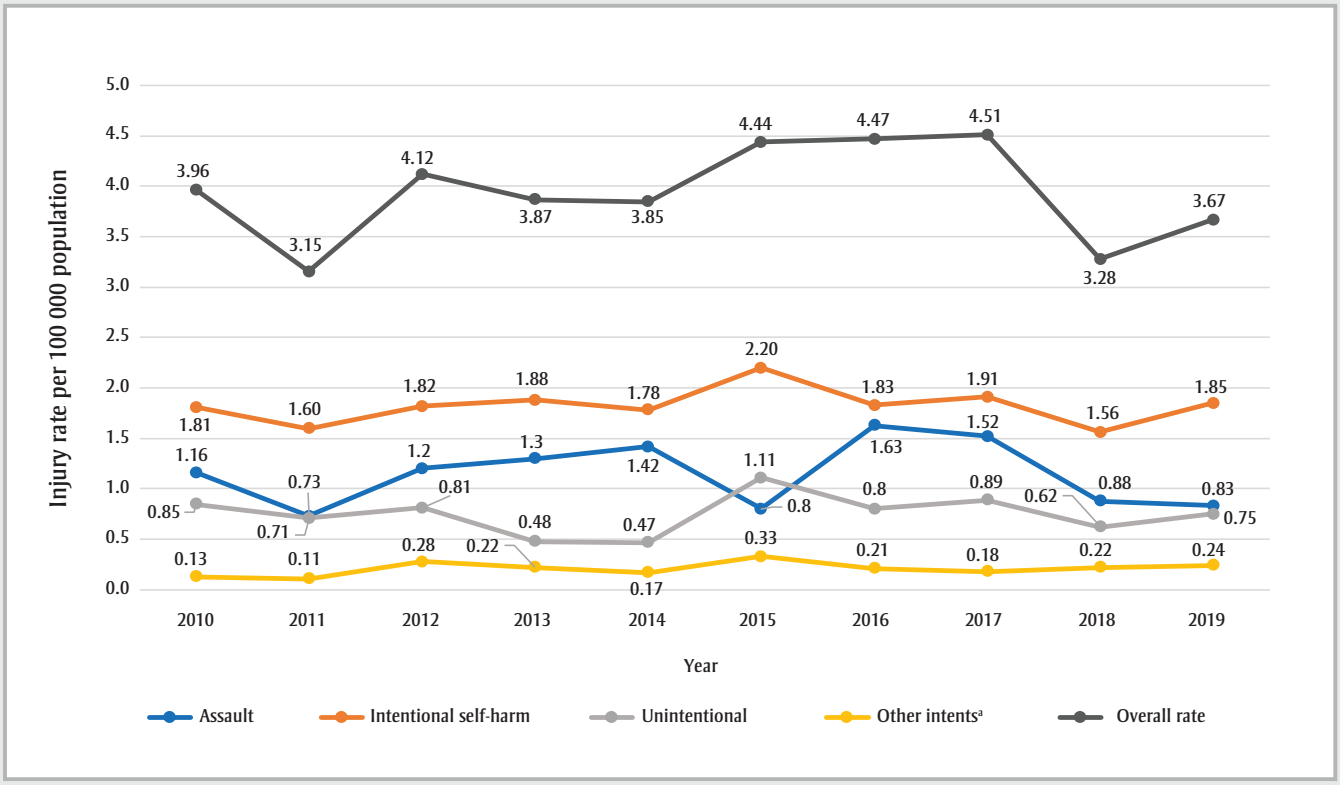
Data source: BC Vital Statistics and the Discharge Abstract Database obtained from the BC Ministry of Health.

Abbreviations: BC, British Columbia; CFR, case fatality rate; NA, not available.

Note: Percentages represent relative frequencies in column; N = 1868.

[a] Rate per 100 000.

FIGURE 1
Rates of firearm-related injuries by year and intent, British Columbia, 2010 to 2019



Data source: BC Vital Statistics and the Discharge Abstract Database obtained from the BC Ministry of Health.

Abbreviation: BC, British Columbia.

[a] "Other intents" include legal intervention and undetermined intent.

firearms (Figure 2). The highest age- and sex-specific FRI rates were observed among men aged 15 to 24 and 25 to 34 years: 11.22 (9.77–12.29) and 11.16 (10.08–12.36) per 100 000 population, respectively (data not shown).

The highest rates of FRI were observed in rural and remote areas (8.00 per 100 000, 95% CI: 7.44–9.00), accounting for 22.7% of FRI. The highest CFR was also observed in rural and remote areas, where 72.5% of FRIs were fatal, followed by 69.2% in rural hub; the lowest CFR was 41.2% in metropolitan areas ($\chi^2 = 110.8$; $p < 0.001$; $df = 5$; Table 1).

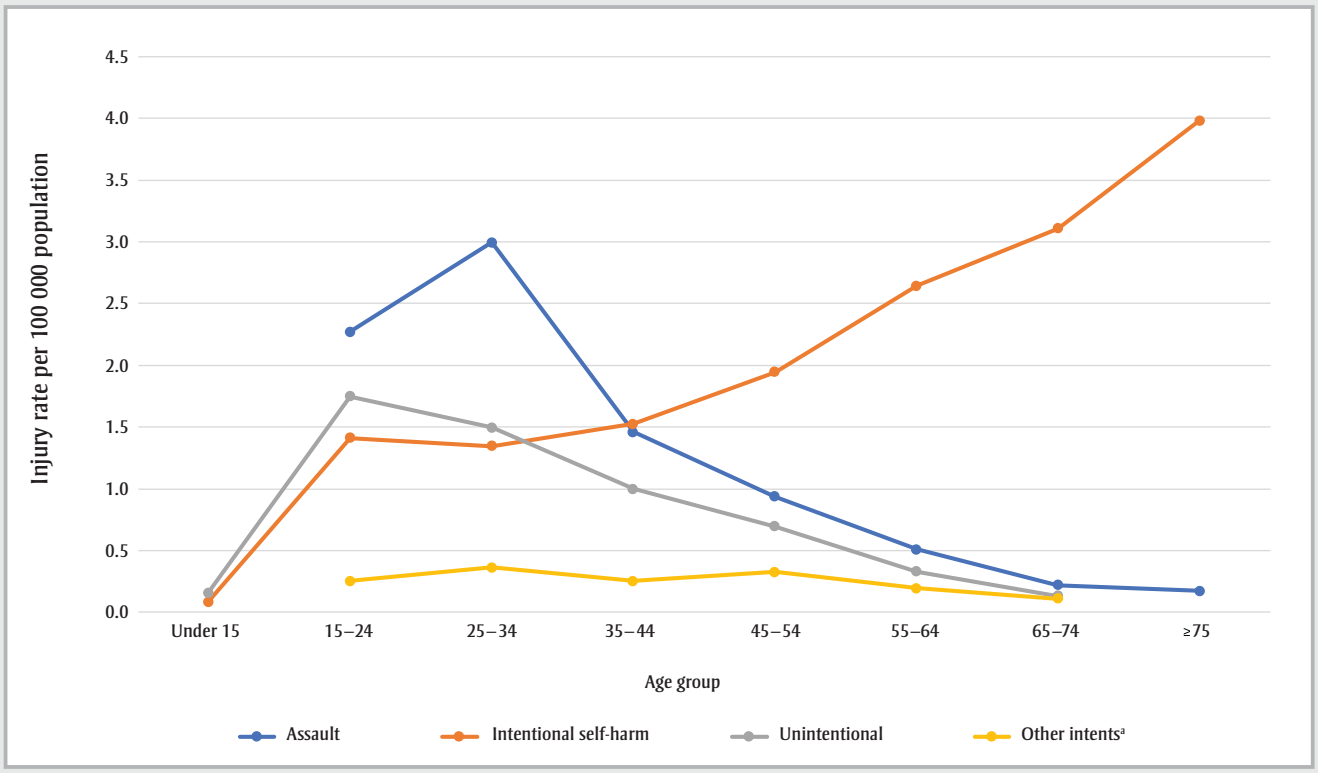
Assaults and unintentional injuries were overrepresented in metropolitan areas (50.1% and 41.9%, respectively), while 34.3% of firearm-related intentional self-harm occurred in rural and remote areas ($\chi^2 = 236.9$; $p < 0.001$; $df = 20$; Table 2).

Almost 21% of FRI were caused by rifles, shotguns or larger firearms; 10.9% by handguns; and 2.4% by nonpowdered guns (i.e. BB and airguns). The remainder were caused by "other" firearms (25.5%) or the type of firearm was missing (40.7%). Rifles, shotguns or larger firearms were involved in more than a quarter of intentional self-harm cases, but in fewer instances of unintentional injuries and assaults (17.7% and 12.7%, respectively). Examining the firearm type across the urban–rural area of residence showed that FRI from rifles, shotguns or larger firearms were more common in small urban areas (33.9%), followed by rural hub (29.9%) and rural and remote areas (28.2%). In contrast, FRI from handguns were more frequent in large urban areas (15.4%), followed by metropolitan areas (12.7%). Stratifying by both intent and urban–rural area of residence further demonstrated that rifles, shotguns or larger firearms were involved in 36.3% of intentional self-harm cases that occurred in small urban areas, in 35.3% of unintentional FRI in rural hubs and 30.0% of assaults in rural hubs.

A nonhomogenous distribution of FRI across the four dimensions of CIMD was observed, in which rates were greatest in neighbourhoods with the least diverse ethno-cultural composition and in neighbourhoods with the most deprived situational vulnerability and economic dependency. Rates were not significantly different across quintiles of residential instability. Stratification by intent further revealed that the disparity in rates among the ethno-cultural composition quintiles was mainly driven by differences in rates of intentional self-harm, although higher FRI rates in the fifth quintile of situational vulnerability were observed for intentional self-harm, assault and unintentional injuries (Figure 3, A–D).

FRI due to intentional self-harm were more common in neighbourhoods with less diverse populations (37.5% in quintile 1 of ethno-cultural composition), and in higher levels of economic dependency and situational vulnerability (30.0% and 27.8% in quintile 5 of the corresponding

FIGURE 2
Rates of firearm-related injuries by age group and intent, British Columbia, 2010 to 2019



Data source: BC Vital Statistics and the Discharge Abstract Database obtained from the BC Ministry of Health.

Abbreviation: BC, British Columbia.

Note: Rates pertaining to n < 5 are not shown due to data sharing policy.

[a] "Other intents" include legal intervention and undetermined intent.

dimensions, respectively). Assault-related FRI were predominant in neighbourhoods with more diverse populations (34.1% in quintile 5), and in higher levels of situational vulnerability (28.8% in quintile 5). Unintentional FRI were more common in neighbourhoods with higher levels of situational vulnerability (28.4% in quintile 5; Table 3).

Discussion

This study revealed that the burden of serious firearm injuries and deaths was not evenly distributed across demographic determinants, neighbourhood deprivation and urban–rural areas of residence throughout BC. The annual rate of FRI leading to death or hospitalization in BC between 2010 and 2019 was 3.93 per 100 000 population (age- and sex-adjusted rate: 3.90 per 100 000 population), which was similar to the standardized rate in ON (3.54 per 100 000 population), but lower than in Nova Scotia (NS; 4.44 per 100 000 population).[11,13] Toigo et al.[3] examined FRI rates in Canada using three administrative databases capturing deaths, hospitalizations and ED visits and found significant differences across provinces and territories, which can be partially attributed to urban–rural differences in firearm ownership. According to these researchers, the rates of firearm-related death and hospitalization in Canada—excluding hospitalizations in QC—were 2.13 and 2.22 per 100 000 population, respectively, for the study period (2016–2020). More than three-quarters of firearm-related hospitalizations occurred in the three provinces of ON, Alberta (AB) and BC, while two-thirds of firearm-related deaths occurred in ON, QC and AB.[3]

Consistent with previous reports, the rate of FRI was highest in 2017 (4.51 per 100 000).[4] Nevertheless, no significant trends were detected across the study period, either overall or stratified by intent. The overall CFR in our study was 55.4%; however, CFRs were higher in rural and remote areas and higher in older age groups. The overall CFR in this study was higher than that reported by Gomez et al. in ON, and may be related to the lower proportion of self-harm injuries in their study compared to the BC setting.[11] Another reason for the lower CFR in Gomez et al. might be that the investigators also included FRI visits at ED, lowering the aggregate injury severities.[11] In comparison, Karkada et al. reported major trauma patients in NS who sustained FRI, with a CFR of 72%, where 64.9% of the FRI were related to intentional self-harm.[13]

British Columbians over the age of 75 years had the highest rate of firearm-related self-harm injuries (3.98 per 100 000 population). The Canadian literature has highlighted that the proportion of firearm-related suicide deaths (of all suicide

TABLE 2
Demographic characteristics and urban–rural area of residence of firearm-related injuries stratified by intent, British Columbia, 2010 to 2019

Characteristic	Categories	Intent							
		Assault		Intentional self-harm		Unintentional		Undetermined	
		n (%)	CFR (%)	n (%)	CFR (%)	n (%)	CFR (%)	n (%)	CFR (%)
Sex	Male	474 (87.0)	33.5	827 (95.4)	93.2	33 (9.3)	4.6	51 (86.4)	9.8
	Female	71 (13.0)	53.5	40 (4.6)	82.5	323 (90.7)	6.1	8 (13.6)	25.0
Age group (years)	Under 15	NS	NS	6 (0.7)	66.7	11 (3.1)	9.1	NS	NS
	15–24	135 (24.8)	34.8	84 (9.7)	85.7	104 (29.2)	6.7	12 (20.3)	8.3
	25–34	198 (36.3)	34.8	89 (10.3)	91.0	99 (27.8)	1.0	17 (28.8)	17.6
	35–44	92 (16.9)	32.6	96 (11.1)	92.7	63 (17.7)	0.0	6 (10.2)	0.0
	45–54	66 (12.1)	37.9	137 (15.8)	89.1	49 (13.8)	4.1	6 (10.2)	0.0
	55–64	34 (6.2)	44.1	176 (20.3)	96.6	22 (6.2)	9.1	13 (22)	23.1
	≥ 65	16 (2.9)	68.8	279 (32.2)	95.3	8 (2.2)	50.0	NS	NS
Urban–rural[a]	Metropolitan	266 (50.1)	36.1	146 (17.5)	95.2	145 (41.9)	1.4	14 (25.0)	7.1
	Large urban	42 (7.9)	35.7	76 (9.1)	88.2	36 (10.4)	2.8	NS	NS
	Medium urban	110 (20.7)	32.7	160 (19.2)	90.0	66 (19.1)	3.0	11 (19.6)	9.1
	Small urban	29 (5.5)	24.1	102 (12.2)	93.1	27 (7.8)	0.0	8 (14.3)	0.0
	Rural hub	20 (3.8)	45.0	64 (7.7)	96.9	17 (4.9)	11.8	5 (8.9)	20.0
	Rural and remote	64 (12.1)	42.2	286 (34.3)	93.4	55 (15.9)	18.2	15 (26.8)	20.0

Data source: BC Vital Statistics and the Discharge Abstract Database obtained from the BC Ministry of Health.

Abbreviations: BC, British Columbia; CFR, case fatality rate; NS: not shown due to data sharing policy for counts less than 5.

Note: The cases with legal intervention as the intent are not included in this table, due to small cell counts after stratification; percentages represent relative frequencies within each column.

[a] The urban–rural data were missing for 64 individuals (3.4%) and the proportions are valid percentages among the cases not missing data.

deaths) significantly increases with age.[18,19] Several factors may contribute to this, including a greater proportion of older adults living in rural and remote areas of BC, bereavement of a close person, mental and physical health conditions and financial constraints, and thus, targeted interventions for older adults are warranted while using comprehensive approaches.[20,21]

This study showed that the highest rate of FRI occurred in rural and remote areas, mainly driven by suicide among men aged over 45 years. Burrows et al. observed that the risk of death by firearm suicides was 3.4 times higher in rural and remote areas of Canada compared to very large urban areas, while such a difference was not detected for other measures of suicide.[22] Being male and living in rural areas were among the significant risk factors associated with suicide deaths among older adults in ON, as shown in another study utilizing linked health care administrative databases.[23] While a literature review has suggested access to firearms, socioeconomic status, limited access to mental health services, stigma and social isolation as other contributing factors to higher firearm-related suicide mortality among older males in rural areas,[24] additional research is required to examine this disparity across the life course.

In our study, the information on the firearm type was not available in a considerable proportion of records; however, rifles, shotguns or larger firearms were noted to be involved in 20.6% and handguns in 10.9% of FRI. Finley et al., who examined the contributing factors of firearm-related in-hospital mortality in Canadian trauma centres, also reported that the firearm type was missing in around 50% of cases.[25] Similar to other Canadian studies, rifles, shotguns or larger firearms were more common in intentional self-harm injuries and among residents of small urban, rural hub and rural and remote areas. In contrast, injuries related to handguns were more prevalent in large urban and metropolitan areas.[26]

We observed higher FRI rates among individuals residing in neighbourhoods within the first quintile of ethno-cultural composition (i.e. areas with lower proportions of individuals who self-identify as a visible minority,[†] are foreign-born, have no knowledge of either official language or are recent immigrants). A population-based study of residents of ON aged 24 years and younger demonstrated that nonimmigrants had higher rates of unintentional FRI compared to immigrants; however, the rate of assault-related firearm injuries was similar.[27] While there is a need for further exploration of injury rates and patterns in immigrant populations in Canada, cultural factors and living in urban centres with high-density immigrant communities may be protective against the risk of experiencing some types of injuries.[28]

This study showed higher rates of FRI among individuals living in greater situational vulnerability. A study of the association between suicide and homicide rates in the presence of firearm availability in Canadian provinces (1981–2016) concluded

[†] Terminology used in the CIMD definition.

FIGURE 3
Rates of firearm-related injuries by neighbourhood deprivation quintiles stratified by intent, British Columbia, 2010 to 2019

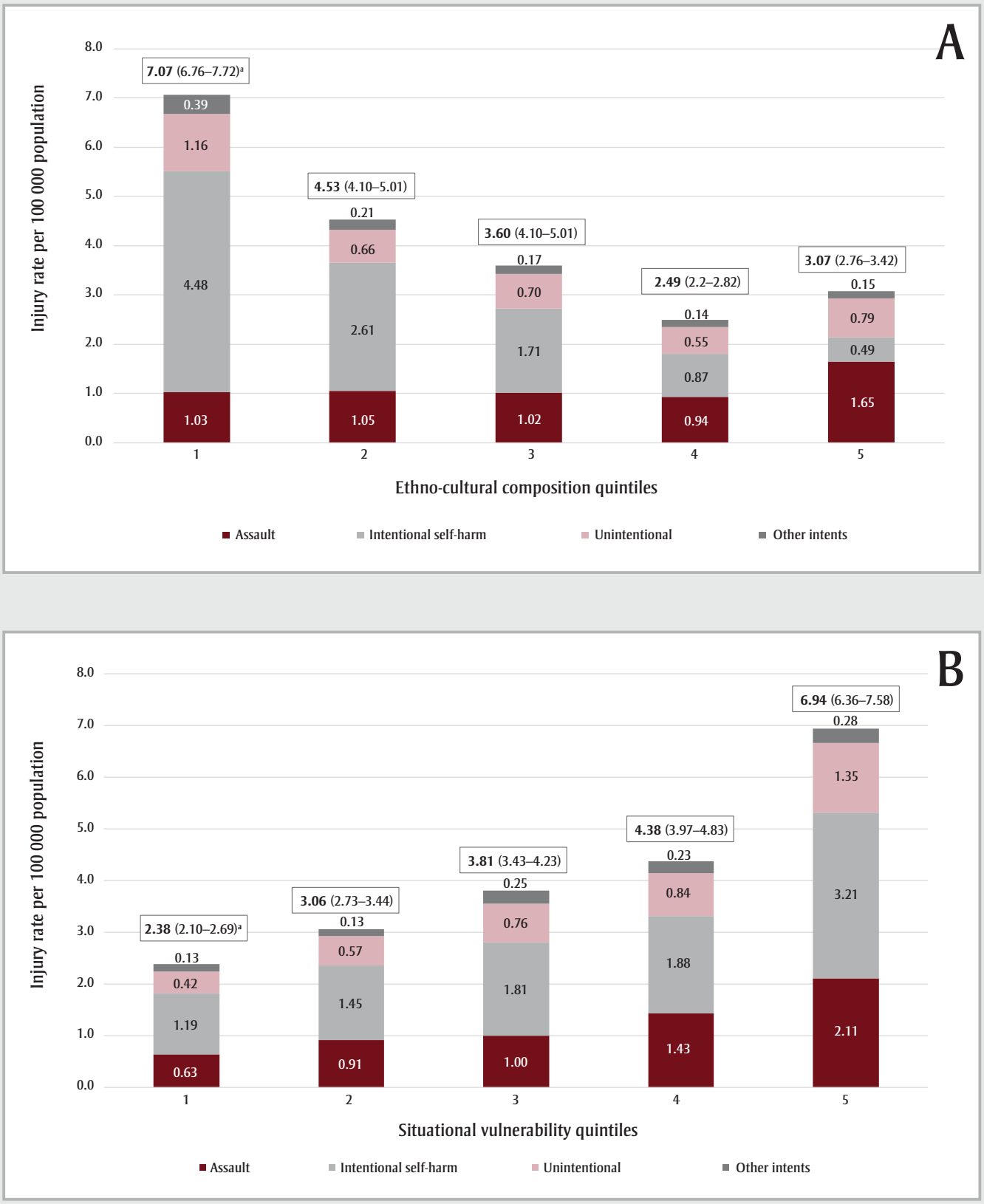
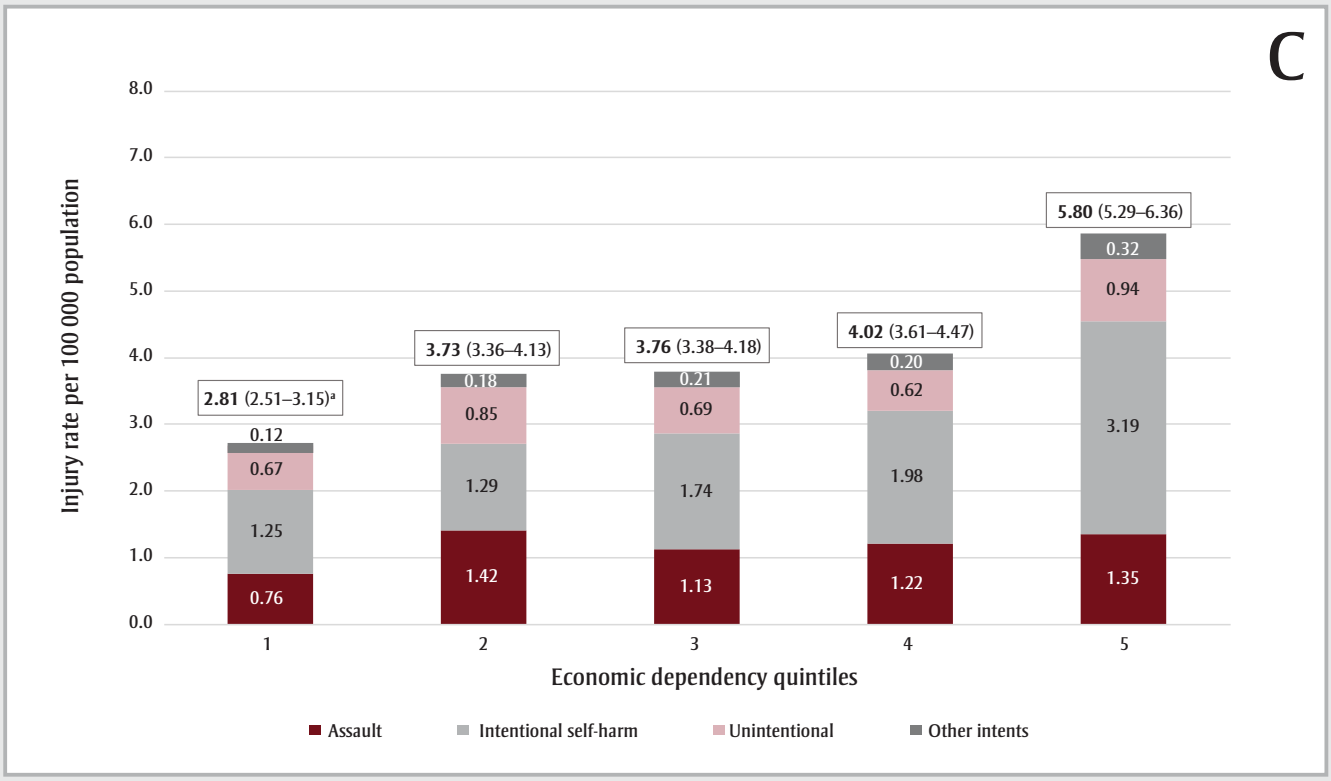
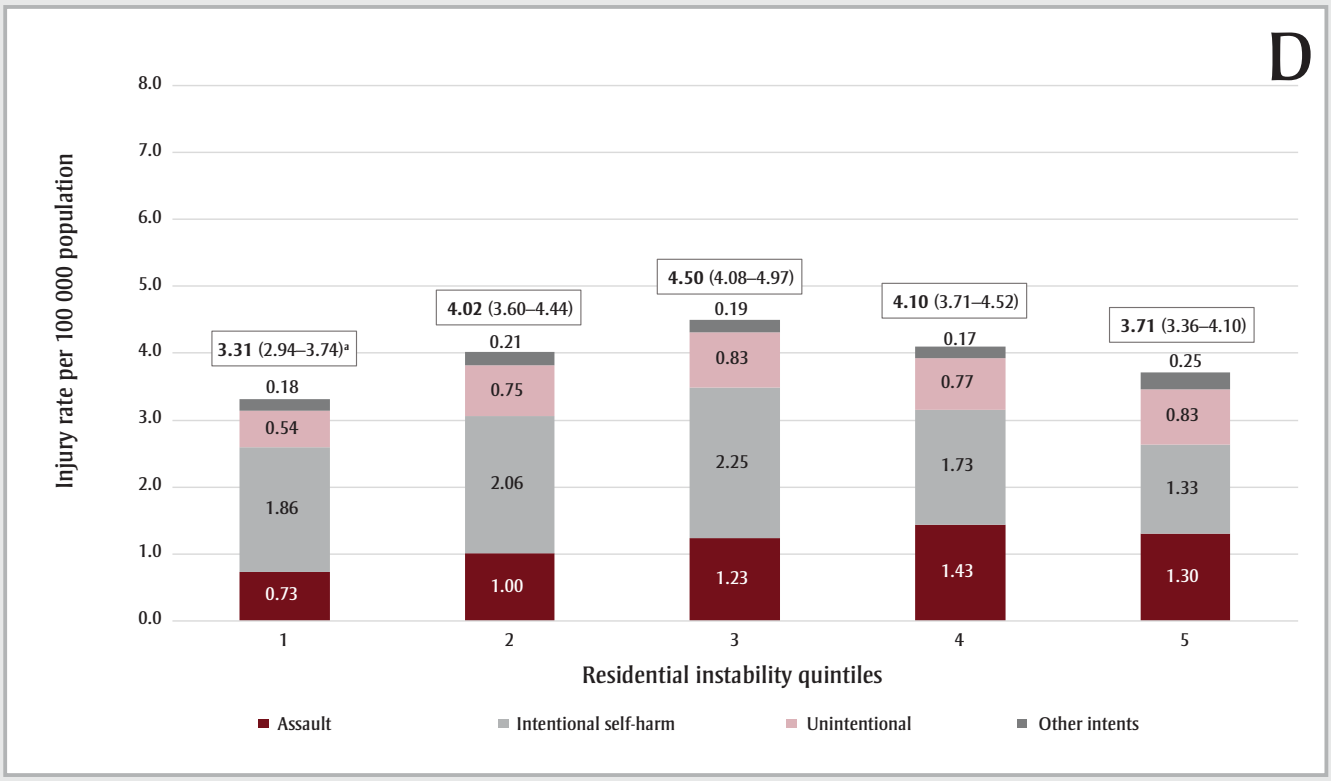


FIGURE 3 (continued)
Rates of firearm-related injuries by neighbourhood deprivation quintiles stratified by intent, British Columbia, 2010 to 2019





Data source: Injury data: BC Vital Statistics and the Discharge Abstract Database obtained from the BC Ministry of Health. Deprivation indices: Statistics Canada.

Abbreviation: BC, British Columbia.

Notes: "Other intents" include legal intervention and undetermined intent.
For each of the dimensions, the first quintile represents the least deprived area and the fifth quintile represents the most deprived. For the ethno-cultural composition, quintiles 1 and 5 represent neighbourhoods with the least and most diverse population, respectively.

[a] Rate per 100 000 and 95% CI for each quintile.

TABLE 3
Distribution of firearm-related injuries and case fatality rate according to quintiles of deprivation dimensions and intent, British Columbia, 2010 to 2019

Deprivation dimension	Q	n (%)[a]	CFR (%)	Intent							
				Assault		Intentional self-harm		Unintentional		Undetermined	
				%	CFR (%)	%	CFR (%)	%	CFR (%)	%	CFR (%)
Ethno-cultural composition	1	492 (27.4)	67.1	13.6	37.5	37.5	92.6	23.7	11.1	35.2	10.5
	2	385 (21.5)	64.4	16.9	42.7	26.7	91.9	16.4	7.1	27.8	13.3
	3	330 (18.4)	52.7	17.6	24.7	18.9	92.4	18.7	1.6	16.7	11.1
	4	250 (13.9)	50.8	17.8	44.7	10.5	93.1	16.1	3.6	11.1	16.7
	5	336 (18.7)	34.5	34.1	33.3	6.5	98.1	25.1	1.2	9.3	0.0
Situational vulnerability	1	248 (13.8)	63.3	12.5	53.0	14.9	97.6	12.9	0.0	11.1	0.0
	2	296 (16.5)	54.7	16.7	34.1	16.8	90.0	16.1	7.3	18.5	20.0
	3	348 (19.4)	56.6	17.2	34.1	19.8	95.8	20.2	4.3	20.4	9.1
	4	401 (22.4)	52.1	24.8	33.6	20.7	90.7	22.5	5.2	22.2	16.7
	5	500 (27.9)	54.0	28.8	32.9	27.8	91.3	28.4	6.2	27.8	6.7
Economic dependency	1	296 (16.5)	53.7	15.2	38.8	15.9	92.4	20.8	5.6	9.3	20.0
	2	361 (20.1)	47.6	25.9	32.1	15.0	98.4	24.0	1.2	18.5	10.0
	3	344 (19.2)	54.7	19.5	39.8	19.1	89.9	18.4	3.2	24.1	0.0
	4	337 (18.8)	58.5	19.3	32.4	20.0	94.6	15.2	5.8	18.5	10.0
	5	455 (25.4)	61.3	20.1	38.7	30.0	90.8	21.6	9.5	29.6	18.0
Residential instability	1	263 (14.7)	62.4	11.0	32.8	17.8	95.3	12.6	0.0	14.8	12.5
	2	353 (19.7)	60.9	16.7	44.3	21.8	93.4	19.3	6.1	16.7	11.1
	3	398 (22.2)	59.0	20.6	39.4	23.9	92.0	21.3	8.2	24.1	15.4
	4	389 (21.7)	54.5	25.8	40.4	19.7	91.5	21.3	4.1	20.4	18.2
	5	390 (21.8)	43.3	25.9	24.8	16.8	92.1	25.4	4.6	24.1	0.0

Data sources: Injury data: BC Vital Statistics and the Discharge Abstract Database obtained from the BC Ministry of Health. Deprivation indices: Statistics Canada.

Abbreviations: BC, British Columbia; CFR, case fatality rate; Q, quintile.

Notes: The cases with legal intervention as the intent are not demonstrated in this table, due to small cell counts after stratification. Percentages represent relative frequencies within each column.

[a] The deprivation quintile was missing for 75 individuals (4.0%) and the proportions are valid percentages among the non-missing cases.

that firearms legislation had no beneficial effect on the overall rates, while higher unemployment, low income and higher proportion of Indigenous population were directly associated with rates of firearm-related suicide.[29] The rates of FRI were also higher in neighbourhoods with greater economic dependency. This was similar to the findings of Gomez et al., who observed higher rates of FRI in areas of ON with the lowest neighbourhood income.[11]

We did not observe significantly different rates across quintiles of residential instability. The results of previous studies of the association of community-level residential instability and FRI are mixed.[30,31] Areas with higher levels of residential instability may represent populations who face challenges in maintaining their place of residence and thus are susceptible to shifting relationships with the community, and are exposed to fluctuating levels of formal and informal supports.[32] Further studies are required to examine the association of this neighbourhood-level deprivation dimension with FRI in the Canadian context.

A novel finding of this study was different deprivation profiles across differing intents of injury and death. The pattern of marginalization for self-harm FRI cases was similar to the overall pattern (i.e. overrepresentation in areas with a less diverse population and with higher economic and situational vulnerability). This was expected, as 46.4% of the FRI were due to intentional self-harm. While unintentional injuries were more prevalent in neighbourhoods with higher levels of situational vulnerability, assaults were more common in neighbourhoods with more diverse populations as well as areas with higher levels of situational vulnerability. While small sample size after stratification by five deprivation quintiles and by intent did not allow statistical comparison within the strata, further studies are required to examine how the neighbourhood deprivation patterns might differ across intents.

As the CIMD has not been previously implemented to examine disparities in the context of FRI, there is limited evidence with which to compare our findings; however, Saunders et al. observed lower or similar rates of assaults among immigrant youths compared to nonimmigrants in ON, except for firearm assaults, and except for interpersonal injuries by cutting or piercing.[27]

The federal legislative and regulatory actions in Canada include the tightening of rules for obtaining firearms licenses and registration; limiting personal ownership of handguns as well as the ability to buy, sell and transfer them within the country; implementing background checks for firearm purchases and taking away firearms licenses for those involved in domestic violence or criminal harassment; and mandatory firearms safety courses for first-time license applicants.[33,34]

While public opinion polls have historically demonstrated strong support of Canadians for tougher gun laws, the *Ending the Long-Gun Registry Act* was a piece of legislation that generated much controversy, augmented by the increasing costs of licensing and registration. Ultimately, this act instituted a major policy change in 2012, eliminating the long-gun registry and requiring registration only for restricted firearms.[35,36] Some scholars believe that the *Common Sense Firearms Licensing Act* further watered down several aspects of the Canadian gun control policies in 2015, by loosening restrictions on the transportation of firearms within the province of possession. This act also drew criticism from pro-gun groups, as it required a classroom-based firearms safety course for first-time licensees; the groups argued that this resulted in undue hardship for rural and northern residents.[37,38]

The research to date evaluating the effectiveness of Canada's gun control legislation has produced mixed results, depending on the study period and outcomes of interest.[10,18,39] While the multiplicity of contributing factors underlying FRI complicates the ability to identify any single effective intervention, policy makers might need to accept this degree of uncertainty and consider implementing packages of legal measures that are more likely to result in major benefits.[40] Evidence from 130 studies across 10 jurisdictions suggests that in certain countries the simultaneous implementation of laws targeting multiple elements of firearms restrictions has been associated with a decreased number of firearm-related deaths.[41] While further investigation is required to explore the impact of legislation on FRI in Canada, there is a need for research and public education on the safe storage practices. A survey on the storage of household firearms in QC conducted in 1994 demonstrated that 35% of respondents who kept long guns in their homes had failed to comply with Canadian firearm storage regulations.[42] While the evidence supports the benefits of safe firearm storage practices, having a gun in the home has shown to be associated with an increased risk of suicide as well as firearm homicide in the household.[43,44]

The study findings highlight the need for addressing FRI at its root causes, by implementing system-level changes to reduce disparities. The intersectionality of material deprivation with FRI calls for examining the problem with a public health lens and adopting strength-based solutions focussed on poverty reduction, housing, employment and education.[11,45]

While assault incidents in metropolitan areas are highlighted by the media, the burden of FRI in BC is mainly driven by suicide deaths in rural and remote areas. This emphasizes the importance of implementing evidence-based suicide prevention programs, including education on the safe storage of firearms, and promoting social connectedness and support, especially among older adult males, who might be otherwise neglected in the preventive initiatives.

Strengths and limitations

While our study is among the first to report the epidemiology of FRI in BC, it has some limitations, particularly that the results are based on existing data drawn from administrative databases. The estimation of the rates was based on hospitalization and death records, and did not include ED visits. The National Ambulatory Care Reporting System (NACRS) is a tool for collecting data and reporting all levels of ambulatory care including ED visits in Canada. In BC, only 30 hospitals report ED data to the NACRS, and it excludes the external cause of injuries—needed for delineating FRI—which is not reported in the available provincial ED data.[46]

Furthermore, the higher proportion of suicide deaths noted in this study might be partially due to not including ED visits (without hospitalization). Cases of intentional self-harm are usually more severe and would require hospitalization beyond the ED, whereas unintentional injuries may be sufficiently treated solely in an ED setting. This lack of consistency in the collection and availability of specific data within the province and across Canada could have an impact on the reported FRI rates and comparability among provinces.

Another limitation pertains to a lack of sufficient data necessary to parse out the FRI due to interpersonal violence (IPV). While some studies have explored the critical intersection of firearms access and IPV,[47] we were not able to delineate cases of IPV from among all FRI related to assault. Future research is essential to examine the impact of Canadian legislation on gender-based violence. This is especially the case for the more recent act entitled *An Act to amend certain Acts and to make certain consequential amendments (firearms)*, which received Royal Assent in December 2023 and allows for an emergency prohibition order in order to remove firearms from individuals who may be a danger to themselves or others.

In addition, some IPV survivors—especially in rural-remote areas—might not seek medical care after sustaining firearm injuries due to the fear of legal consequences and stigma.[48,49] While further studies are required to examine this in the Canadian context, it is less likely to have impacted our results due to the scope of our study including only hospitalizations and deaths.

A further limitation was the implementation of the neighbourhood multiple deprivation index as a proxy for individual-level information. The dissemination area–based index has the potential for ecological fallacy, since not everyone who lives in an area identified as deprived is necessarily affected or marginalized in the same way. Nevertheless, in the absence of comprehensive individual-level information, this index is valuable, providing a profile of the population and potentially facilitating public health action, and this approach is generally accepted in the research literature.[15]

In our setting, information on the urban–rural area of residence was missing for 3.4% of individuals, and the overall proportion of missing information for determination of deprivation quintiles was 4.0%. This missing proportion is considered small and is not expected to affect any interpretation of results.[50]

An additional limitation of the study was the lack of availability of recent data, specifically, for 2020 to the present. The

coroner investigation processes can take several months before a final cause of death is assigned, and additional time might be required to update vital statistics registries. The social and economic circumstances around the COVID-19 pandemic and the postpandemic social and economic circumstances may have affected real and reported FRI rates and patterns, and further studies are needed to examine any impact. Despite this limitation, this study provides a baseline for the ongoing surveillance and policy making, as well as for examining the impact of public health interventions on the burden of FRI in the province.

Conclusion

Between 2010 and 2019, a total of 1035 British Columbians lost their lives, and another 833 were seriously injured, due to firearms. The highest rates of FRI were observed among men aged 15 to 24 and 25 to 34 years; among residents of rural and remote areas; and in neighbourhoods with less diverse populations and greater situational vulnerability and economic dependency.

The association between neighbourhood deprivation and FRI highlights the need for targeted interventions in overrepresented populations. A multifaceted, collaborative approach by policy makers, public health professionals and health care providers is required to reduce poverty and systemic inequalities, and to implement evidence-based suicide prevention initiatives. While progress is being made to understand the incidence, determinants, patterns and impacts of FRI across Canada and in other countries, much more needs to be done to move toward a safer societal approach to gun control, to address the underlying disparities and to effectively reduce the burden of FRI, especially among the overrepresented populations.

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Conflicts of interest

The authors declare that they have no competing interests.

Authors' contributions and statement

MK: conceptualization, methodology, data curation, formal analysis, writing—original draft, writing—review and editing.

FR: conceptualization, methodology, data curation, writing—review and editing.

AZ: methodology, data curation, formal analysis, writing—review and editing.

IP: conceptualization, supervision, writing—review and editing.

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References

1. Institute for Health Metrics and Evaluation (IHME). Global Burden of Disease Study 2019 Results [Internet]. Seattle (WA): IHME; 2020 [cited 2023 May 23]. Available from: https://vizhub.healthdata.org/gbd-results/

2. Institute for Health Metrics and Evaluation (IHME). On gun violence, the United States is an outlier. Seattle (WA): IMHE; 2021 [cited 2023 May 23]. https://www.healthdata.org/acting-data/gun-violence-united-states-outlier

3. Toigo S, Pollock NJ, Liu L, Contreras G, McFaull SR, Thompson W. Fatal and non-fatal firearm-related injuries in Canada, 2016–2020: a population-based study using three administrative databases. Inj Epidemiol. 2023; 10(1):10. https://doi.org/10.1186/s40621-023-00422-z

4. Statistics Canada. Homicide in Canada, 2017. [The Daily, 2018 Nov 21.] Ottawa (ON): Statistics Canada; 2018 [cited 2023 Oct 23]. Available from: https://www150.statcan.gc.ca/n1/en/daily-quotidien/181121/dq181121a-eng.pdf?st=BFEAJRkm

5. Statistics Canada. Dictionary, Census of Population, 2021: census metropolitan area (CMA) and census agglomeration (CA). Ottawa (ON): Statistics Canada; 2021 [cited 2024 Jul 24]. Available from: https://www12.statcan.gc.ca/census-recensement/2021/ref/dict/az/Definition-eng.cfm?ID=geo009

6. Allen M. Trends in firearm-related violent crime in Canada, 2009 to 2020. Juristat. 2022;27:1-51. https://www150.statcan.gc.ca/n1/en/pub/85-002-x/2022001/article/00009-eng.pdf?st=Dn3WewDj

7. Rajabali F, Turcotte K, Zheng A, et al. The cost of firearm violent crime in British Columbia, Canada. Front Public Health. 2022;10:938091. https://doi.org/10.3389/fpubh.2022.938091. Erratum in: Front Pub Health. 2023;10:938091. https://doi.org/10.3389/fpubh.2023.1180968

8. Dandurand Y. Firearms, accidental deaths, suicides and violent crime: an updated review of the literature with special reference to the Canadian situation [Internet]. Ottawa (ON): Department of Justice Canada; 1998 [cited 2024 Feb 7]. Available from: https://www.justice.gc.ca/eng/rp-pr/csj-sjc/jsp-sjp/wd98_4-dt98_4/p2.html#a22

9. Block R. Firearms in Canada and eight other western countries: selected findings of the 1996 international crime (victim) survey. [Report No.: WD1997-3e.] Ottawa (ON): Canadian Firearms Centre, Department of Justice Canada; 1998 [cited 2024 Feb 7]. 37 p. Available from: https://publications.gc.ca/collections/collection_2011/jus/J3-8-1997-3-eng.pdf

10. Pare P-P, Korosec L. Regional variations in self-protection in Canada. Violence Vict. 2014;29(5):828-42. https://doi.org/10.1891/0886-6708.vv-d-12-00110

11. Gomez D, Saunders N, Greene B, Santiago R, Ahmed N, Baxter NN. Firearm-related injuries and deaths in Ontario, Canada, 2002-2016: a population-based study. CMAJ. 2020; 192(42):E1253-E1263. https://doi.org/10.1503/cmaj.200722

12. Lawson F, Schuurman N, Amram O, Nathens AB. A geospatial analysis of the relationship between neighbourhood socioeconomic status and adult severe injury in Greater Vancouver. Inj Prev. 2015;21(4):260-5. https://doi.org/10.1136/injuryprev-2014-041437

13. Karkada M, Bennett N, Erdogan M, Kureshi N, Tansley G, Green RS. A population-based study on the epidemiology of firearm-related injury in Nova Scotia. Injury. 2022;53(11):3673-9. https://doi.org/10.1016/j.injury.2022.08.050

14. Bang F, McFaull S, Cheesman J, Do MT. The rural–urban gap: differences in injury characteristics. Health Promot Chronic Dis Prev Can. 2019;39(12):317-322. https://doi.org/10.24095/hpcdp.39.12.01

15. Statistics Canada. The Canadian Index of Multiple Deprivation [Internet]. Ottawa (ON): Statistics Canada [Catalogue No. 45-20-0001]; 2019 [modified 2024 Jan 5; cited 2025 Feb 12]. Available from: https://www150.statcan.gc.ca/n1/pub/45-20-0001/452000012019002-eng.htm

16. Newcombe RG. Confidence intervals for proportions and related measures of effect size. 1st ed. CRC Press; 2012. 468 p. https://doi.org/10.1201/b12670

17. BC Ministry of Health. B.C.'s health boundaries, Version 2018–B.C. geographies and CHSA urban-rural designations; 2019.

18. Langmann C. Suicide, firearms, and legislation: a review of the Canadian evidence. Prev Med. 2021;152 (Pt 1):106471. https://doi.org/10.1016/j.ypmed.2021.106471

19. Navaneelan T. Suicide rates: an overview. Ottawa (ON); Statistics Canada; 2012 [cited 2024 Feb 05]. [Catalogue No. 82–624-X.] 11 p. Available from: https://www.suicideinfo.ca/wp-content/uploads/2013/09/Suicide-Rates-An-Overview_oa.pdf

20. Channer NS, Biglieri S, Hartt M. Aging in rural Canada. In: Hartt M, Biglieri S, Rosenberg M, Nelson S, editors. Aging people, aging places: experiences, opportunities, and challenges of growing older in Canada. Bristol (UK): Bristol University Press; 2021:141-8. https://doi.org/10.56687/9781447352570-014

21. Moazzami B. Strengthening rural Canada: fewer & older: the population and demographic dilemma in rural British Columbia. An executive summary. Ottawa (ON): Government of Canada; 2015. 22 p. Available from https://www.strengtheningruralcanada.ca/file/Executive-Summary-Fewer-and-Older-The-Population-and-Demographic-Dilemma-in-Rural-BC.pdf

22. Burrows S, Auger N, Gamache P, Hamel D. Leading causes of unintentional injury and suicide mortality in Canadian adults across the urban-rural continuum. Public Health Rep. 2013;128(6):443-53. https://doi.org/10.1177/003335491312800604

23. Novilla-Surette EM, Shariff SZ, Le B, Booth RG. Trends and factors associated with suicide deaths in older adults in Ontario, Canada. Can Geriatr J. 2022;25(2):134-61. https://doi.org/10.5770/cgj.25.541

24. Casant J, Helbich M. Inequalities of suicide mortality across urban and rural areas: a literature review. Int J Environ Res Public Health. 2022;19(5):2669. https://doi.org/10.3390/ijerph19052669

25. Finley CJ, Hemenway D, Clifton J, Brown DR, Simons RK, Hameed SM. The demographics of significant firearm injury in Canadian trauma centres and the associated predictors of inhospital mortality. Can J Surg. 2008;51(3):197-203.

26. Saunders NR, Hepburn CM, Huang A, et al. Firearm injury epidemiology in children and youth in Ontario, Canada: a population-based study. BMJ Open. 2021;11(11):e053859. https://doi.org/10.1136/bmjopen-2021-053859

27. Saunders NR, Lee H, Macpherson A, Guan J, Guttmann A. Risk of firearm injuries among children and youth of immigrant families. CMAJ. 2017;189(12):E452-E458. https://doi.org/10.1503/cmaj.160850

28. Saunders NR, Guan J, Macpherson A, Lu H, Guttmann A. Association of immigrant and refugee status with risk factors for exposure to violent assault among youths and young adults in Canada. JAMA Netw Open. 2020;3(3):e200375. https://doi.org/10.1001/jamanetworkopen.2020.0375

29. Langmann C. Effect of firearms legislation on suicide and homicide in Canada from 1981 to 2016. PLoS One. 2020;15(6):e0234457. https://doi.org/10.1371/journal.pone.0234457

30. Magee LA. Community-level social processes and firearm shooting events: a multilevel analysis. J Urban Health. 2020;97(2):296-305. https://doi.org/10.1007/s11524-020-00424-y

31. Drake SA, Lemke MK, Yang Y. Exploring the complexity of firearm homicides in Harris County, Texas, from 2009 to 2021: implications for theory and prevention. Soc Sci Med. 2022;305:115048. https://doi.org/10.1016/j.socscimed.2022.115048

32. Czechowski K, Sylvestre J, Gogosis E, et al. Cycles of instability: proximal and distal influences on residential instability among people with histories of homelessness in three Canadian cities. J Community Psychol. 2022;50(8):3402-20. https://doi.org/10.1002/jcop.22843

33. McLellan H. Firearm availability and suicide in Canada: examining the effects of gun control, unemployment, divorce and sex on firearm suicides from 2009-2020 [dissertation]. St. John's (NL): Memorial University of Newfoundland; 2023. 125 p. Available from: http://research.library.mun.ca/id/eprint/15943

34. Yanchar NL, Beno S. Can we do better?: A Canadian perspective on firearm injury prevention. Ann Surg. 2018;267(6):1009-10. https://doi.org/10.1097/SLA.0000000000002688

35. Stamatel JP. Gun control. In: Stamatel JP, editor. Examining crime and justice around the world. Santa Barbara (CA): ABC-CLIO; 2021. p.269-300. https://doi.org/10.5040/9798400648779.ch-009

36. Lee J. A comparative analysis of gun policy in Canada and the United States [thesis]. Hartford (CT): Trinity College; 2021. 68 p. Available from: https://digitalrepository.trincoll.edu/theses/936

37. Heinmiller BT, Hennigar MA. Aiming to explain: theories of policy change and Canadian gun control. Toronto (ON): University of Toronto Press; 2022. 260 p.

38. Brown RB. The ghost of the long-gun registry: Prime Minister Justin Trudeau and gun control in Canada, 2015-2019. Can Stud. 2020;(89):125-49. https://doi.org/10.4000/eccs.4015

39. Bennett N, Karkada M, Erdogan M, Green RS. The effect of legislation on firearm-related deaths in Canada: a systematic review. CMAJ Open. 2022; 10(2):E500-E507. https://doi.org/10.9778/cmajo.20210192

40. Patel J, Leach-Kemon K, Curry G, Naghavi M, Sridhar D. Firearm injury—a preventable public health issue. Lancet Public Health. 2022;7(11): e976-e982. https://doi.org/10.1016/S2468-2667(22)00233-X

41. Santaella-Tenorio J, Cerdá M, Villaveces A, Galea S. What do we know about the association between firearm legislation and firearm-related injuries? Epidemiol Rev. 2016;38(1):140-57. https://doi.org/10.1093/epirev/mxv012

42. Lavoie M, Cardinal L, Chapdelaine A, St-Laurent D. The storage of household long guns: the situation in Quebec. Chronic Dis Can. 2001;22(1):24-9. Available from: https://epe.bac-lac.gc.ca/100/202/301/maladies_chroniques_canada/html/2008/v28n04/publicat/cdic-mcc/22-1/e_e.html

43. Anglemyer A, Horvath T, Rutherford G. The accessibility of firearms and risk for suicide and homicide victimization among household members: a systematic review and meta-analysis. Ann Intern Med. 2014;160(2):101-10. https://doi.org/10.7326/M13-1301

44. Dahlberg LL, Ikeda RM, Kresnow M-J. Guns in the home and risk of a violent death in the home: findings from a national study. Am J Epidemiol. 2004; 160(10):929-36. https://doi.org/10.1093/aje/kwh30

45. Alphonsus L, Filler R, Strauss R, De Silva T, Kobylianski J. Tackling the increasing public health impact of firearms: a call to action [position paper]. Toronto (ON): Ontario Medical Students Association; 2023. 10 p. https://omsa.ca/policy-position/tackling-the-increasing-public-health-impact-of-firearms-a-call-to-action/

46. BC Ministry of Health. National Ambulatory Care Reporting System. Vancouver (BC): Population data BC (PopData); 2024. Available from: https://www.popdata.bc.ca/sites/default/files/documents/data/Core%20and%20Non-Core/NACRS_All_Available_Variables_Jan_23_2024.pdf

47. Zeoli AM, Malinski R, Brenner H. The intersection of firearms and intimate partner homicide in 15 nations. Trauma Violence Abuse. 2020;21(1): 45-56. https://doi.org/10.1177/1524838017738725

48. Holliday CN, Kahn G, Thorpe RJ, Shah R, Hameeduddin Z, Decker MR. Racial/ethnic disparities in police reporting for partner violence in the National Crime Victimization Survey and survivor-led interpretation. J Racial Ethn Health Disparities. 2020;7:468-80. https://doi.org/10.1007/s40615-019-00675-9

49. Gezinski LB. "It's kind of hit and miss with them": a qualitative investigation of police response to intimate partner violence in a mandatory arrest state. J Fam Violence. 2022; 37(1):99-111. https://doi.org/10.1007/s10896-020-00227-4

50. Heymans MW, Twisk JW. Handling missing data in clinical research. J Clin Epidemiol. 2022;151:185-8. https://doi.org/10.1016/j.jclinepi.2022.08.016

https://doi.org/10.24095/hpcdp.45.6.04

Commentary

A call for increased measurement of eating disorders and disordered eating in federal surveillance in Canada

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This article has been peer reviewed.

Abstract

Eating disorders (EDs) and disordered eating present a significant health burden given their prevalence and associated health risks; however, there are notable gaps in population-level surveillance of EDs and disordered eating in Canada. These data gaps limit our understanding of the scope of the problem and present challenges to monitoring trends in EDs and disordered eating in response to changing health and policy contexts, such as the COVID-19 pandemic. We screened Canadian federal health surveillance surveys to identify measures of ED diagnosis, engagement in disordered eating behaviours (e.g. binge eating, self-induced vomiting) and related constructs (e.g. weight perception, body satisfaction). Among adults, there was a 10-year gap in ED measurement, and there has been no assessment of engagement in any type of disordered eating behaviours. Among children and adolescents, there have been recent improvements in the measurement of disordered eating behaviours, but there are no surveys that include measures of binge eating, the most common disordered eating behaviour. National surveillance data assessing EDs and disordered eating are necessary to quantify their burden, assess trends in relation to evolving health and policy contexts and identify individuals who face barriers to seeking treatment services. We conclude by providing recommendations for constructs that should be measured, as well as guidelines for measurement development in conjunction with community members and clinical and research experts.

Keywords: *feeding and eating disorders, body image, public health surveillance, health policy, nutrition policy*

Highlights

- Although the public health burden of eating disorders is significant, little is known of their prevalence in Canada.
- Canadian federal surveillance health surveys do not accurately assess eating disorders and disordered eating across age groups.
- The exclusion of eating disorders and disordered eating from federal health surveillance has important, negative consequences on Canadian public health and health policy, including the inability to track incidence in response to exacerbating events or to assess differences among groups that are often marginalized.
- Eating disorders must be adequately represented, monitored and tracked in Canadian federal surveillance using items that are informed by research, clinical and community partners.

Introduction

Eating disorders (EDs) are severe psychiatric illnesses that present an often neglected and growing public health burden.[1] EDs, including anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED), other specified feeding or eating disorder (OSFED) and avoidant/restrictive food intake disorder, carry an estimated international point prevalence between 2.2% and 4.6%.[2] Although the case mortality rate for AN is among the highest of any psychiatric illness, second only to that of opioid use,[3] it is important to note that all EDs present significant risks to the mental, physical and emotional well-being of those affected[4] as well as those caring for them.[5]

"Disordered eating" encompasses attitudes and behaviours that may not meet the diagnostic threshold for an ED but still present risks to population health, such as excessive exercise; extreme caloric restriction; self-induced vomiting; the misuse of diuretics, laxatives and muscle-building and weight-loss products; and binge eating. A key risk factor for the development of EDs, disordered eating is also associated with poor cardiometabolic outcomes and worsened mental health.[6,7]

Globally, there were an estimated 55.5 million cases of EDs in 2019, with BED

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and OSFED accounting for the most cases.[8] In Canada, the prevalence of EDs depends on the sample studied—one survey of 3043 adolescents found that 2.2% to 4.5% met diagnostic criteria for ED,[9] another study of a community-based sample found that 8% to 15% of participants aged 15 to 71 years reported clinically significant ED disturbances,[10] while data from the nationally representative 2002 Canadian Community Health Survey (CCHS) found that 0.47% of the population self-reported an ED diagnosis.[11] One meta-analysis of studies from 16 countries revealed that 22% of children and adolescents engage in disordered eating,[12] and survey studies of community-based (i.e. nonclinical) samples of children and adolescents in Canada have estimated similar prevalences.[10,13-15]

However, the prevalence of EDs and disordered eating in Canada are likely grossly underestimated for several reasons. First, there is a common misconception that EDs only affect a small minority of the population; however, a growing body of literature now highlights disparities in ED screening, identification and diagnosis by weight, gender, racialized identity, ethnicity and income.[16,17] Therefore, the use of clinical data sources or the reliance on self-reported diagnosis likely leads to underestimation of the actual prevalence of EDs, particularly among marginalized populations.[18] Further, in Canada, ED research is significantly underfunded relative to health care utilization costs and other mental health conditions,[19] limiting researchers' ability to conduct representative cross-sectional and cohort studies that can more accurately estimate prevalence, incidence and severity of behaviours.

Finally, EDs and disordered eating do not exist in a vacuum, but rather are heavily influenced by broader health and policy contexts, including changes to health care administration, evolving food environments and external stressors, such as the COVID-19 pandemic. In fact, the COVID-19 pandemic led to significant increases in emergency department visits and hospitalizations for Canadians across the lifespan that have not yet returned to prepandemic levels.[20] There are massive gaps in population-level surveillance of EDs and disordered eating, which limits our knowledge of the scope of the problem and precludes our ability to monitor trends over time, especially given shifts seen since the onset of the COVID-19 pandemic.[21] Despite these limitations, there have been some federal-level efforts to capture ED presentations and disordered eating symptoms.

Mapping the landscape of eating disorder surveillance in Canada

To assess the landscape of ED-related measures in Canadian federal surveillance, we screened health surveys conducted or supported by Statistics Canada and the Public Health Agency of Canada.[22] We aimed to identify measures of self-reported ED diagnosis; self-reported engagement in disordered eating, including binge eating, self-induced vomiting and the use of diet pills; weight or appearance modification efforts, such as attempts to lose, gain or maintain weight; and related constructs, including weight perception and body or weight satisfaction. Five surveys were identified through this process: the CCHS, the Canadian Health Measures Survey (CHMS), the Canadian Health Survey on Children and Youth (CHSCY), the Mental Health and Access to Care Survey (MHACS) and the Health Behaviour in School-aged Children (HBSC). A summary is presented in Table 1.

Among adults, self-reported ED diagnosis was measured in the 2012 CCHS – Mental Health component and the 2022 MHACS, leaving a 10-year gap in ED observations. Parent-reported eating disorder diagnosis and age of diagnosis were included in the 2016, 2019 and 2023 iterations of the CHSCY. The items used to assess self-reported ED diagnosis in these surveys all query whether the affected person has "an eating disorder such as anorexia or bulimia," despite BED and OSFED being the most common EDs.[8] This limits the construct validity of the question for the assessment of EDs more broadly and the ability of researchers to know the true prevalence of EDs in Canada. Instead of ED diagnosis, the 2002 CCHS Mental Health and Well-being survey used a 2-item screener to assess whether respondents should fill out the 26-item Eating Attitudes Test,[23] a comprehensive assessment of eating disturbances that has not been administered since.

Disordered eating is severely undermeasured, as there has been no federal surveillance of engagement in any type of disordered eating behaviours among Canadian adults. The development of the CHSCY, first piloted in 2016 and implemented in 2019 and 2023, is a positive advancement for tracking disordered eating among youth; however, even this survey only incorporates the assessment of one behaviour—self-induced vomiting—alongside an attitudinal measure of preoccupation with thinness. There are no surveys, either of children or adults, that include measures of binge eating, the most common disordered eating behaviour.[24] Further, there are no known measures of the misuse of dieting-related products, including laxatives and natural health products (NHPs) with claims related to weight-loss and muscle-building, which have been associated with an increased prospective risk of disordered eating and EDs among adolescents and young adults.[25,26]

Additional ED-related constructs, including weight perception, weight satisfaction and general weight modification efforts have been assessed through single-item measures in several surveys (Table 1). Notably, the items focus on weight satisfaction rather than satisfaction with overall appearance, body shape and muscularity, which may underestimate body dissatisfaction among boys and men,[27] or even the general population as appearance ideals shift over time.[28] Relatedly, the disparate measurement of constructs across surveys limits our ability to assess longitudinal trends in outcomes related to EDs and disordered eating. Although the HBSC, CCHS and CHSCY include recurring measures over at least two waves, no one survey alone provides a true picture of the population prevalence or incidence of EDs and disordered eating in Canada.

Public health and policy implications

The gaps in national surveillance of EDs and disordered eating result in several consequences. First, national data are needed to quantify and make visible the burden of EDs. As the common health policy truism states, "if something cannot be measured, it cannot be improved."[29] Accordingly, a better understanding of the prevalence of EDs is needed to dispel pervasive myths about their low prevalence and the affected populations,[30] to better estimate related costs[21] and to support clinical and research funding that matches the burden they represent.[20]

Relatedly, if EDs and disordered eating are not measured across representative national samples, then we will fail to assess trends

TABLE 1
Overview of measures assessing disordered eating, eating disorders and related constructs in federal surveillance

Construct	Year(s) – survey name[a]	Measure details (response options)
Self-reported eating disorder diagnosis	2012 – CCHS Mental Health 2022 – MHACS	"Do you have an eating disorder such as anorexia or bulimia?" (Y/N)
Parent-reported eating disorder diagnosis	2016 – CHSCY 2019 – CHSCY 2023 – CHSCY	"Does [your child] have an eating disorder such as anorexia nervosa or bulimia?" (Y/N) Age of diagnosis was also assessed
Eating disturbances	2002 – CCHS Mental Health and Well-being	Participants who answered "yes" to both questions were presented with the full Eating Attitudes Test (EAT-26)[23] (1) "Was there ever a time in your life when you had a strong fear or a great deal of concern about being too fat or overweight?" (Y/N) (2) "During the past 12 months, did you have a strong fear or a great deal of concern about being too fat or overweight?" (Y/N)
Weight perception	2012 – CCHS Mental Health 2010 and subsequent iterations – CCHS Annual Component 2016 – CHSCY (parent and child) 2007 and subsequent iterations – CHMS	"Do you consider yourself…?" (Overweight/Underweight/Just about right)
	2001/02 – HBSC 2009/10 – HBSC 2013/14 – HBSC 2017/18 – HBSC	"Do you think your body is…?" (Much too thin/A bit too thin/About right/A bit too fat/Much too fat)
Body/weight satisfaction	2010 and subsequent iterations – CCHS Annual Component	"How satisfied are you with the way your body looks?" (Very satisfied/Satisfied/Neither satisfied nor dissatisfied/Dissatisfied/Very dissatisfied)
	2016 – CHSCY	"How often are you satisfied with your weight?" (Never/Rarely/Sometimes/Often/Always)
General weight modification efforts	2016 – CHSCY 2019 – CHSCY 2023 – CHSCY	"In the past 12 months, how often have you … Changed your eating habits in order to manage your weight?" (Never/A few times/Monthly/Weekly/Daily)
	2001/02 – HBSC 2005/06 – HBSC 2009/10 – HBSC 2013/14 – HBSC	"At present are you on a diet or doing something else to lose weight?" (No, weight fine/No, need to lose/No, need to put on/Yes)
Preoccupation with thinness	2016 – CHSCY 2019 – CHSCY 2023 – CHSCY	"In the past 12 months, how often have you … Been preoccupied with a desire to be thinner?" (Never/A few times/Monthly/Weekly/Daily)
Self-induced vomiting	2016 – CHSCY 2019 – CHSCY 2023 – CHSCY	"In the past 12 months, how often have you … Vomited to lose weight?" (Never/A few times/Monthly/Weekly/Daily)

Abbreviations: CCHS, Canadian Community Health Survey; CHMS, Canadian Health Measures Survey; CHSCY, Canadian Health Survey on Children and Youth; HBSC, Health Behaviour in School-aged Children; MHACS, Mental Health and Access to Care Survey; Y/N, yes/no.

[a] The sample for CCHS consists of persons aged 18 years and older living in the 10 provinces and the three territories. The sample for MHACS consists of persons aged 15 years and older living in the 10 provinces. The sample for CHSCY consists of persons aged 1 to 22 years (and their guardians) living in the 10 provinces. The sample for CHMS consists of persons aged 1 to 79 years living in the 10 provinces. The HBSC study is a World Health Organization research study that focusses on the health and well-being of young people aged 11 to 15 years.

in relation to rapidly changing health and policy contexts. Changes to health care policy and administration may lead to changes in the incidence of EDs that cannot be assessed without adequate surveillance. For example, the introduction of Ontario's Eating Disorders quality standards[31] to guide services will require the ability to measure how their implementation may shift ED incidence in the province.

As well, external population-level stressors, such as the COVID-19 pandemic, may exacerbate the burden of EDs and disordered eating on health care systems and society more broadly. Indeed, a recent analysis of the impact of the pandemic on ED-related costs in Canada specifically highlighted that the lack of adequate surveillance data limited their analyses and makes any future attempts at costing studies futile until better measurement of prevalence is in place.[21]

Ongoing food policy changes, including Canada's Healthy Eating Strategy,[38] may have the potential to heighten or ameliorate disordered eating among populations. For example, concerns have been raised about the potential of mandatory calorie labelling on menus to worsen disordered eating pathology among vulnerable people,[32] but the impact of this policy on population-level disordered eating incidence over time is challenging to appraise. In light of newly introduced food environment legislation, it is necessary to assess the impacts of nutrition policy on disordered eating in the population.

Finally, improved federal surveillance of disordered eating and EDs is a matter of health equity. Relying on diagnosis alone through health administration databases (e.g. those of the Canadian Institute for Health Information, the Institute for Clinical Evaluative Sciences) limits our knowledge of who is affected because of known barriers to diagnosis and accessing treatment. It also does not take into account the estimated 76.8% of those with a diagnosable ED who never receive care.[33] Therefore, a dependence on clinical administrative data sources leads to the insufficient and inconsistent inclusion of those who are less likely to seek out and obtain care, including individuals with higher weights, boys and men, older adults and racialized people.[17,18]

Health equity is important to consider relative to disordered eating as well. Several disordered eating behaviours, including binge eating and the use of unprescribed weight-loss NHPs, are significantly more prevalent among populations who experience elevated discrimination.[34,35] The exclusion of binge eating from surveillance surveys is especially noteworthy, as it is more common among racialized populations and individuals with higher weights relative to their peers,[36,37] limiting our ability to assess inequities in disordered eating engagement.

Conclusions and recommendations

EDs and disordered eating are not adequately measured by Canadian federal surveillance, which presents significant implications for public health and policy evaluation in Canada. The lack of surveillance data also limits the research of population health scientists who are interested in these topics, which subsequently leads to less funding and a lower priority in Canada's health funding sphere. Comprehensive and representative assessments of EDs and disordered eating are aligned with Canada's current strategies to improve healthy eating and food environments,[38] as well as the recently announced CAD 500 million Youth Mental Health Fund.[39] EDs, which historically have been left out of federal mental health discourse, require adequate monitoring to ensure that this renewed commitment to youth mental health does not neglect their ongoing burden.

There are several different parameters relative to EDs and disordered eating that can be assessed. We recommend the inclusion of all of the following items on assessment instruments, where possible:

- **self-reported ED diagnosis**, as a single item but listing several diagnoses, including BED and OSFED, in addition to AN and BN;
- **binge eating**, which should always be included in the assessment of disordered eating behaviours, given its prevalence, high burden among diverse populations and associations with a range of physical and emotional well-being outcomes;
- **restrictive disordered eating behaviours**, including fasting or skipping meals, as well as engagement in diet programs that eliminate or restrict food groups (e.g. a no-carb diet);
- **compensatory disordered eating behaviours**, including weight-loss and muscle-building NHP use, laxative misuse and excessive exercise; and
- **psychological contributors to disordered eating**, including body dissatisfaction, weight-based bullying and preoccupation with body weight or shape.

The wording of measures, including their assessment of frequency (e.g. binge eating in the past 30 days vs. the past 3 months), should be decided and co-developed with community members, clinical experts and research experts depending on the survey. For example, the US-based Youth Risk Behavior Survey (YRBS) enquires about past–30 day engagement in disordered eating behaviours to align with survey measures for other health behaviours (e.g. smoking, vaping).[40]

We also recognize the challenges that decision makers encounter in developing federal surveillance surveys, including the costs associated with measurement development and testing, survey respondent burnout, and shifting governmental health priorities. The adequate measurement of EDs and disordered eating using brief or even single items is challenging but can be done through expert- and community-informed measure development, the latter of which can bolster survey response rates and increase the uptake of study results.[41]

For example, after the US Centers for Disease Control and Prevention removed disordered eating items from the nationally representative YRBS in 2015, a grassroots collective of ED experts launched a working group that generated evidence-based recommendations for the inclusion of brief disordered eating measures.[40] This list of measures is tailored to YRBS developers and includes specific recommendations for the inclusion of one to four questions, depending on availability. The group recommends the use of composite measures (e.g. combining multiple behaviours into a single item), which can be used to minimize survey length and participant burden. As a result of their efforts, the national 2024 YRBS now includes a single item assessing binge eating in its nationally representative survey.[40] State representatives can also choose to elect to

add one or more of the following: a composite measure of disordered eating behaviours (i.e. fasting or skipping meals, taking diet pills or supplements not prescribed by a doctor, or vomiting or taking laxatives); a measure assessing weight victimization; and/or a series of three independent questions enquiring about the frequency of disordered eating behaviours.

ED researchers and advocates in other countries, such as Australia,[30] have made similar calls to improve surveillance efforts. To allow for cross-country comparison, where possible, we encourage global collaboration in measure development and the creation of common minimum measures.

EDs and disordered eating present significant challenges to health care systems and population health in Canada. Adequate and evidence-informed monitoring of EDs and disordered eating are sorely lacking in federal health surveillance but are needed to address the urgent and growing burden of these conditions.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

Authors' contributions and statement

AR, MN: conceptualization.

AR, MN, CG: investigation, visualization.

AR: writing—original draft, supervision.

AR, MN, CG, NO: writing—review and editing.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References

1. Austin SB, Hutcheson R, Wickramatilake-Templeman S, Velasquez K. The second wave of public policy advocacy for eating disorders: charting the course to maximize population impact. Psychiatr Clin North Am. 2019;42(2):319-36. https://doi.org/10.1016/j.psc.2019.01.013

2. Galmiche M, Déchelotte P, Lambert G, Tavolacci MP. Prevalence of eating disorders over the 2000-2018 period: a systematic literature review. Am J Clin Nutr. 2019;109(5):1402-13. https://doi.org/10.1093/ajcn/nqy342

3. Chesney E, Goodwin GM, Fazel S. Risks of all-cause and suicide mortality in mental disorders: a meta-review. World Psychiatry. 2014;13(2):153-60. https://doi.org/10.1002/wps.20128

4. Ágh T, Kovács G, Supina D, et al. A systematic review of the health-related quality of life and economic burdens of anorexia nervosa, bulimia nervosa, and binge eating disorder. Eat Weight Disord. 2016;21(3):353-64. https://doi.org/10.1007/s40519-016-0264-x

5. Oketah NO, Hur JO, Talebloo J, Cheng CM, Nagata JM. Parents' perspectives of anorexia nervosa treatment in adolescents: a systematic review and metasynthesis of qualitative data. J Eat Disord. 2023;11:193. https://doi.org/10.1186/s40337-023-00910-z

6. Kärkkäinen U, Mustelin L, Raevuori A, Kaprio J, Keski-Rahkonen A. Do disordered eating behaviours have long-term health-related consequences? Eur Eat Disord Rev. 2018;26(1):22-8. https://doi.org/10.1002/erv.2568

7. Nagata JM, Garber AK, Tabler J, Murray SB, Vittinghoff E, Bibbins-Domingo K. Disordered eating behaviors and cardiometabolic risk among young adults with overweight or obesity. Int J Eat Disord. 2018;51(8):931-41. https://doi.org/10.1002/eat.22927

8. Santomauro DF, Melen S, Mitchison D, Vos T, Whiteford H, Ferrari AJ. The hidden burden of eating disorders: an extension of estimates from the Global Burden of Disease Study 2019. Lancet Psychiatry. 2021;8(4):320-8. https://doi.org/10.1016/S2215-0366(21)00040-7

9. Flament MF, Henderson K, Buchholz A, et al. Weight status and DSM-5 diagnoses of eating disorders in adolescents from the community. J Am Acad Child Adolesc Psychiatry. 2015;54(5):403-11. https://doi.org/10.1016/j.jaac.2015.01.020

10. Smith AJ, Farstad SM, von Ranson KM. Self-reported eating disorder psychopathology prevalence in community-based female and male Albertans: gender and age group comparisons. Int J Eat Disord. 2021;54(3):438-44. https://doi.org/10.1002/eat.23434

11. Pedram P, Patten SB, Bulloch AG, Williams JV, Dimitropoulos G. Self-reported lifetime history of eating disorders and mortality in the general population: a Canadian population survey with record linkage. Nutrients. 2021;13(10):3333. https://doi.org/10.3390/nu13103333

12. López-Gil JF, García-Hermoso A, Smith L, et al. Global proportion of disordered eating in children and adolescents: a systematic review and meta-analysis. JAMA Pediatr. 2023;177(4):363-72. https://doi.org/10.1001/jamapediatrics.2022.5848

13. Jones JM, Bennett S, Olmsted MP, Lawson ML, Rodin G. Disordered eating attitudes and behaviours in teenaged girls: a school-based study. CMAJ. 2001;165(5):547-52.

14. McVey G, Tweed S, Blackmore E. Dieting among preadolescent and young adolescent females. CMAJ. 2004;170(10):1559-61. https://doi.org/10.1503/cmaj.1031247

15. Fan J, Nagata JM, Cuccolo K, Ganson KT. Associations between dieting practices and eating disorder attitudes and behaviors: results from the Canadian Study of Adolescent Health Behaviors. Eat Behav. 2024;54:101886. https://doi.org/10.1016/j.eatbeh.2024.101886

16. Sonneville KR, Lipson SK. Disparities in eating disorder diagnosis and treatment according to weight status, race/ethnicity, socioeconomic background, and sex among college students. Int J Eat Disord. 2018;51(6):518-26. https://doi.org/10.1002/eat.22846

17. Burke NL, Schaefer LM, Hazzard VM, Rodgers RF. Where identities converge: the importance of intersectionality in eating disorders research. Int J Eat Disord. 2020;53(10):1605-09. https://doi.org/10.1002/eat.23371

18. Field AE, Ziobrowski HN, Eddy KT, Sonneville KR, Richmond TK. Who gets treated for an eating disorder? Implications for inference based on clinical populations. BMC Public Health. 2024;24(1):1758. https://doi.org/10.1186/s12889-024-19283-2

19. Stone KD, Dimitropoulos G, MacMaster FP. Food for thought: a dissonance between healthcare utilization costs and research funding for eating disorders in Canada. J Can Acad Child Adolesc Psychiatry. 2021;30(3):197-203. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC8315219/

20. Toulany A, Saunders NR, Kurdyak P, et al. Acute presentations of eating disorders among adolescents and adults before and during the COVID-19 pandemic in Ontario, Canada. CMAJ. 2023;195(38):E1291-E1299. https://doi.org/10.1503/cmaj.221318

21. Obeid N, Coelho JS, Booij L, et al. Estimating additional health and social costs in eating disorder care for young people during the COVID-19 pandemic: implications for surveillance and system transformation. J Eat Disord. 2024;12(1):52. https://doi.org/10.1186/s40337-024-01003-1

22. Statistics Canada. Health - Complete list of surveys and statistical programs [Internet]. Ottawa (ON): Statistics Canada; 2024 [cited 2024 Apr 17]. Available from: https://www23.statcan.gc.ca/imdb/pIX.pl?Function=getThemeSV&PItem_Id=97413&PCE_Id=412&PCE_Start=01010001&CItem_Id=97413&CCE_Id=412&CCE_Start=01010001&lang=en

23. Garner DM, Olmsted MP, Bohr Y, Garfinkel PE. The Eating Attitudes Test: psychometric features and clinical correlates. Psychol Med. 1982;12(4):871-8. https://doi.org/10.1017/s0033291700049163

24. Santana DD, Mitchison D, Mannan H, et al. Twenty-year associations between disordered eating behaviors and sociodemographic features in a multiple cross-sectional sample. Psychol Med. 2023;53(11):5012-21. https://doi.org/10.1017/S0033291722001994

25. Hazzard VM, Simone M, Austin SB, Larson N, Neumark-Sztainer D. Diet pill and laxative use for weight control predicts first-time receipt of an eating disorder diagnosis within the next 5 years among female adolescents and young adults. Int J Eat Disord. 2021;54(7):1289-94. https://doi.org/10.1002/eat.23531

26. Nagata JM, Hazzard VM, Ganson KT, Austin SB, Neumark-Sztainer D, Eisenberg ME. Muscle-building behaviors from adolescence to emerging adulthood: a prospective cohort study. Prev Med Rep. 2022;27:101778. https://doi.org/10.1016/j.pmedr.2022.101778

27. Lavender JM, Brown TA, Murray SB. Men, muscles, and eating disorders: an overview of traditional and muscularity-oriented disordered eating. Curr Psychiatry Rep. 2017;19(6):32. https://doi.org/10.1007/s11920-017-0787-5

28. Bozsik F, Whisenhunt BL, Hudson DL, Bennett B, Lundgren JD. Thin is in? Think again: the rising importance of muscularity in the thin ideal female body. Sex Roles. 2018;79(9-10):609-15. https://doi.org/10.1007/s11199-017-0886-0

29. Berenson RA. If you can't measure performance, can you improve it? JAMA. 2016;315(7):645-6. https://doi.org/10.1001/jama.2016.0767

30. Hart LM, Mitchison D, Hay PJ. The case for a national survey of eating disorders in Australia. J Eat Disord. 2018;6(1):30. https://doi.org/10.1186/s40337-018-0221-3

31. Health Quality Ontario. Evidence to improve care: eating disorders [Internet]. Toronto (ON): Health Quality Ontario; 2023 [cited 2024 Jul 30]. Available from: https://www.hqontario.ca/Evidence-to-Improve-Care/Quality-Standards/View-all-Quality-Standards/Eating-Disorders

32. Raffoul A, Gibbons B, Boluk K, Neiterman E, Hammond D, Kirkpatrick SI. "Maybe a little bit of guilt isn't so bad for the overall health of an individual": a mixed-methods exploration of young adults' experiences with calorie labelling. BMC Public Health. 2022;22:938. https://doi.org/10.1186/s12889-022-13364-w

33. Hart LM, Granillo MT, Jorm AF, Paxton SJ. Unmet need for treatment in the eating disorders: a systematic review of eating disorder specific treatment seeking among community cases. Clin Psychol Rev. 2011;31(5):727-35. https://doi.org/10.1016/j.cpr.2011.03.004

34. Raffoul A, Beccia AL, Jackson DA, et al. Associations between weight discrimination and the use of potentially harmful dietary supplements during the COVID-19 pandemic in the United States. Soc Sci Med. 2023;335:116232. https://doi.org/10.1016/j.socscimed.2023.116232

35. Mason TB, Mozdzierz P, Wang S, Smith KE. Discrimination and eating disorder psychopathology: a meta-analysis. Behav Ther. 2021;52(2):406-17. https://doi.org/10.1016/j.beth.2020.05.003

36. Simone M, Telke S, Anderson LM, Eisenberg M, Neumark-Sztainer D. Ethnic/racial and gender differences in disordered eating behavior prevalence trajectories among women and men from adolescence into adulthood. Soc Sci Med. 2022;294:114720. https://doi.org/10.1016/j.socscimed.2022.114720

37. Nightingale BA, Cassin SE. Disordered eating among individuals with excess weight: a review of recent research. Curr Obes Rep. 2019;8(2):112-27. https://doi.org/10.1007/s13679-019-00333-5

38. Health Canada. Healthy eating strategy. Ottawa (ON): Health Canada; 2016. Available from: https://publications.gc.ca/collections/collection_2016/sc-hc/H164-196-2016-eng.pdf

39. Government of Canada. Government announces new Youth Mental Health Fund [Internet]. Ottawa (ON): Government of Canada [2024 April 9; cited 2024 Jul 30]. Available from: https://www.canada.ca/en/department-finance/news/2024/04/government-announces-new-youth-mental-health-fund.html

40. Harvard TH Chan School of Public Health. Strategic Training Initiative for the Prevention of Eating Disorders (STRIPED) [Internet]. Boston (MA): Harvard TH Chan School of Public Health; date unknown [cited 2024 Jul 30]. Available from: https://hsph.harvard.edu/research/eating-disorders-striped/policy-translation/eating-disorders-public-health-surveillance

41. Santana MJ, Manalili K, Zelinsky S, et al. Improving the quality of person-centred healthcare from the patient perspective: development of person-centred quality indicators. BMJ Open. 2020;10(10):e037323. https://doi.org/10.1136/bmjopen-2020-037323

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Release notice

Congenital Anomalies in Canada Data Exploration Tool: latest update on prevalence estimates and temporal trends for congenital anomalies over 15 years (2008–2023)

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The Public Health Agency of Canada (PHAC) is pleased to announce the release of the latest Congenital Anomalies in Canada Data Exploration Tool. The interactive Data Exploration Tool, located on the Health Infobase website (https://health-infobase.canada.ca/congenital-anomalies/), has recent information on 38 congenital anomalies grouped into 12 categories based on the Canadian modification of the *International Classification of Diseases and Related Health Problems, Tenth Revision* (ICD-10-CA).

The data shown in the Data Exploration Tool were derived from the Canadian Institute for Health Information's Discharge Abstract Database, as well as the Maintenance et exploitation des données pour l'étude de la clientèle hospitalière (MED-ÉCHO) database. The Data Tool shows prevalence estimates and temporal trends of congenital anomalies at the national and jurisdictional level (excluding Alberta). The data include livebirth and stillbirth data from 2008 to 2023 using a follow-up period of up to 1 year after birth. Data from Quebec include livebirth data from 2008 to 2022.

This edition of the Congenital Anomalies Data Exploration Tool includes a new "Quick Facts" page, a new "Supplemental Congenital Anomalies Statistics" section, and a new "Additional Resources" tab.

Notable findings include:

- Temporal trends for most congenital anomaly categories remained stable at the national level over the years 2008 to 2023; however, there was an increasing trend for urinary tract defects and a decreasing trend for central nervous system defects.
- Case fatality rates were highest among infants with neural tube defects (24.1 per 100 livebirths), with the highest fatality rates among infants with anencephaly (86.0 per 100 livebirths).

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https://doi.org/10.24095/hpcdp.45.6.06

Corrigendum

Global prevalence of post-COVID-19 condition: a systematic review and meta-analysis of prospective evidence

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This corrigendum is being published to correct a number of errors and imprecisions, on pages 113, 120–125 and 138, of the following article:

Taher MK, Salzman T, Banal A, Morissette K, Domingo FR, Cheung AM, Cooper CL, Boland L, Zuckermann AM, Mullah MA, Laprise C, Colonna R, Hashi A, Rahman P, Collins E, Corrin T, Waddell LA, Pagaduan JE, Ahmad R, Jaramillo Garcia AP. Global prevalence of post-COVID-19 condition: a systematic review and meta-analysis of prospective evidence. Health Promot Chronic Dis Prev Can. 2025;45(3):112-38. https://doi.org/10.24095/hpcdp.45.3.02

The authors would like to clarify a few points specifically related to the referencing of results from the 2023 Canadian COVID-19 Antibody and Health Survey (CCAHS).[1] These clarifications reflect refinements in how the source data are interpreted and attributed, and do not affect the core findings or conclusions of the review. Bold has been used to identify the changes and updated text.

1. p. 113, middle column, paragraph 2:

Before correction

Results from recent population surveys conducted to assess the overall prevalence of PCC symptoms among adults vary from 14.3% in the USA[15] to 6.8% in Canada[16] and 4.7% in Australia.[17]

After correction

Results from recent population surveys conducted to assess the **prevalence** of PCC symptoms among adults vary from 14.3% in the USA[15] to **11.7%** in Canada[16] and 4.7% in Australia.[17]

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2. p. 120, last column, paragraph 3 and p. 125, first column, paragraph 1:

The changes made in the following paragraph include the addition of a new reference, numbered 257 for convenience. The statement regarding higher PCC prevalence among females, individuals hospitalized during acute infection and those with pre-existing chronic conditions was previously attributed only to a Statistics Canada table which did not include all of those breakdowns. The new reference (see item 3, below) contains the comprehensive data supporting this statement.

Before correction

Results of the 2023 Canadian COVID-19 Antibody and Health Survey (CCAHS) revealed that nearly 20% of COVID-19 survivors (6.8% of adults in Canada) experienced PCC symptoms.[16] Of this group, nearly 80% continued to experience these symptoms for 6 months or longer, and more than 40% for a year or longer.[16] Earlier results reported that prevalence was higher among females, those initially hospitalized for severe COVID-19 and individuals with preexisting chronic conditions.[18] Common symptoms reported from Cycle 1 of the survey included fatigue (72.1%), dyspnea (38.5%) and brain fog (32.9%).[231]

After correction

Results of the 2023 Canadian COVID-19 Antibody and Health Survey (CCAHS) revealed that nearly 20% of COVID-19 survivors experienced PCC symptoms.[16] **This corresponds to 11.7% of the total adult population, or approximately 3.5 million Canadians. Among those who experienced PCC symptoms during the time of the survey (6.8%),** nearly 80% continued to experience these symptoms for 6 months or longer, and more than 40% for a year or longer.[16] Earlier results reported that prevalence **of PCC among COVID-19 survivors** was higher among females, those initially hospitalized for severe COVID-19 and individuals with preexisting chronic conditions.[18,257] Common symptoms reported from **Cycle 2** of the survey included fatigue (72.1%), dyspnea (38.5%) and brain fog (32.9%).[231]

3. p. 138, new reference:

257. Government of Canada. COVID-19: Longer-term symptoms among Canadian adults – Second report [Internet]. Ottawa (ON): Health Infobase Canada; [updated 2024 Aug 21; cited 2025 May 13]. Available from: https://health-infobase.canada.ca/covid-19/post-covid-condition/spring-2023-report.html#a6

Reference

1. Kuang S, Earl S, Clarke J, Zakaria D, Demers A, Aziz S. Experiences of Canadians with longterm symptoms following COVID-19. Ottawa (ON): Statistics Canada; 2023. Available from: https://www150.statcan.gc.ca/n1/pub/75-006-x/2023001/article/00015-eng.htm

Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals and books. Look for the following articles published in 2025:

Alami A, **Dave S**, **Ebrahim M**, **Zareef I**, **Uhlik C**, **Laroche J**. Exploring parent-driven determinants of COVID-19 vaccination in Indigenous children: insights from a national survey. Vaccines (Basel). 2025;13(2):132. https://doi.org/10.3390/vaccines13020132

Hamm NC, **Bartholomew S**, Zhao Y, Peterson S, Al-Azazi S, McGrail K, et al. Minimum elements for reporting a multi-jurisdiction feasibility assessment of algorithms based on routinely collected health data: Health Data Research Network Canada recommendations. Int J Popul Data Sci. 2025;10(2):2466. https://doi.org/10.23889/ijpds.v10i2.2466

Ramage K, **Yee J**, **Srugo S**, Little J, **Liu S**. Prenatal opioid use disorder and the risk of congenital anomalies in offspring: a population-based study. Birth Defects Res. 2025;117(2):e2456. https://doi.org/10.1002/bdr2.2456

Reynolds DL, Daoust R, **Subnath M**, **Limburg H**. Preventing harms from first prescriptions of opioids. CMAJ. 2025;197(5):E133-4. https://doi.org/10.1503/cmaj.250094

Salman L, Gien LT, Vicus D, Shier M, Kupets R, **Gibbons S**, **Ashfaq S**, **Severini A**, et al. What are the current HPV types contributing to cervical high-grade squamous intraepithelial lesions, adenocarcinoma in situ, and early cervical cancer? J Obstet Gynaecol Can. 2025;47(3):102783. https://doi.org/10.1016/j.jogc.2025.102783

Shi Y, **Macrae K**, **de Groh M**, **Thompson W**, Stockwell T. Mortality and hospitalizations fully attributable to alcohol use before versus during the COVID-19 pandemic in Canada. CMAJ. 2025;197(4):E87-95. https://doi.org/10.1503/cmaj.241146

Shields M, **Tonmyr L**, **Pollock NJ**, Gonzalez A, **McKinnon B**, Joshi D, **Crompton L**, et al. Health status among women and men in Canada who reported experiences of non-physical intimate partner violence, Canada. Prev Med Rep. 2025;51:103011. https://doi.org/10.1016/j.pmedr.2025.103011

Vigod SN, Babujee A, Huang A, Fung K, **Vercammen K**, **Lye J**, **Dzakpasu S**, **Luo W**. Perinatal mental illness in Ontario (2007–2021): a population-based repeated cross-sectional surveillance study. Can J Public Health. Epub 2025 Feb 24. https://doi.org/10.17269/s41997-024-00987-2

Wang J, **Orpana H**, Carrington A, Kephart G, Vasiliadis H-M, Leikin B. Development and validation of prediction models for perceived and unmet mental health needs in the Canadian general population: model-based synthetic estimation study. JMIR Public Health Surveill. 2025;11:e66056. https://doi.org/10.2196/66056