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Original quantitative research

Pandemic-related impacts and suicidal ideation among adults in Canada: a population-based cross-sectional study

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Abstract

Introduction: Recent evidence has suggested that there has been an increase in suicidal ideation during the COVID-19 pandemic. Our objectives were to estimate the likelihood of suicidal ideation among adults in Canada who experienced pandemic-related impacts and to determine if this likelihood changed during the pandemic.

Methods: We analyzed pooled data for 18 936 adults 18 years or older from two cycles of the Survey on COVID-19 and Mental Health collected from 11 September to 4 December 2020 and from 1 February to 7 May 2021. We estimated the prevalence of suicidal ideation since the pandemic began and conducted logistic regression to evaluate the likelihood of suicidal ideation by adults who experienced pandemic-related impacts, and by factors related to social risk, mental health status, positive mental health indicators and coping strategies.

Results: Adults who had adverse pandemic-related experiences were significantly more likely to experience suicidal ideation; a dose–response relationship was evident. People who increased their alcohol or cannabis use, expressed concerns about violence in their home or who had moderate to severe symptoms of depression, anxiety or posttraumatic stress disorder also had significantly higher risk of suicidal ideation. The risk was significantly lower among people who reported high self-rated mental health, community belonging or life satisfaction, who exercised for their mental and/or physical health or who pursued hobbies.

Conclusion: The COVID-19 pandemic has influenced suicidal ideation in Canada. Our study provides evidence for targeted public health interventions related to suicide prevention.

Keywords: *suicidal ideation, surveillance, COVID-19 pandemic, coronavirus, substance use, violence, mental health, coping*

Highlights

- Adults in Canada who had adverse experiences related to the COVID-19 pandemic were significantly more likely to think about suicide.
- The higher the number of pandemic-related adverse experiences people had, the greater the odds that they thought about suicide (i.e. there was a dose–response relationship).
- Adults who increased their alcohol or cannabis use, who were concerned about violence in their home or who had moderate to severe symptoms of depression, anxiety or posttraumatic stress disorder (PTSD) also had significantly higher risk of suicidal ideation.
- The risk of suicidal ideation was significantly lower among people who self-rated their mental health, community belonging or life satisfaction as high, who exercised for their physical and/or mental health or who pursued hobbies.

Introduction

The COVID-19 pandemic led to widespread concerns about both individual and collective health. Together, concerns about infection and pandemic-related public health interventions appear to have had adverse consequences for population mental health[1-5] as a result of economic insecurity, quarantine and travel restrictions, social isolation, closure of educational institutions and workplaces, along with increased caregiving responsibilities, and grief and loss.

Early in the pandemic, community cohesion and a sense of mutual support may have contributed towards a "pulling together" effect[6] that mediated or delayed impacts on mental illness and suicidality.[7]

As the pandemic continued, negative effects on mental health emerged.[2,3] A systematic review of studies from the first year of the pandemic reported elevated rates of distress and symptoms of mental illness.[2] In Canada, job or income loss, death of a family member, friend or colleague, increased alcohol or cannabis use, concerns about violence in people's own homes, and social isolation impacts attributed to the COVID-19 pandemic were independent risk factors for symptoms of

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depression and had a dose–response relationship.[3] Similar effects have been reported for alcohol and substance use;[8-10] evidence on the prevalence of suicidal ideation has varied.[11-13]

The pre-pandemic 12-month prevalence of suicidal ideation was approximately 2.0% globally.[14] An international meta-analysis found that the pooled prevalence of suicidal ideation during the pandemic was 10.8%.[13] In Canada, the prevalence of suicidal ideation since the pandemic began was 2.4% in fall 2020,[11] but nearly doubled, to 4.2%, in spring 2021;[15] this was significantly higher than the prevalence of suicidal ideation in the past 12 months in 2019 of 2.7%.[15]

Pandemic-related stress appears to have disproportionately affected the mental health of young adults, racialized people and those with a mental illness.[8,11,16-20] Frontline and essential workers, including health professionals, also faced unique and increased risks as a result of occupational exposure to COVID-19 and its consequences, including increased exposure to end-of-life care, moral injury and increased risk of infection.[21] Survey data show that 8.4% of the public health workforce in the United States reported suicidal ideation in the prior 2 weeks and that more than 30% reported symptoms of depression, anxiety and posttraumatic stress disorder (PTSD) in 2021.[22]

The primary objective of our study was to estimate the likelihood of suicidal ideation since the start of the pandemic in relation to experiences of pandemic-related impacts, social risks, mental health and coping strategies. The secondary objective was to determine if the patterns of suicidal ideation in these subgroups changed between different periods of the pandemic.

This public health surveillance is necessary to track population-level health changes over time, identify subpopulation differences and assess relationships between suicidality, pandemic-specific experiences and other social and health-related factors.

Methods

This study is reported according to the STROBE guidelines for cross-sectional studies.[23]

Data sources

We analyzed cross-sectional data from the 2020 and 2021 cycles of the nationally representative, population-based Survey on COVID-19 and Mental Health (SCMH).[24,25] The first survey cycle was administered between 11 September and 4 December 2020; the second between 1 February and 7 May 2021. In partnership with the Public Health Agency of Canada (PHAC), Statistics Canada conducted the SCMH to gather data on mental health outcomes and risk and protective factors related to the pandemic. A data-sharing agreement between PHAC and Statistics Canada authorized data access. Respondents were asked for permission to share the information they provided with PHAC. This study is based on data from those shared files. Because this is secondary analysis, research ethics board review is not required.

People aged 18 years or older in the 10 provinces and the 3 territorial capitals (Whitehorse, Yellowknife and Iqaluit) made up the SCMH study population. The SCMH sampling frame was stratified by province, and a simple random sample of dwellings was selected within each province and territorial capital from the Dwelling Universe File; a resident within each selected dwelling was then sampled.

The sampling frame excluded people living in institutions, in collective, unmailable, inactive or vacant dwellings, in First Nations communities designated as federal reserves or in territorial communities outside of the capital cities; together, these groups represented less than 2% of the population of interest.

The SCMH is a voluntary survey completed through an electronic questionnaire or via a computer-assisted telephone interview. Respondents were first contacted via a letter mailed out to the sampled dwellings and given the opportunity to respond using the online questionnaire. Up to two letters were sent reminding residents to respond to the survey before interviewers began phoning to suggest that residents complete the questionnaire over the phone.

As part of the error detection/edit process, incoming data were verified to ensure that the data file contained only one questionnaire per dwelling.

The response rate was 53.3% (n = 14 689 respondents) for the 2020 cycle and 49.3% (n = 8032 respondents) for the 2021 cycle. We analyzed data for a total of 18 936 respondents who agreed to share their information with PHAC (n = 12 344 in 2020; n = 6592 in 2021).

Measures

The dependent variable was recent suicidal ideation. Survey respondents were asked: "Have you seriously contemplated suicide since the COVID-19 pandemic began?" We assessed the following potential correlates (as independent variables): COVID-19-related impacts; increased alcohol and cannabis consumption; concerns about violence in people's own homes; symptoms of mental illness; stressful/traumatic events; work status; positive mental health outcomes; and coping strategies. Details about these variables are provided in Table 1.

Analysis

We conducted the analyses using SAS Enterprise Guide version 7.1 (SAS Institute, Cary, NC, USA). To account for the complex survey design and to ensure that the results were population representative, all estimates were adjusted with sampling weights generated by Statistics Canada. The weighting procedures involved several steps to reduce bias,[24] and accounted for both non-responses and respondents who did not agree to share their responses with PHAC. We estimated 95% modified Clopper–Pearson confidence intervals (CI)[26] using the bootstrap technique.

The analysis for the primary objective, to estimate the likelihood of suicidal ideation since the start of the pandemic in relation to experiences of pandemic-related impacts, social risks, mental health and coping strategies, was based on pooled data from the 2020 and 2021 SCMH. Because the two SCMH cycles had nearly identical methodologies and independent samples and their respective collection periods were close in time, we combined the datasets for analysis based on the user guideline provided by Statistics Canada. We estimated the prevalence of recent suicidal ideation across COVID-19-related impacts and used both univariate and adjusted logistic regression models to determine the likelihood of suicidal ideation associated with COVID-19-related impacts within the general population. We included

Factor	Questions posed	Response options plus variable coding
COVID-19- related impact	Respondents were asked: "Have you experienced any of the following impacts due to the COVID-19 pandemic?" • Loss of job or income • Difficulty meeting financial obligations or essential needs • Death of a family member, friend or colleague • Feelings of loneliness or isolation • Emotional distress • Physical health problems • Challenges in personal relationships with members of your household We also investigated the cumulative exposure effect of these 7 impacts by summing the number of impacts that people reported experiencing.	"Yes" and "no."
Increased alcohol consumption	Respondents were asked: "On average, over the course of the COVID-19 pandemic, how has your alcohol consumption changed when comparing to before the pandemic?"	"Increased," "decreased" or "no change." We coded the variable as "Increased" vs. "decreased/no change."
Ever used cannabis	Respondents were asked: "In the past 30 days, how often did you use cannabis?"	"Never used cannabis," "used previously, but not in past 30 days," "1 day in past 30 days," "2 or 3 days in past 30 days," "1 or 2 days per week," "3 or 4 days per week," "5 or 6 days per week" or "daily." We coded "never used cannabis" as "no" and the remainder as "yes."
Increased cannabis use	Respondents who did not respond "never used cannabis" were asked: "On average, over the course of the COVID-19 pandemic, how has your use of cannabis changed when compared to before the pandemic?"	"Increased," "decreased" or "no change." We coded the variable as "increased" vs. "decreased/no change."
Concerns about violence in people's own homes	Respondents were asked: "How concerned are you about violence in your home?"	"Not at all," "somewhat" and "very/extremely." We coded "not at all" as "no," and "some-what" and "very/extremely" as "yes."
Moderate to severe symptoms of major depressive disorder	Respondents who scored ≥10 on the Patient Health Questionnaire (PHQ-9). The scale assessed symptoms over the past 2 weeks.	N/A
Moderate to severe symptoms of generalized anxiety disorder	Respondents who scored ≥10 on the Generalized Anxiety Disorder scale (GAD-7). The scale assessed symptoms over the past 2 weeks.	N/A
Moderate to severe symptoms of PTSD	Respondents who scored ≥33 on the PTSD Checklist for DSM-5 (PCL-5). The PTSD questions asked about the past month.	N/A
Experienced traumatic/ stressful event	Respondents were asked: "Have you ever experienced a highly stressful or traumatic event during your life?"	"Yes" and "no."
Work status: essential worker/frontline worker	Respondents were asked if during the past 7 days they were considered an "essential worker." This was defined as "an individual who works in a service, facility or in an activity that is necessary to preserve life, health, public safety and basic societal functions of Canadians, for example, by working in transportation (public transit, gas stations, etc.), financial institutions, health care or as first responders (police, firefighters, paramedics, etc.), pharmacies, childcare, food supply (grocery stores, truck drivers, etc.)." Respondents were also asked if during the past 7 days they were considered a "frontline worker." This was defined as "an individual who has the potential to come in direct contact with COVID-19 by assisting those who have been diagnosed with the virus, for example, police officers, firefighters, paramedics, nurses or doctors."	We coded respondents as frontline workers if they answered "yes." to being considered a frontline worker. We coded respondents as essential workers if they answered "yes" to being considered an essential worker and "no" to being considered a frontline worker. We coded the remaining respondents as having "other" worker status.
Self-rated mental health	Respondents were asked: "In general, how is your mental health?"	"Excellent," "very good," "good," "fair" and "poor." We coded "excellent" and "very good" as "high" and the rest as "low."
Life satisfaction	Respondents were asked: "Using a scale of 0 to 10, where 0 means 'very dissatisfied' and 10 means 'very satisfied,' how do you feel about your life as a whole right now?"	We coded scores of ≥8 as "high" and the rest as "low."

Factor	Questions posed	Response options plus variable coding
Community belonging	Respondents were asked: "How would you describe your sense of belong to your local community?"	"Very strong," "somewhat strong," "somewhat weak" and "very weak." We coded "very strong" and "somewhat strong" as "high" and the remaining two as "low."
Coping strategies	Respondents were asked: "Are you currently doing any of the following activities for your health?" • Communicating with friends and family • Meditating • Praying or seeking spiritual guidance • Exercising (outdoors and/or indoors) • Changing food choice • Pursuing hobbies • Changing sleep patterns	"Yes, for my mental health," "Yes, for my physical health," "Yes, for both my mental and physical health" and "No." We coded "yes" and "no" for the responses.

Abbreviations: N/A, not applicable; PTSD, posttraumatic stress disorder.

gender, age group and survey cycle in the adjusted models.

For the secondary objective, to determine if the patterns of suicidal ideation changed between different periods of the pandemic, we analyzed data from the 2020 and 2021 SCMH separately to evaluate changes in the likelihood of suicidal ideation across pandemic-related experiences, social risks, mental health and coping strategies during the pandemic. We used overlapping confidence intervals to determine statistically significant change in odds ratios in the 2020 and 2021 SCMH.

We also conducted gender-stratified analyses for males and females. We did not further analyze respondents who reported gender diversity because of the small number of self-reports (<1% of sample), but included gender-diverse respondents in the overall analyses.

We excluded missing data (maximum 4.5% for all the estimates) from the analysis. We used a p value of less than 0.05 to identify statistically significant results in all the analyses.

Results

Of the 18936 respondents in 2020 and 2021 SCMH combined data, 579 reported suicidal ideation since the pandemic began (78 respondents did not respond to the suicidal ideation question and were excluded from the analysis). In the 2020 SCMH, 2.4% (95% CI: 2.0–2.9) of adults (2.7%, 95% CI: 2.2–3.3 for females; 2.1%, 95% CI: 1.5–2.8 for males) reported suicidal ideation. In the 2021 SCMH, the overall prevalence was 4.2% (95% CI: 3.4–5.0), with 4.0% (95% CI: 3.0–5.2) for females and 4.1% (95% CI: 3.0–5.5) for males.

Table 2 shows that the sociodemographic characteristics for the 2020 and 2021 SCMH samples were similar, except for slightly fewer young adults (18–34 years) and more middle-aged adults (35–64 years) in the 2021 SCMH.

People who experienced any COVID-19-related impacts were significantly more likely to experience suicidal ideation than people who did not experience these impacts; this was evident across most factors for both males and females (see Table 3). Overall, 43.3% of adults in Canada reported feeling lonely or isolated during the pandemic. Feelings of loneliness or isolation had the largest impact on suicidal ideation (adjusted odds ratio [aOR] = 8.1; 95% CI: 5.8–11.2), followed by emotional distress (aOR = 6.8; 95% CI: 4.7–9.7) and physical health problems (aOR = 3.7; 95% CI: 2.7–5.1).

Nearly half of adults in Canada (48.8%) experienced two or more pandemic-related impacts; their odds of suicidal ideation were 8.7 times higher than the odds for those who experienced one or no impact, after adjusting for gender, age group and survey cycle.

A positive dose–response relationship between pandemic-related impacts and suicidal ideation was apparent. The odds of suicidal ideation among people who experienced six or more impacts were 25.4 times higher than the odds for those who experienced one or no impact in the adjusted model.

Adults in Canada who increased alcohol or cannabis consumption, who had ever used cannabis or who had concerns about violence in their own home were significantly more likely to experience suicidal ideation, with the odds ratios higher among males than among women (see Table 4). People who had moderate to severe symptoms of any mental illness during the pandemic had a significantly higher prevalence of suicidal ideation, with odds ratios of 7.6 (95% CI: 5.4–10.6) for anxiety, 13.7 (95% CI: 9.6–19.5) for depression and 10.2 (95% CI: 7.2–14.5) for PTSD.

In contrast, people with high self-rated mental health, a strong sense of community belonging or high life satisfaction or who exercised for their mental and/or physical health were significantly less likely to report recent suicidal ideation (see Table 5). People who pursued their hobbies were also significantly less likely to report recent suicidal ideation, but in gender-stratified analyses, this association was statistically significant in males only. Moreover, frontline workers and essential non-frontline workers were no more or less likely than others to consider suicide (see Table 4).

For the second objective of this study, when we analyzed the data from the 2020 and 2021 SCMH separately (results available on request from the authors), odds ratios were decreased for female frontline

TABLE 2
Sociodemographic characteristics of the 2020 and 2021 SCMH survey samples

Sociodemographic characteristics	n (%)[b]		
	2020 SCMH n = 12 344	2021 SCMH n = 6592	Total n = 18 936
Gender			
Female	7063 (50.7)	3755 (50.6)	10 818 (50.6)
Male	5255 (49.1)	2827 (49.2)	8082 (49.2)
Gender diverse	20 (0.2)	8 (0.2)	28 (0.2)
Age, years			
18–34	2104 (28.2)	1161 (24.8)	3265 (26.5)
35–64	6747 (49.6)	3592 (53.0)	10 339 (51.3)
65+	3493 (22.2)	1839 (22.2)	5332 (22.2)
Racialized group member[a]			
Yes	2119 (26.6)	1125 (25.8)	3244 (26.2)
No	10 104 (73.4)	5403 (74.2)	15 507 (73.8)
Immigrant status			
Yes	2173 (27.0)	1172 (27.6)	3345 (27.3)
No	10 117 (73.0)	5391 (72.4)	15 508 (72.7)
Place of residence			
Population centre	9249 (82.3)	4956 (82.1)	14 205 (82.2)
Rural area	2998 (17.7)	1578 (17.9)	4576 (17.8)
Educational attainment			
High school or lower	3641 (31.2)	1857 (29.3)	5498 (30.2)
Post-secondary	8678 (68.8)	4716 (70.7)	13 394 (69.8)
Median household income, thousand CAD (95% CI)	83.5 (80.5, 86.5)	83.6 (80.6, 86.6)	83.6 (79.5, 87.7)

Source: 2020 and 2021 cycles of the Survey on COVID-19 and Mental Health, Canada.

Abbreviations: CI, confidence interval; SCMH, Survey on COVID-19 and Mental Health.

[a] We coded individuals who were classified as visible minorities or Indigenous as racialized group members and those who identified only as White as non-racialized.

[b] Percentages were weighted to represent the population. Missing data were not included in the number of samples and percentage by each sociodemographic characteristics, but included in total numbers for the 2020 and 2021 SCMH and combined data.

workers versus other females in the 2021 SCMH (OR = 0.4, 95% CI: 0.1–1.0; aOR = 0.3, 95% CI: 0.1–0.8) compared to those in the 2020 SCMH (OR = 2.3, 95% CI: 1.2–4.4; aOR = 1.7, 95% CI: 0.9–3.3). We did not observe significant changes in odds ratios between the 2020 and 2021 SCMH for other variables.

Discussion

We used nationally representative, population-based survey data to examine suicidal ideation among adults who experienced pandemic-related impacts in Canada. Nearly half the population aged 18 years or older reported two or more such adverse impacts, and they were significantly more likely to report that they had seriously considered suicide. As with a 2021 study of depression in Canada,[3] a clear dose–response relationship was evident; the risk of suicidal ideation rose with the number of impacts experienced.

The risk of suicidal ideation was also significantly higher among people who reported increased alcohol or cannabis consumption, who expressed concerns about violence in their own home or who had moderate to severe symptoms of depression, anxiety or PTSD. Those who reported high self-rated mental health, community belonging and life satisfaction or who exercised for their mental and/or physical health had significantly lower risk.

The pandemic resulted in numerous interrelated stresses and magnified existing vulnerabilities. A US survey conducted in March and April 2020 found that suicidal ideation was associated with markers of economic insecurity (e.g. difficulty paying rent) and social isolation.[4] Canadian survey data from 2020 show that major sources of stress were fear of becoming ill or infecting a family member, financial concerns, social isolation and the potential for illness or death of a family member.[5] With successive waves of COVID-19, these concerns became realities for many. At a population level, the accumulation of negative experiences may have amplified risks for adverse mental health outcomes and contributed to the strong dose–response relationship observed with suicidal ideation.

Our results align with evidence that the prevalence of suicidal ideation increased in 2021 compared with 2019[11] in Canada and elsewhere.[13] This suggests that pandemic-related impacts may be directly associated with suicidal ideation, although the effects were not immediate and varied

TABLE 3
Suicidal ideation during the pandemic, by experiences of COVID-19-related impacts, ≥18 years, Canada

Count and prevalence of COVID-19-related impacts, n (%)	Prevalence and odds ratio of suicidal ideation								
	Overall (n = 18 936)			Female (n = 10 818)			Male (n = 8 082)		
	Prevalence, % (95% CI)	OR (95% CI)	aOR[a] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)
Loss of job/income									
No 14 930 (75.0)	2.5 (2.1, 3.0)	(Ref.)	(Ref.)	2.4 (1.9, 3.1)	(Ref.)	(Ref.)	2.4 (1.8, 3.1)	(Ref.)	(Ref.)
Yes 3808 (25.0)	5.7 (4.5, 7.1)	2.4 (1.8, 3.2)***	1.9 (1.4, 2.6)***	6.3 (4.8, 8.2)	2.7 (1.9, 4.0)***	2.0 (1.4, 3.0)***	5.2 (3.5, 7.3)	2.2 (1.4, 3.6)***	1.8 (1.1, 2.9)*
Difficulty meeting financial obligations/essential needs									
No 16 378 (84.4)	2.4 (2.0, 2.9)	(Ref.)	(Ref.)	2.6 (2.1, 3.3)	(Ref.)	(Ref.)	2.0 (1.5, 2.8)	(Ref.)	(Ref.)
Yes 2558 (15.6)	8.0 (6.4, 9.9)	3.5 (2.6, 4.7)***	2.9 (2.2, 4.0)***	7.4 (5.5, 9.8)	3.0 (2.0, 4.4)***	2.3 (1.5, 3.5)***	8.5 (6.1, 11.5)	4.5 (2.8, 7.1)***	3.8 (2.4, 6.1)***
Death of family/friend/colleague									
No 17 276 (91.3)	3.1 (2.7, 3.6)	(Ref.)	(Ref.)	3.0 (2.5, 3.7)	(Ref.)	(Ref.)	3.1 (2.4, 3.9)	(Ref.)	(Ref.)
Yes 1462 (8.7)	5.1 (3.5, 7.3)	1.7 (1.1, 2.5)*	1.5 (1.0, 2.3)	6.1 (3.7, 9.4)	2.1 (1.2, 3.6)**	2.0 (1.1, 3.4)*	3.7 (1.8, 6.5)	1.2 (0.6, 2.4)	1.0 (0.5, 2.1)
Loneliness/sense of isolation									
No 10 871 (56.7)	0.7 (0.5, 1.0)	(Ref.)	(Ref.)	0.7 (0.4, 1.0)	(Ref.)	(Ref.)	0.8 (0.5, 1.2)	(Ref.)	(Ref.)
Yes 7867 (43.3)	6.7 (5.8, 7.7)	9.7 (7.0, 13.5)***	8.1 (5.8, 11.2)***	6.2 (5.1, 7.4)	10.0 (6.2, 16.1)***	8.5 (5.3, 13.5)***	6.9 (5.4, 8.8)	9.3 (5.7, 15.3)***	7.7 (4.8, 12.5)***
Emotional distress									
No 11 460 (59.7)	0.9 (0.6, 1.2)	(Ref.)	(Ref.)	1.0 (0.6, 1.5)	(Ref.)	(Ref.)	0.8 (0.5, 1.2)	(Ref.)	(Ref.)
Yes 7278 (40.3)	6.9 (5.9, 8.0)	8.4 (5.9, 11.7)***	6.8 (4.7, 9.7)***	6.0 (4.9, 7.3)	6.4 (3.8, 10.8)***	5.0 (2.9, 8.6)***	7.6 (5.9, 9.7)	10.4 (6.5, 16.7)***	8.8 (5.5, 14.3)***
Physical health problem									
No 13 860 (72.2)	1.7 (1.4, 2.2)	(Ref.)	(Ref.)	1.8 (1.2, 2.5)	(Ref.)	(Ref.)	1.7 (1.2, 2.4)	(Ref.)	(Ref.)
Yes 4878 (27.8)	7.4 (6.2, 8.7)	4.5 (3.3, 6.1)***	3.7 (2.7, 5.1)***	6.6 (5.4, 8.1)	3.9 (2.6, 6.0)***	3.3 (2.1, 5.1)***	7.8 (5.8, 10.3)	5.0 (3.2, 7.9)***	4.2 (2.6, 6.6)***

TABLE 3 (continued)
Suicidal ideation during the pandemic, by experiences of COVID-19-related impacts, ≥18 years, Canada

Count and prevalence of COVID-19-related impacts, n (%)	Prevalence and odds ratio of suicidal ideation								
	Overall (n = 18 936)			Female (n = 10 818)			Male (n = 8 082)		
	Prevalence, % (95% CI)	OR (95% CI)	aOR[a] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)
Challenges in personal relationship									
No — 15 403 (79.4)	2.3 (1.9, 2.8)	(Ref.)	(Ref.)	2.3 (1.7, 2.9)	(Ref.)	(Ref.)	2.2 (1.5, 3.0)	(Ref.)	(Ref.)
Yes — 3335 (20.6)	7.2 (5.9, 8.7)	3.3 (2.5, 4.5)***	2.7 (2.0, 3.7)***	7.0 (5.4, 9.0)	3.3 (2.2, 4.8)***	2.5 (1.7, 3.9)***	7.1 (5.1, 9.7)	3.5 (2.2, 5.5)***	2.9 (1.8, 4.7)***
Number of COVID-19-related impacts experienced									
0 or 1 — 10 160 (51.2)	0.6 (0.4, 0.9)	(Ref.)	(Ref.)	0.7 (0.3, 1.3)	(Ref.)	(Ref.)	0.5 (0.3, 0.9)	(Ref.)	(Ref.)
2 — 3265 (17.3)	3.0 (2.0, 4.4)	5.3 (3.0, 9.5)***	4.7 (2.6, 8.4)***	2.9 (1.6, 4.8)	4.5 (1.8, 11.1)**	3.8 (1.5, 9.6)**	3.1 (1.7, 5.4)	6.2 (2.9, 13.6)***	5.5 (2.5, 11.9)***
3 — 2459 (13.3)	5.1 (3.5, 7.1)	9.1 (5.2, 16.1)***	7.1 (4.0, 12.9)***	3.9 (2.5, 5.8)	6.1 (2.7, 14.1)***	4.9 (2.1, 11.7)***	5.6 (2.9, 9.6)	11.5 (5.1, 25.9)***	10.0 (4.4, 22.4)***
4 — 1645 (9.9)	7.2 (5.4, 9.3)	13.2 (7.9, 22.0)***	10.1 (5.9, 17.5)***	7.8 (5.4, 11.0)	12.8 (5.6, 29.3)***	9.9 (4.2, 23.7)***	5.8 (3.4, 9.1)	11.9 (5.8, 24.3)***	9.3 (4.5, 19.3)***
5 — 765 (5.0)	11.1 (7.7, 15.3)	21.3 (12.2, 37.1)***	16.1 (9.0, 28.7)***	8.0 (4.9, 12.1)	13.1 (5.5, 31.0)***	9.1 (3.6, 23.0)***	15.1 (8.9, 23.4)	34.3 (16.1, 73.1)***	26.2 (12.5, 54.8)***
≥6 — 444 (3.3)	17.1 (12.2, 22.9)	35.2 (20.1, 61.6)***	25.4 (13.8, 47.0)***	15.9 (10.1, 23.5)	28.7 (12.3, 66.9)***	19.1 (7.4, 49.3)***	18.6 (10.7, 29.1)	44.1 (19.6, 99.2)***	33.6 (14.6, 77.2)***
≥2 — 8578 (48.8)	6.2 (5.3, 7.1)	11.3 (7.2, 17.7)***	8.7 (5.5, 14.0)***	5.7 (4.7, 6.8)	9.1 (4.3, 19.2)***	6.9 (3.2, 15.1)***	6.4 (5.0, 8.1)	13.2 (7.4, 23.6)***	10.7 (6.0, 19.1)***

Source: 2020 and 2021 Survey on COVID-19 and Mental Health, Canada, combined data.

Abbreviations: CI, Clopper–Pearson confidence interval; OR, crude odds ratio; aOR, adjusted odds ratio; Ref, reference group.

Note: For prevalence and odds ratio estimates, number of missing samples was 275 for gender combined, 141 for females and 34 for males. Missing samples for each estimate were less than 1.5%.

[a] Odds ratio adjusted by gender, age group and survey cycle.

[b] Odds ratio adjusted by age group and survey cycle.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Count and prevalence of social risks and mental illness, n (%)	Prevalence and odds ratio of suicidal ideation								
	Overall (n = 18 936)			Female (n = 10 818)			Male (n = 8082)		
	Prevalence, % (95% CI)	OR (95% CI)	aORa (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aORb (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aORb (95% CI)
Substance use									
Increased alcohol consumption									
No 15 920 (83.9)	2.9 (2.4, 3.4)	(Ref.)	(Ref.)	3.2 (2.6, 3.9)	(Ref.)	(Ref.)	2.4 (1.7, 3.2)	(Ref.)	(Ref.)
Yes 2961 (16.1)	5.7 (4.5, 7.1)	2.1 (1.5, 2.8)***	1.8 (1.4, 2.5)***	4.3 (3.1, 5.8)	1.4 (0.9, 2.0)	1.2 (0.8, 1.8)	6.8 (4.9, 9.2)	3.0 (1.9, 4.7)***	2.8 (1.8, 4.5)***
Used cannabis in past 30 days									
No 13 526 (72.1)	2.1 (1.7, 2.6)	(Ref.)	(Ref.)	2.3 (1.7, 3.1)	(Ref.)	(Ref.)	1.8 (1.2, 2.6)	(Ref.)	(Ref.)
Yes 5390 (27.9)	6.4 (5.3, 7.6)	3.1 (2.4, 4.2)***	2.4 (1.8, 3.3)***	6.4 (5.0, 7.9)	2.9 (2.0, 4.1)***	2.1 (1.4, 3.2)***	6.0 (4.5, 7.9)	3.5 (2.2, 5.5)***	2.8 (1.8, 4.5)***
Increased cannabis use									
No 4367 (78.3)	5.2 (4.1, 6.5)	(Ref.)	(Ref.)	5.8 (4.3, 7.5)	(Ref.)	(Ref.)	4.7 (3.1, 6.7)	(Ref.)	(Ref.)
Yes 1033 (21.7)	10.7 (8.0, 13.9)	2.2 (1.5, 3.2)***	1.8 (1.2, 2.7)**	8.5 (5.6, 12.2)	1.5 (0.9, 2.5)	1.4 (0.8, 2.4)	11.0 (6.8, 16.7)	2.5 (1.4, 4.7)**	2.3 (1.2, 4.3)*
Concerns about violence in people's own homes									
No 18 237 (95.4)	3.2 (2.7, 3.7)	(Ref.)	(Ref.)	3.3 (2.7, 4.0)	(Ref.)	(Ref.)	2.9 (2.2, 3.6)	(Ref.)	(Ref.)
Yes 657 (4.6)	6.0 (3.3, 9.9)	1.9 (1.1, 3.5)*	1.8 (1.0, 3.3)	4.4 (2.5, 7.0)	1.3 (0.8, 2.3)	1.2 (0.7, 2.1)	7.4 (2.8, 15.3)	2.7 (1.0, 7.2)*	2.6 (1.0, 6.7)
Mental illness									
Moderate to severe symptoms of generalized anxiety disorder									
No 16 141 (85.8)	1.7 (1.3, 2.1)	(Ref.)	(Ref.)	1.4 (1.0, 1.9)	(Ref.)	(Ref.)	1.9 (1.3, 2.5)	(Ref.)	(Ref.)
Yes 2454 (14.2)	13.4 (11.3, 15.8)	9.2 (6.8, 12.5)***	7.6 (5.4, 10.6)***	12.7 (10.2, 15.5)	10.1 (6.8, 15.0)***	8.3 (5.4, 12.8)***	13.4 (9.4, 18.1)	8.2 (5.0, 13.4)***	6.8 (4.1, 11.6)***
Moderate to severe symptoms of depressive disorder									
No 15 580 (83.0)	1.1 (0.8, 1.4)	(Ref.)	(Ref.)	1.0 (0.7, 1.5)	(Ref.)	(Ref.)	1.0 (0.6, 1.5)	(Ref.)	(Ref.)
Yes 2876 (17.0)	14.4 (12.2, 16.8)	15.8 (11.4, 21.9)***	13.7 (9.6, 19.5)***	12.4 (10.0, 15.2)	13.5 (8.7, 20.8)***	10.9 (6.8, 17.3)***	16.6 (12.8, 21.1)	20.2 (12.0, 34.2)***	17.2 (10.0, 29.8)***

Count and prevalence of social risks and mental illness, n (%)	Prevalence and odds ratio of suicidal ideation								
	Overall (n = 18 936)			Female (n = 10 818)			Male (n = 8082)		
	Prevalence, % (95% CI)	OR (95% CI)	aOR[a] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)
Moderate to severe symptoms of PTSD									
No	16 909 (93.1)	2.0 (1.6, 2.5)	(Ref.)	(Ref.)	1.9 (1.4, 2.5)	(Ref.)	(Ref.)	2.1 (1.5, 2.8)	(Ref.)	(Ref.)
Yes	1220 (6.9)	20.2 (16.8, 24.0)	12.2 (8.9, 16.7)***	10.2 (7.2, 14.5)***	18.1 (14.1, 22.6)	11.2 (7.5, 16.7)***	9.0 (5.8, 14.0)***	21.9 (15.2, 30.0)	13.3 (7.9, 22.4)***	12.1 (7.0, 20.8)***
Experienced stressful/traumatic event									
No	6132 (37.2)	1.6 (1.1, 2.3)	(Ref.)	(Ref.)	1.7 (0.9, 2.9)	(Ref.)	(Ref.)	1.6 (0.9, 2.5)	(Ref.)	(Ref.)
Yes	12 763 (62.8)	4.3 (3.7, 5.0)	2.7 (1.8, 4.1)***	3.0 (2.0, 4.5)***	4.2 (3.5, 5.0)	2.6 (1.4, 4.9)**	3.0 (1.6, 5.5)***	4.1 (3.2, 5.3)	2.7 (1.6, 4.7)***	3.1 (1.8, 5.3)***
Work status									
Frontline worker	1381 (6.2)	3.5 (2.3, 5.1)	1.1 (0.7, 1.6)	0.8 (0.5, 1.2)	3.6 (2.1, 5.6)	1.1 (0.6, 1.8)	0.8 (0.5, 1.4)	3.0 (1.3, 5.9)	0.9 (0.4, 2.2)	0.8 (0.3, 1.8)
Essential non-front-line worker	3844 (22.9)	3.1 (2.2, 4.1)	0.9 (0.6, 1.3)	0.7 (0.5, 1.0)*	3.3 (2.0, 5.1)	1.0 (0.6, 1.7)	0.8 (0.4, 1.3)	2.6 (1.7, 4.0)	0.8 (0.5, 1.3)	0.6 (0.4, 1.0)
Others	13 670 (70.9)	3.4 (2.8, 3.9)	(Ref.)	(Ref.)	3.3 (2.7, 4.1)	(Ref.)	(Ref.)	3.2 (2.4, 4.2)	(Ref.)	(Ref.)

Source: 2020 and 2021 Survey on COVID-19 and Mental Health, Canada, combined data.

Abbreviations: CI, Clopper–Pearson confidence interval; OR, odds ratio; aOR, adjusted odds ratio; PTSD, posttraumatic stress disorder; Ref, reference group.

Note: For prevalence and odds ratio estimates, number of missing samples was 26–877 for gender combined, 65–512 for females and 42–365 for males. Estimates for moderate to severe symptoms of PTSD, moderate to severe symptoms of depressive disorder and moderate to severe symptoms of anxiety disorder had the highest number of missing samples, at 847, 547 and 416 for gender combined, respectively. Missing samples for each estimate were less than 4.5%.

[a] Odds ratio adjusted by gender, age group and survey cycle.

[b] Odds ratio adjusted by age group and survey cycle.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Count and prevalence of positive mental health and coping, n (%)	Prevalence and odds ratio of suicidal ideation								
	Overall (n = 18 936)			Female (n = 10 818)			Male (n = 8082)		
	Prevalence, % (95% CI)	OR (95% CI)	aOR[a] (95% CI)	Prevalence,% (95% CI)	OR (95% CI)	aOR[b] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)
Positive mental health indicators									
Self-rated mental health									
High 10 768 (55.7)	0.5 (0.3, 0.9)	0.07 (0.04, 0.13)***	0.09 (0.05, 0.16)***	0.6 (0.3, 1.2)	0.09 (0.04, 0.20)***	0.11 (0.05, 0.24)***	0.4 (0.1, 1.0)	0.05 (0.02, 0.16)***	0.06 (0.02, 0.29)***
Low 8157 (44.3)	6.8 (5.9, 7.8)	(Ref.)	(Ref.)	6.4 (5.3, 7.6)	(Ref.)	(Ref.)	7.0 (5.5, 8.7)	(Ref.)	(Ref.)
Community belonging									
High 12 454 (60.5)	1.4 (1.1, 1.8)	0.22 (0.16, 0.31)***	0.28 (0.20, 0.38)***	1.6 (1.1, 2.2)	0.25 (0.16, 0.39)***	0.31 (0.20, 0.48)***	1.2 (0.8, 1.8)	0.20 (0.12, 0.33)***	0.24 (0.15, 0.40)***
Low 6427 (39.5)	6.1 (5.2, 7.2)	(Ref.)	(Ref.)	6.0 (4.7, 7.4)	(Ref.)	(Ref.)	5.9 (4.5, 7.7)	(Ref.)	(Ref.)
Life satisfaction									
High 9705 (47.6)	0.5 (0.3, 0.9)	0.09 (0.05, 0.15)***	0.10 (0.06, 0.17)***	0.6 (0.3, 1.1)	0.10 (0.05, 0.20)***	0.12 (0.06, 0.26)***	0.4 (0.2, 0.8)	0.07 (0.03, 0.16)***	0.08 (0.03, 0.19)***
Low 9201 (52.4)	5.8 (5.1, 6.7)	(Ref.)	(Ref.)	5.7 (4.7, 6.8)	(Ref.)	(Ref.)	5.7 (4.5, 7.2)	(Ref.)	(Ref.)
Coping strategies									
Communication with friends and family									
No 2223 (12.8)	3.9 (2.8, 5.3)	(Ref.)	(Ref.)	4.8 (2.8, 7.7)	(Ref.)	(Ref.)	3.4 (2.2, 5.1)	(Ref.)	(Ref.)
Yes 16 578 (87.2)	3.2 (2.8, 3.8)	0.8 (0.6, 1.2)	0.7 (0.5, 1.0)	3.2 (2.6, 3.9)	0.7 (0.4, 1.1)	0.6 (0.3, 1.0)	3.0 (2.3, 3.9)	0.9 (0.5, 1.5)	0.8 (0.5, 1.4)
Meditating									
No 14 633 (77.5)	3.1 (2.7, 3.7)	(Ref.)	(Ref.)	3.5 (2.8, 4.3)	(Ref.)	(Ref.)	2.7 (2.1, 3.4)	(Ref.)	(Ref.)
Yes 3995 (22.5)	4.1 (3.1, 5.3)	1.3 (1.0, 1.8)	1.2 (0.8, 1.7)	3.1 (2.2, 4.2)	0.9 (0.6, 1.3)	0.8 (0.5, 1.2)	5.0 (3.0, 7.8)	1.9 (1.1, 3.3)*	1.8 (1.0, 3.1)*
Praying or seeking spiritual guidance									
No 12 776 (68.5)	3.3 (2.8, 3.9)	(Ref.)	(Ref.)	3.5 (2.8, 4.4)	(Ref.)	(Ref.)	3.0 (2.3, 3.8)	(Ref.)	(Ref.)
Yes 5877 (31.5)	3.4 (2.6, 4.4)	1.0 (0.7, 1.4)	1.1 (0.8, 1.6)	3.2 (2.3, 4.3)	0.9 (0.6, 1.3)	1.1 (0.7, 1.6)	3.5 (2.1, 5.4)	1.2 (0.7, 2.0)	1.2 (0.7, 2.1)

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Count and prevalence of positive mental health and coping, n (%)		Prevalence and odds ratio of suicidal ideation								
		Overall (n = 18 936)			Female (n = 10 818)			Male (n = 8082)		
		Prevalence, % (95% CI)	OR (95% CI)	aOR[a] (95% CI)	Prevalence,% (95% CI)	OR (95% CI)	aOR[b] (95% CI)	Prevalence, % (95% CI)	OR (95% CI)	aOR[b] (95% CI)
Exercising for their mental and/or physical health										
No	3591 (18.8)	5.0 (3.7, 6.6)	(Ref.)	(Ref.)	4.8 (3.2, 7.0)	(Ref.)	(Ref.)	5.2 (3.3, 7.7)	(Ref.)	(Ref.)
Yes	15 253 (81.2)	2.9 (2.5, 3.4)	0.6 (0.4, 0.8)**	0.5 (0.4, 0.8)***	3.0 (2.5, 3.7)	0.6 (0.4, 1.0)*	0.6 (0.4, 1.0)*	2.6 (2.0, 3.4)	0.5 (0.3, 0.8)**	0.5 (0.3, 0.8)**
Changing food choices										
No	7047 (39.2)	2.9 (2.3, 3.5)	(Ref.)	(Ref.)	2.9 (2.1, 3.8)	(Ref.)	(Ref.)	2.7 (2.0, 3.6)	(Ref.)	(Ref.)
Yes	11 638 (60.8)	4.0 (3.3, 4.9)	1.4 (1.1, 1.9)*	1.2 (0.9, 1.7)	4.1 (3.3, 5.1)	1.5 (1.0, 2.1)*	1.2 (0.8, 1.8)	3.8 (2.6, 5.4)	1.4 (0.9, 2.3)	1.2 (0.7, 2.0)
Pursuing hobbies										
No	7134 (40.6)	3.8 (3.0, 4.7)	(Ref.)	(Ref.)	3.8 (2.8, 4.9)	(Ref.)	(Ref.)	3.9 (2.7, 5.4)	(Ref.)	(Ref.)
Yes	11 630 (59.4)	3.0 (2.4, 3.6)	0.8 (0.6, 1.0)	0.7 (0.5, 1.0)*	3.1 (2.4, 4.0)	0.8 (0.6, 1.2)	0.9 (0.6, 1.3)	2.4 (1.7, 3.3)	0.6 (0.4, 1.0)	0.6 (0.4, 1.0)*
Changing sleep patterns										
No	3515 (20.4)	2.9 (2.4, 3.4)	(Ref.)	(Ref.)	2.9 (2.3, 3.6)	(Ref.)	(Ref.)	2.7 (2.0, 3.5)	(Ref.)	(Ref.)
Yes	15 167 (79.6)	5.3 (4.1, 6.7)	1.9 (1.4, 2.6)***	1.5 (1.1, 2.1)**	5.3 (3.7, 7.2)	1.9 (1.2, 2.8)**	1.5 (1.0, 2.3)	4.9 (3.2, 7.1)	1.8 (1.1, 3.0)*	1.6 (1.0, 2.6)

Source: 2020 and 2021 Survey on COVID-19 and Mental Health, Canada, combined data.

Abbreviations: CI, Clopper–Pearson confidence interval; OR, odds ratio; aOR, adjusted odds ratio; Ref., reference group.

Note: For prevalence and odds ratio estimates, number of missing samples was 89–382 for gender combined, 52–200 for females and 37–160 for males. Missing samples for each estimate were no more than 2.0%.

[a] Odds ratio adjusted by gender, age group and survey cycle for overall.

[b] Odds ratio adjusted by age group and survey cycle for females and males.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

across populations. As in previous cross-sectional studies,[5,8] we found that people with a mental illness had a significantly higher prevalence of suicidal ideation during the pandemic than those who did not have a mental illness. The consistency of these results across studies underscores the need to overcome existing and new barriers to accessing mental health care and support timely deployment of evidence-based treatments.

Our analysis also shows higher odds of suicidal ideation with increased alcohol and cannabis use and concerns about violence in their home. These factors may serve as indirect pathways through which the pandemic has influenced suicidality. For example, pandemic-related stresses may have increased risks for family violence, particularly in periods of lockdown.[27,28] While rates of child maltreatment and intimate partner violence have varied during the pandemic,[29-31] they are both forms of violence that often occur at home and are strongly associated with suicidal ideation and attempts.[32,33] To the extent that "concerns" might be a proxy for actual experiences of violence, interventions that reduce risks by providing social support, improving clinical follow-up care and supporting victims of violence to attain financial security[28] may have the secondary benefit of reducing ideating suicide.

Frontline and essential workers faced occupational stresses during the pandemic that may have affected mental health and suicidal behaviors.[21,34-36] Our analyses of the data from the 2020 SCMH show that female frontline workers were significantly more likely to report suicidal ideation than other females, but the opposite was the case for the 2021 SCMH, when female frontline workers were significantly less likely to report suicidal ideation. A possible explanation is that those who experienced the worst outcomes in the early stages of the pandemic were on stress leave and may not have worked during the second survey period. Overall, data on the mental health of health care workers are lacking,[34] and further studies are needed to understand experiences of moral injury, burnout and pandemic stress on suicidality in these groups. The negative associations between suicidal ideation, indicators of positive mental health and exercise that we observed align with other evidence.[3,37-39]

Strengths and limitations

Our study was based on two iterations of a nationally representative, population-based survey, and examined suicidal ideation across a broad range of factors related to COVID-19 and health and social risks with standardized measures. These strengths align with those reported in previous studies using the SCMH.[3,11] Nonetheless, several limitations should be considered when interpreting our results.

Prevalence and odds ratio estimates were based on combined data from two survey cycles, so they do not reflect a single time point during the pandemic. Another limitation is that the recall periods for suicidal ideation were not the same for the two cycles.

Further, the effects of the modest response rate and of respondents who did not agree to share their data with PHAC on suicidal ideation were not clear, though Statistics Canada adjusted the sample weights through a comprehensive weight redistribution process that controlled demographic factors and other survey variables and used a quality control step to reduce bias. Moreover, this is a cross-sectional study where it is difficult to determine the temporal relationship between suicidal ideation and experiences of pandemic-related impacts with other independent factors. Suicidal ideation and mental illness were self-reported or based on screening questions, not clinical diagnostic assessments, and coping strategies were not measured through specific validated tools; as a result, report biases might exist.

Lastly, the outcome variable suicidal ideation and several other variables included in this study (e.g. concerns about violence in people's own homes) had relatively low prevalence. To account for this and attain maximum statistical power, we used a lenient alpha level of 0.05 to determine statistical significance. This approach may result in false positives because of the numerous comparisons made in this work.

Conclusion

The COVID-19 pandemic was strongly associated with suicidal ideation among adults in Canada. Our study has contributed, in a timely manner, to understanding the influence of the pandemic on population mental health, and the results can help inform interventions that address factors related to suicidality. This work can also inform future public health programs and policies that target specific population groups with elevated risks for suicidal ideation, such as people with mental illness as well as those who experienced multiple pandemic impacts and recently increased their alcohol and drug consumption.

The results are generalizable to the adult population in Canada, but some subpopulations with an elevated pre-pandemic prevalence of suicidal ideation were not part of the sample frame of the SCMH (e.g. youth) or were not identifiable in the data (e.g. LGTBQ2+). Future studies should investigate suicidal ideation in these subpopulations.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

All authors advised on the conception and design of the analysis.

LL conducted the statistical analysis.

All authors interpreted the results.

NJP and LL drafted and revised the manuscript.

All authors critically reviewed every draft of the article and approved the final submission.

The content and conclusions in this article are those of the authors and do not necessarily reflect the official position of the Government of Canada.

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Original quantitative research

Shifts in medical cannabis use in Canada during the COVID-19 pandemic

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Abstract

Introduction: The COVID-19 pandemic has had widespread secondary negative health impacts including loss of material security and exacerbation of mental illness in at-risk populations. While increases in the nonmedical use of certain substances, including cannabis, have been observed in samples of the Canadian population, no research has documented COVID-concurrent shifts in medical cannabis use in Canada.

Methods: Data were derived from the 2021 Canadian Cannabis Patient Survey, an online survey administered in May 2021 to people authorized to use medical cannabis recruited from one of two Canadian licensed medical cannabis producers. McNemar tests assessed for changes in past 3-month medical cannabis frequency from before to during the pandemic. We explored correlates of increasing frequency of cannabis use since before the pandemic in bivariable and multivariable logistic models.

Results: In total, 2697 respondents (49.1% women) completed the survey. Daily medical cannabis use increased slightly but significantly from before the pandemic (83.2%) to during the pandemic (90.3% at time of survey; $p < 0.001$). Factors significantly associated with increasing frequency of medical cannabis use included female gender, younger age, pandemic-related job loss, primary cannabis use to manage mental health, prescription drug use and nonmedical cannabis use ($p < 0.05$).

Conclusion: There were slight shifts towards higher frequency of medical cannabis use after the onset of the COVID-19 pandemic. While short- and long-term impacts of cannabis use on pandemic-related mental distress are unknown, clinicians working with patients who use medical cannabis should be aware of possible changes in use patterns during the pandemic.

Keywords: *COVID-19, cannabis, medical cannabis, Canada, survey*

Highlights

- We conducted a survey of Canadians authorized to use medical cannabis to learn whether and how their use changed during the COVID-19 pandemic.
- Daily medical cannabis use increased slightly and significantly after the onset of the pandemic.
- Increases in medical cannabis use were more common among women, younger people, people who lost their job during the pandemic and people who used cannabis to manage their mental health.

The disruption to everyday life, coupled with fears about contracting or transmitting SARS-CoV-2, became the source of substantial stress for many people.[3-7] Indeed, early studies observed marked deteriorations in mental health in populations world-wide as well as exacerbated symptoms of anxiety, distress, depression, insomnia and posttraumatic stress disorder (PTSD).[8-12]

Secondary to these pandemic-induced shifts in social, economic and psychological health states have been changes to the contexts, motivations and patterns of substance use. For example, approximately 1 in 8 adults in a representative sample of the US population reported starting or increasing the use of a substance to cope with pandemic-related negative emotions alongside high rates of self-reported anxiety and/or depression (31%)

Introduction

The COVID-19 pandemic and associated policy response measures have had widespread, long-lasting and compounding direct and indirect impacts on population health and quality of life around the world. In many settings, nonemergency medical procedures were deferred to focus health care resources on the COVID-19 response, and public health measures such as restrictions on in-person gatherings, travel and non-essential service operations were implemented to curb community transmission of the virus. While critical to reducing case rates, these abrupt changes spurred increased feelings of loneliness, boredom and isolation[1] in addition to rising material and income insecurity.[2]

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and trauma- and stress-related disorder symptoms (26%).[13] Studies from Australia, Canada and the US have shown increased alcohol consumption among people experiencing elevated stress, anxiety and depression.[14-19]

In Canada, where cannabis has been legal and regulated since 2018, the prevalence of current (past-week) nonmedical cannabis use in the overall population does not appear to have shifted noticeably during the COVID-19 pandemic;[20] however, between 30% and 50% of people who used non-medical cannabis pre-pandemic increased their frequency of use during the pandemic;[3,20-22] this estimate is even higher among those with depression, anxiety and/or suicidality.[3]

Surveys found that between 30% and 40% of people who use cannabis do so for both medical and nonmedical purposes.[23,24] In Canada, clinicians can authorize medical cannabis for a wide range of conditions or symptoms, including pain, anxiety, depression, PTSD and sleep disorders.[25,26] About 22% of people who use cannabis for medical purposes in Canada are authorized to do so by a health care professional.[27]

Although many overlapping symptoms and conditions commonly managed with medical cannabis (e.g. chronic pain, anxiety, depression, PTSD, insomnia) are reported to have worsened in the population during the COVID-19 pandemic,[28,29] studies investigating changes in medical cannabis use among Canadians authorized to use it are lacking. Annual data from the Canadian Cannabis Survey suggest that the prevalence of self-reported (i.e. not necessarily authorized) medical cannabis use has remained stable over 2019, 2020 and 2021.[27,30] We are unaware of any study examining shifts in frequency of medical cannabis use over this time in a single sample of people who use medical cannabis.

Using information collected from a large sample of Canadian residents authorized to use medical cannabis, we sought to (1) document changes in the frequency of medical cannabis use; (2) explore concurrent changes in use of alcohol, tobacco, and prescription and unregulated drugs; and (3) identify independent correlates of increasing medical cannabis use during the COVID-19 pandemic.

Methods

Study sample

Data for this study were derived from the 2021 Canadian Cannabis Patient Survey. The survey was developed in consultation with academic partners at institutions across Canada and the United States and administered by Tilray, a Canadian licensed producer of medical cannabis.

All people authorized to use medical cannabis registered with Tilray and/or the licensed producer Aphria were emailed a password-protected link to complete the survey. The survey was available from 7 to 14 May 2021 on REDCap, a HIPAA- (in the USA) and PIPEDA- (in Canada) compliant electronic data capture system. Respondents provided informed consent prior to participating in the study and answered questions on demographics, the reasons they are using medical cannabis and their patterns of use of cannabis and other substances. People who completed the survey and provided a valid Tilray or Aphria patient number were entered into a draw for one of three CAD 1000 credits towards the purchase of medical cannabis from their licensed provider.

Ethics approval for this survey was granted by Advarra, an independent institutional review board (approval number: Pro00050772).

Measures

Medical cannabis use frequency

To explore patterns of medical cannabis use during the COVID-19 pandemic, we added a block of pandemic-related questions to the 2021 Canadian Cannabis Patient Survey.

First, we asked respondents to report their average frequency of medical cannabis use during three time periods that we defined in relation to the onset of the global pandemic: "pre-COVID" was the approximate 3-month period preceding the declaration of the COVID-19 pandemic (i.e. approximately 1 January 2020 to 15 March 2020); "Wave 1" was the initial period after the declaration of the pandemic during which new cases steadily increased, then decreased and remained relatively stable (i.e. approximately 15 March 2020 to 30 August 2020; and "Wave 2" was associated with much more rapid and higher surge of new cases (i.e.

approximately 1 October 2020 to the time of data collection).

For each pre-specified period, participants were asked how often they used medical cannabis. Consistent with the Alcohol, Smoking and Substance Involvement Screening Test (ASSIST),[31] the response categories were "never," "once or twice," "monthly," "weekly" and "daily or almost daily." In anticipation of high rates of daily use among this sample of medical users,[24] respondents authorized to use medical cannabis daily were further prompted to specify the approximate number of times they used cannabis per day: 1 to 2, 3 to 5, 6 to 10, or more than 10.

To obtain a measure corresponding to change and direction of change of medical cannabis use frequency during the COVID-19 pandemic, we ordered the original frequency categories on a scale from 0 to 7 (i.e. never [0] to > 10 times/day [7]) and calculated a change from baseline (i.e. "pre-COVID") score separately for Wave 1 and Wave 2 by subtracting the pre-COVID frequency from the Wave 1 and Wave 2 frequencies, respectively. Change scores of 1 or more, −1 or less and 0, respectively, corresponded to an increase, decrease or no change in medical cannabis use frequency for that period. A change score of 1 or more in either period was considered an increase from baseline; a change score of 1 or less in either period was considered a decrease from baseline.

Reasons for changing medical cannabis use

We asked respondents whether they perceived their medical cannabis use as having changed during the pandemic. Those who responded "yes" were prompted to identify the reason(s) underlying this change. The response categories included adjustment to medical cannabis authorization; change in access or availability of cannabis; cost; social distancing regulations; time at home; anxiety; sleep problems; isolation; loneliness; COVID-19 risk; COVID-19 symptom severity; and other (with a text box for additional responses).

Changes in other substance use

We asked respondents to report how their use of other substances, including alcohol, tobacco, prescription drugs (opioids and non-opioids) and unregulated drugs (cocaine or crack, methamphetamine, unregulated opioids) changed during the pandemic (i.e. after 15 March 2020).

Respondents could report an increase, decrease, no change or no use of that substance.

Statistical analysis

First, we examined the number and proportion of respondents who reported less than weekly, weekly and daily medical cannabis use in each assessment period. We used a McNemar–Bowker test to assess for overall within-group changes in frequency of use, and McNemar tests with Bonferoni correction to examine pairwise changes in frequency between assessment periods (e.g. less than weekly to weekly from pre-COVID to Wave 1, less than weekly to weekly from Wave 1 to Wave 2, etc.). We then descriptively examined the reasons given for increased or decreased frequency of use since the pre-COVID assessment period.

Next, we used Chi-square tests (or Fisher exact tests, as appropriate) to examine changes in secondary substance use during the pandemic (i.e. stable or decrease or increase in frequency), stratified by increased medical cannabis use during the pandemic (yes vs. no). We followed up significant ($p < 0.05$) results with post hoc pairwise Chi-square tests with Bonferroni correction.

Finally, we built exploratory bivariable and multivariable logistic regression models to examine sociodemographic, substance use and health-related correlates of increasing medical cannabis use during the COVID-19 pandemic. The analytic sample for the model was restricted to respondents who were eligible to increase their medical cannabis use frequency (i.e. those who used medical cannabis less than 10 times per day during the pre-COVID period).

We considered the following covariates: gender (female vs. male); age (per 5-year increase); household annual income (in CAD, < 40 000, 40 000–99 999, 100 000–159 999, ≥160 000); employment status (part/full-time, unemployed/on disability, retired); lost employment during the pandemic (yes vs. no); community setting (urban/suburban vs. rural); nonmedical cannabis use (yes vs. no); alcohol use (yes vs. no); tobacco use (yes vs. no); use of cocaine/crack, illicit opioids (e.g. heroin) or methamphetamine (pooled together into a category for "unregulated drugs"; yes vs. no); prescription opioids, non-opioid prescription drugs (pooled into a category for prescription drugs; yes vs. no); and primary symptom(s) treated with medical cannabis. The information about primary symptoms treated with medical cannabis was derived from a checklist of symptom categories including an option to describe additional symptoms.

We derived the following binary (yes vs. no) groupings from the predetermined and self-described symptoms: (1) pain, inflammation, nerve damage; (2) sleep problems; (3) anxiety, stress, hypersensitivity; (4) depression, low mood; (5) addiction, dependence, withdrawal; (6) attention deficit, memory loss; (7) nausea, appetite loss or gastrointestinal issues; (8) seizures, muscle spasms, tremors; and (9) other (responses that could not be reasonably re-categorized into any of the above groups).

We adopted a conservative multivariable model-building approach in which all these covariates with a bivariable significance level ($p < 0.20$) were included in multivariable analyses.

As some participants may have increased their medical cannabis use because they received medical authorization to do so, we conducted a sensitivity analysis. Participants whose sole underlying reason for their increased use of medical cannabis was a change to their medical cannabis authorization were recoded to 0 for the outcome.

All analyses were conducted in R Version 1.4.1106 using RStudio (R Foundation for Statistical Computing, Vienna, AT). All *p*-values are two-sided.

Results

Of the 27 431 people registered with Tilray or Aphria (or both) and who were sent a link to the survey, 2697 (9.8%) provided complete responses. Of these, 1325 (49.1%) were women (mean [SD] age: 54.3 [14.0] years). Most respondents (91.3%) were White and living in central Canada or the Prairies (see Table 1).

The prevalence of daily medical cannabis use in the sample was 83.2% (n = 2245) during the pre-COVID period; 85.9% (n = 2317) during Wave 1; and 90.3% (n = 2422) during Wave 2 (see Table 2). A McNemar–Bowker test confirmed significant changes in the frequency of medical cannabis use during the pandemic ($p < 0.001$), with pairwise post hoc tests showing a significant increase from less than weekly use to weekly and daily use between the pre-COVID period and Wave 1 (both adjusted $p < 0.001$), and a significant increase from less than weekly to daily use from Wave 1 to Wave 2 (adjusted $p < 0.001$; Table 2).

About 546 (18.4%) respondents increased their medical cannabis use frequency since the pre-COVID period. Common reasons for increasing use frequency included anxiety (n = 280 [51.3%]); sleep problems (n = 206 [37.7%]); social distancing regulations and/or more time at home (n = 194 [35.5%]); isolation and/or loneliness (n = 149 [27.3%]); and change to medical cannabis authorization (n = 91 [16.7%]; see Table 3).

Another 123 (18.4%) respondents decreased their use frequency. The top reasons given for changing use frequency were anxiety and sleep problems, reported by 18.7% (n = 23) and 21.1% (n = 26) of the group, respectively.

In total, 50 (9.2%) of the respondents who increased their use and 6 (4.9%) of those who decreased their use cited risk of COVID-19 infection or symptom severity as a reason for changing frequency (see Table 3 for reasons for changing frequency of medical cannabis use during the COVID-19 pandemic).

Significantly more respondents who increased their medical cannabis frequency during the pandemic reported an increase in alcohol use, while significantly more respondents who did not increase their medical cannabis frequency reported no change in alcohol use (both $p < 0.001$). The groups did not differ in terms of perceived reductions in alcohol consumption. Similar group differences were noted for perceived changes in tobacco consumption (see Table 4). Reported changes in consumption of prescription opioids, unregulated opioids, non-opioid prescription drugs, crack/cocaine and methamphetamine did not differ during the pandemic between the groups.

The odds of increasing medical cannabis use during the COVID-19 pandemic were significantly elevated among women (adjusted odds ratio [aOR] = 1.67; 95%

TABLE 1
Demographic characteristics of a sample of Canadian residents authorized to use medical cannabis (n = 2697)

Characteristic	n	%
Mean age (SD), in years		54.3 (14.0)
Gender		
Male	1352	50.1
Female	1325	49.1
Other[a]	10	0.4
Did not disclose	10	0.4
Race/ethnicity[b]		
White	2463	91.3
Black	36	1.3
Hispanic	27	1.0
Asian	60	2.2
Indigenous	67	2.5
Métis	64	2.4
Other	70	2.6
Geographical region		
Atlantic Canada	251	9.3
Central Canada	1276	47.3
Prairies	930	34.5
West Coast	235	8.7
Northern Territories	5	0.2
Community setting		
Urban	2077	77.0
Rural	620	23.0
Annual household income, CAD		
<40 000	607	22.5
40 000–99 999	1281	47.5
100 000–159 999	599	22.2
≥160 000	210	7.8
Employment		
Full-time or part-time	1202	44.6
Unemployed	608	22.5
Retired	887	32.9
Nonmedical cannabis use		
Yes	923	34.2
No	1764	65.4

Abbreviation: SD, standard deviation.

[a] Self-described genders listed under "Other" include nonbinary (n = 6), gender-fluid (n = 2), trans woman (n = 1) and gender-queer (n = 1).

[b] Respondents could select multiple options to describe their race/ethnicity.

confidence interval [CI]: 1.36–2.05); respondents who lost their jobs during the pandemic (1.38; 1.06–1.80); those who use cannabis for nonmedical purposes (1.35; 1.09–1.68); those who use prescription drugs (1.24; 1.00–1.54); and those who reported anxiety/stress (1.43; 1.12–1.81) and/or depression/low mood (1.36;

1.05–1.76) as a primary symptom treated with medical cannabis (see Table 5).

For every 5-year increase in age, the odds of increasing medical cannabis use decreased by approximately 11% (aOR: 0.89; 95% CI: 0.85–0.94; Table 5). All significant findings remained after recoding

the outcome for 42 respondents whose only self-reported reason for increasing medical cannabis use was a change to medical cannabis authorization (data not shown).

Discussion

In this study of Canadian residents authorized to use medical cannabis, we sought to examine changes in frequency of medical cannabis use and identify correlates of increasing use during the first two waves of the COVID-19 pandemic. While other Canadian surveys have documented increases in nonmedical cannabis use during the pandemic,[3,19-22] to our knowledge this is the first Canadian study to examine changes in authorized medical cannabis use.

Daily medical cannabis use increased by 7 percentage points, from 83.2% pre-pandemic to 90.3% in Wave 2. Given that prevalence of daily use pre-pandemic was already relatively high, the modest increase observed may reflect a ceiling effect. The magnitude of this change is similar to what we recently documented in a web-based sample of people who use cannabis for medical purposes in the United States, in which daily cannabis use increased from 16.2% pre-pandemic to 20.7% in the first few months of the pandemic.[32] Our previous study's sample comprised people who self-reported using cannabis for therapeutic purposes.[32] We suspect that the current study recorded a substantially higher prevalence of daily medical cannabis use because the sample consisted solely of people authorized to use cannabis for medical purposes.

We also asked about perceived changes in other prescribed and non-prescribed substance use during the pandemic and observed a few differences according to concurrent changes in medical cannabis frequency. We found that significantly more respondents whose medical cannabis use increased also self-reported increases in alcohol and tobacco use during the pandemic. Studies exploring the impact of the COVID-19 pandemic on alcohol consumption suggest that boredom, loneliness, depression, stress and anxiety may be particularly pertinent to upwards shifts in individual usage trajectories.[16-18,33,34] While we did not assess for motives for alcohol or tobacco use, respondents' reasons for shifting medical cannabis use reveals certain contexts that

TABLE 2
Frequency of medical cannabis use before and during the COVID-19 pandemic reported by a sample of Canadian residents authorized to use medical cannabis (n = 2697)

Frequency	n (%)		
	Pre-COVID[a]	Wave 1[b]	Wave 2[c]
<Weekly	294 (10.9)	243 (9.0)	135 (5.0)
Weekly	158 (5.9)	137 (5.1)	125 (4.7)
Daily	2245 (83.2)	2317 (85.9)	2422 (90.3)

Notes: McNemar–Bowker test for net change (pre-COVID–Wave 2): $p < 0.001$.

Significant pairwise post hoc comparisons (pre-COVID–Wave 1): <weekly–daily: adjusted $p < 0.001$; weekly–daily, adjusted $p < 0.001$.

Significant pairwise post hoc comparisons (Wave 1–Wave 2): <weekly–daily: adjusted $p < 0.001$.

[a] Pre-COVID = 3-month period immediately preceding the declaration of the COVID-19 pandemic (approximately 1 January to 15 March 2020).

[b] Wave 1 = Start of pandemic to end of summer 2020 (approximately 15 March to 30 August 2020).

[c] Wave 2 = Fall 2020 and winter 2021 (approximately 1 October 2020 to 15 February 2021).

may trigger coping-oriented substance use, such as anxiety, isolation/loneliness and boredom (time at home). In contrast, approximately 20% of respondents reported reducing their use of alcohol and tobacco regardless of any shift in medical cannabis use frequency, possibly reflecting shared motive-related reductions in alcohol and tobacco use across the increasing, stable and decreasing medical cannabis use groups. This will be an important area to monitor in longer-term evaluations of the impact of the pandemic on the mental health of vulnerable populations. We found no differences for use of prescription opioids, unregulated opioids, non-opioid prescription drugs, crack/cocaine or methamphetamine, but low numbers were recorded for unregulated opioids, crack/cocaine and methamphetamine, reducing power to detect a change in these substances.

Our exploratory multivariable model highlighted several markers of higher susceptibility to increasing medical cannabis use during the pandemic. First, women in our study had approximately 67% higher odds of increasing medical cannabis use than men, consistent with a growing number of studies documenting disproportionate effects of the pandemic on women's mental health and substance use,[6,9-11,14,29,35] Research focussing on sex/gender-based health disparities has shown how reinforcement of gender roles during the pandemic likely contributed to increased stress among women,[36,37] with increased household and childcare burdens resting disproportionately on women.[38,39]

In our previous analysis of the US-based sample, the odds of increasing medical cannabis use for anxiety early in the pandemic approximately doubled among women.[32] This current study examined medical cannabis use more broadly; although anxiety was the most common reason cited among those who increased their use (51.3% overall, and 52.3% among women), we cannot attribute the observed increases solely to mental health or stress reasons. More research is needed to further contextualize underlying drivers of sex differences in substance use and mental health changes during the pandemic.

In this current study, respondents who lost their jobs during the pandemic had higher odds of increasing their medical cannabis use. It is plausible that they used cannabis more often out of boredom and reduced work-related responsibilities. However, taking into account evidence linking income loss and material insecurity to increasing alcohol use during the pandemic,[7,11,14,40] increased medical cannabis use in this group may also indicate a coping-related response to emergent stress, anxiety, depression and other health problems exacerbated by income instability.

Survey respondents who reported using cannabis to alleviate symptoms of anxiety and depression were more susceptible to increasing their medical cannabis use during the pandemic, aligning with a

TABLE 3
Reasons for changing medical cannabis use, by direction of frequency change from baseline, given by a sample of Canadian residents authorized to use medical cannabis (n = 2697)

Reason for change from the pre-COVID period	n (%)	
	Increase (n = 546; 18.4%)	Decrease (n = 123; 4.6%)
Change to medical cannabis authorization	91 (16.7)	5 (4.1)
Change in access or availability	33 (6.0)	5 (4.1)
Cost	45 (8.2)	19 (15.4)
Social distancing regulations / time at home	194 (35.5)	19 (15.4)
Anxiety	280 (51.3)	23 (18.7)
Sleep problems	206 (37.7)	26 (21.1)
Isolation / loneliness	149 (27.3)	10 (8.1)
COVID-19 risk or symptom severity	50 (9.2)	6 (4.9)
Other		
Change in medical need	15 (2.7)	2 (1.6)
Stress	3 (0.6)	0
Started a different treatment	0	4 (3.3)
Self-guided experimentation	3 (0.5)	5 (4.1)
Not achieving desired effect	0	3 (1.6)
Negative side effects	0	5 (4.1)
Uncategorized other	2 (0.7)[a]	3 (3.3)[b]
Not reported[c]	155 (28.4)	49 (39.8)

[a] Uncategorized other reasons for increased use: lack of counselling availability, restabilizing on medication after missing doses before COVID.

[b] Uncategorized other reasons for decreased use: loss of interest, less free time, implementation of new work policies around medical cannabis use.

[c] Respondents who did not report a change in their medical cannabis use during the COVID-19 pandemic were not asked to report a reason for a change.

TABLE 4
Changes in secondary substance use during the COVID-19 pandemic, stratified by medical cannabis use change (increase/no increase) reported by a sample of Canadian residents authorized to use medical cannabis (n = 2697)

Secondary substance[a]	Increased medical cannabis use[b] n (%)		p value
	Yes	No	
Prescription opioids (n = 364)	79 (21.7)	285 (78.3)	0.199
Stable	53 (67.1)	203 (71.2)	
Decrease	14 (17.7)	58 (20.4)	
Increase	12 (15.2)	24 (8.4)	
Unregulated opioids (n = 49)	13 (26.5)	36 (73.5)	0.086[c]
Stable	8 (61.5)	29 (80.6)	
Decrease	2 (15.4)	0 (0.0)	
Increase	3 (23.1)	7 (19.4)	
Non-opioid prescription drugs (n = 1017)	223 (21.9)	794 (78.1)	0.119
Stable	174 (78.0)	666 (83.8)	
Decrease	29 (13.0)	71 (8.9)	
Increase	20 (9.0)	57 (7.2)	
Crack or cocaine (n = 46)	15 (32.6)	31 (67.4)	1.000[c]
Stable	9 (60.0)	20 (64.5)	
Decrease	3 (20.0)	5 (16.1)	
Increase	3 (20.0)	6 (19.4)	
Methamphetamine (n = 42)	10 (23.8)	32 (76.2)	0.391
Stable	8 (80.0)	24 (75.0)	
Decrease	1 (10.0)	1 (3.1)	
Increase	1 (10.0)	7 (21.9)	
Alcohol (n = 1538)	339 (22.0)	1199 (78.0)	<0.001
Stable	182 (53.7)	853 (71.1)	<0.001
Decrease	77 (22.7)	208 (17.3)	0.149
Increase	80 (23.6)	138 (11.5)	<0.001
Tobacco (n = 471)	116 (24.6)	355 (75.4)	<0.001
Stable	55 (47.4)	246 (69.3)	<0.001
Decrease	29 (25.0)	65 (18.3)	0.705
Increase	32 (27.6)	44 (12.4)	<0.001

[a] We derived non-cannabis substance use changes from a question assessing self-perceived change/direction of change during the COVID-19 pandemic.

[b] Increased medical cannabis use frequency from self-reported data corresponding with three time periods (one preceding the COVID-19 pandemic, two during the pandemic).

[c] Fisher test for group comparisons, with Bonferroni correction for post hoc pairwise tests (alcohol and tobacco).

previously documented association in an online sample of 1200 self-identified medical cannabis users in the United States.[41] Considering the well-documented effects of the pandemic on mental health more broadly, this finding is not surprising. While survey research involving people who use medical cannabis shows a high level of consensus that cannabis is an effective treatment for anxiety and depression,[42] more experimental research is needed to confirm the therapeutic potential of cannabis in these areas.[43] As our study did not track symptom relief due to cannabis use in response to increased mental health challenges, future research should seek to understand potential long-term therapeutic and/or adverse health outcomes.

For health care providers, the results of this study should serve as a reminder to check in with patient–clients who are using cannabis about potential shifts in their use in response to changes and stresses induced by the pandemic. Of note, given that respondents could report symptom management with medical cannabis for conditions secondary to their primary reason for authorization, clinicians should be aware that usage may have also increased among those who were not initially authorized to use cannabis for anxiety or depression.

We also observed a significant association with increasing medical cannabis use among respondents who were taking concurrent prescription drugs, possibly signifying complex morbidity, heavier disease burden or worsening of disease over time. This indicated susceptibility to increasing intensity of medical cannabis use. Further research will be required to understand whether those taking medical cannabis concurrently with prescription medications were differentially impacted by the COVID-19 pandemic (e.g. through increased symptom flare-ups, managed with cannabis).

Finally, younger age and nonmedical use of cannabis was significantly associated with increasing medical cannabis use during the pandemic, reflecting the high degree of overlap between medical and nonmedical use, particularly among younger people and those using medical cannabis for mental health needs.[24] Although shifting frequency of use of cannabis for medical purposes was the focus of the current analysis, given that one-third of our sample reported at least some use of cannabis for nonmedical purposes (see Table 1), additional research is needed to understand the overlap with medical cannabis changes during the pandemic.

Strengths and limitations

The inclusion of almost 3000 people authorized to access regulated cannabis for medical purposes is a major strength of this study, but our findings should be interpreted in light of certain limitations. First, respondents were a self-selected group of authorized medical cannabis users who were registered with two medical cannabis companies. Although the respondents lived in Canada, generalizability is limited as the sample does not represent all registered medical cannabis users across the provinces and territories.

TABLE 5
Characteristics associated with increasing medical cannabis use during the COVID-19 pandemic in a sample of Canadian residents eligible to increase their medical cannabis use (n = 2622)[a]

Characteristic	Bivariable		Multivariable	
	OR (95% CI)	p value	aOR (95% CI)	p value
Sociodemographic characteristics				
Gender[b]				
Male	1.00 (Reference)		1.00 (Reference)	
Female	1.54 (1.27–1.85)	<0.001	1.67 (1.36–2.05)	<0.001
Age				
Per 5-year increase	0.85 (0.82–0.88)	<0.001	0.89 (0.85–0.94)	<0.001
Household income, CAD				
<40 000	1.20 (0.91–1.60)	0.189	NA	
40 000–99 999	1.06 (0.84–1.36)	0.604	NA	
100 000–159 999	1.00 (Reference)		NA	
≥160 000	0.94 (0.63–1.42)	0.785	NA	
Employment				
Part-/full-time	1.00 (Reference)		1.00 (Reference)	
Unemployed	1.15 (0.91–1.45)	0.235	1.13 (0.87–1.45)	0.361
Retired	0.54 (0.43–0.68)	<0.001	1.10 (0.80–1.51)	0.553
Lost job during the pandemic				
No	1.00 (Reference)		1.00 (Reference)	
Yes	1.64 (1.28–2.11)	<0.001	1.38 (1.06–1.80)	0.017
Community setting				
Urban / suburban	1.00 (Reference)		1.00 (Reference)	
Rural	0.80 (0.63–1.01)	0.052	0.81 (0.63–1.03)	0.086
Substance use				
Nonmedical cannabis use[c]				
No	1.00 (Reference)		1.00 (Reference)	
Yes	1.76 (1.45–2.14)	<0.001	1.35 (1.09–1.68)	0.007
Alcohol use				
No	1.00 (Reference)		1.00 (Reference)	
Yes	1.26 (1.04–1.53)	0.016	1.22 (0.99–1.49)	0.061
Tobacco use				
No	1.00 (Reference)		1.00 (Reference)	
Yes	1.43 (1.13–1.81)	0.004	1.24 (0.96–1.59)	0.105
Unregulated drug use				
No	1.00 (Reference)		NA	
Yes	1.19 (0.66–2.15)	0.561	NA	
Prescription drug use				
No	1.00 (Reference)		1.00 (Reference)	
Yes	1.21 (1.10–1.47)	0.048	1.24 (1.00–1.54)	0.047
Primary symptoms treated with medical cannabis (yes vs. no)				
Pain, inflammation, nerve damage	0.75 (0.61–0.92)	0.007	0.88 (0.70–1.10)	0.254
Sleep problems	1.41 (1.17–1.72)	<0.001	0.94 (0.75–1.17)	0.553
Anxiety, stress, hypersensitivity	2.20 (1.82–2.66)	<0.001	1.43 (1.12–1.81)	0.004
Depression, low mood	2.18 (1.77–2.69)	<0.001	1.36 (1.05–1.76)	0.020
Addiction, dependence, withdrawal	1.74 (0.82–3.70)	0.043	0.83 (0.36–1.92)	0.662

TABLE 5 (continued)
Characteristics associated with increasing medical cannabis use during the COVID-19 pandemic in a sample of Canadian residents eligible to increase their medical cannabis use (n = 2622)[a]

Characteristic	Bivariable		Multivariable	
	OR (95% CI)	*p* value	aOR (95% CI)	*p* value
Attention deficit, memory loss	1.85 (1.29–2.64)	0.001	1.09 (0.73–1.64)	0.678
Nausea, appetite loss, gastrointestinal issues	1.88 (1.49–2.38)	<0.001	1.18 (0.89–1.54)	0.246
Seizures, muscle spasms, tremors	1.21 (0.87–1.68)	0.265	N/A	–
Other symptoms	1.20 (0.48–3.03)	0.700	NA	–

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio.

[a] 75 respondents were removed from the original sample as they were at the highest frequency of medical cannabis use in the pre-COVID period.

[b] 20 respondents did not identify as male or female and were excluded from the bivariable model for gender and the multivariable model.

[c] 9 respondents had missing data for nonmedical cannabis use and were excluded from the bivariable model for nonmedical cannabis use and the multivariable model.

Second, the pandemic was a shared experience across the whole sample; while respondents could indicate whether they perceived that the pandemic affected their medical cannabis use, we cannot rule out the possibility of observing similar changes in use outside of the pandemic. However, it is worth noting that previous longitudinal studies of medical cannabis use show relatively stable frequency and dosage patterns over 6- to 12-month periods.[44-46]

Third, the study relied on respondents self-reporting frequency patterns, introducing the possibility of recall deficiencies—particularly for the pre-pandemic and Wave 1 periods. Frequency of medical cannabis use in each period was captured on a categorical scale. As these categories are not linearly equidistant, we created a binary outcome that corresponds with any frequency increase, and this approach does not reflect the magnitude of increase. In addition, incremental increases within each ASSIST category (e.g. from 2 to 4 times per week) could not be measured.

Our use of a predetermined set of reasons for changing frequency of medical cannabis use during the COVID-19 pandemic may have missed some important factors, including possible shifts to nonmedical sources for ease of accessibly; however, we tried to mitigate these oversights by including a free-form text box for participants to add more information if they thought their reasons were not accurately represented by the pre-determined categories. Not all respondents for whom we detected a change in medical cannabis use frequency during the pandemic self-perceived a change in their use. Accordingly,

28% (n = 155) of those who increased and 40% (n = 49) of those who decreased medical cannabis use did not provide a reason for the change (see Table 3). The reasons provided, expressed as the proportion of respondents who increased or decreased their medical cannabis use frequency, may be underestimated and are only meant to generate hypotheses, not confirm underlying connections. Nonmedical use of cannabis was not captured in the question assessing secondary substance shifts since the onset of the pandemic. Nonmedical use of cannabis deserves detailed consideration in future research of pandemic-concurrent trends in this population.

Finally, the current findings represent self-reported changes that occurred early in the pandemic. Further research is needed to characterize ongoing shifts in medical cannabis use later in the pandemic and associated long-term impacts.

Conclusions

We documented modest but significant and persistent increases in the frequency of medical cannabis use early in the COVID-19 pandemic in this sample of authorized medical cannabis users in Canada. We observed increased use of alcohol and tobacco more often among those who increased their medical cannabis use frequency. Women, younger people, those who lost employment during the pandemic, those who used nonmedical cannabis and prescription drugs and those who used medical cannabis to manage depression and anxiety had greater odds of increasing their medical cannabis use during the pandemic.

Our findings highlight a subset of the people authorized to use medical cannabis who may be particularly vulnerable to increased substance use and adverse mental health outcomes during the pandemic, underscoring the need for clinicians to check in with patients who use medical cannabis.

Conflicts of interest

The Canadian Cannabis Patient Survey was sponsored by Tilray, a licensed producer of medical cannabis. At the time of data collection, KO was Clinical Research Manager and PL was Vice-President, Global Patient Research and Access at Tilray. Over the past 12 months, ZDC reports receiving honorariums from Canopy Growth Corporation.

Authors' contributions and statement

SL – Conceptualization, Investigation, Methodology, Formal analysis, Data curation, Writing – Original draft

ZDC – Methodology, Writing – Review and Editing

KO – Software, Resources, Project Administration, Writing – Review and Editing

PL – Conceptualization, Investigation, Methodology, Administration, 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.

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Original quantitative research

Impact of substance-related harms on injury hospitalizations in Canada, from 2010 to 2020

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Abstract

Introduction: Injuries continue to be a leading cause of death and contribute significantly to hospitalizations each year in Canada. Substance use has been associated with an increase in intentional and unintentional injuries, resulting in hospitalizations. This study examines trends in injury hospitalizations with a co-occurring substance diagnosis, to quantify the burden of injuries and identify at risk populations.

Methods: We analyzed Discharge Abstract Database data between 2010/11 and 2020/21, for clinical and demographic information about hospital discharges across Canada. We used ICD-10 codes to identify injury hospitalizations with co-occurring substance diagnostic codes, by injury intent and substance type. Rates, proportions, age-specific rates and age-standardized rates were calculated, trends quantified using average annual percent change and results stratified by sex and age group.

Results: From 2010/11 to 2020/21, unintentional injuries accounted for over half of all substance-related injury hospitalizations. Substance-related injuries accounted for 12% of total injury hospitalizations over this period. Overall, substance-related injury hospitalizations with co-occurring use of stimulants, opioids, cannabinoids and alcohol increased significantly among males and females. Unintentional substance-related, injury hospitalizations were more common later in life, and intentional substance-related injuries were more common among adolescents and young adults.

Conclusion: These results highlight key demographic groups with higher rates of substance-related injury hospitalizations that would benefit from targeted prevention efforts.

Keywords: surveillance, trends, Canada, unintentional injury, intentional injury, alcohol, polysubstance, psychoactive substances

Introduction

Injuries have been a leading cause of death in Canada over the past two decades.[1] Injuries contribute significantly to hospitalization rates each year (600 per 100 000 people), with over 270 000 injury-related hospitalizations in the 2018/19 fiscal year.[2]

Injuries are often grouped by intent: unintentional injuries, which are injuries that occur without intention to harm, versus intentional injuries, that are the result of purposeful harm to oneself or another person.[3] Injuries can be further classified by their external cause. In 2018/19, the largest proportion of unintentional injuries, by external cause, included unintentional falls, poisonings and motor vehicle collisions. Non-fatal suicide attempts and self-inflicted injuries made up the largest proportion of intentional injuries.[2]

It is well-known that substance use contributes to injuries, regardless of cause.[4,5]

Highlights

- Injuries with a substance diagnosis accounted for 12% of total injury hospitalizations in Canada over the past 11 years.
- Between 2010/11 and 2020/21, substance-related injury hospitalizations increased significantly.
- Polysubstance (multiple substance group codes, e.g. cannabinoids and alcohol, during an episode of care), alcohol and unspecified psychoactive substances were the substance groups most frequently reported with injury hospitalizations.
- Injury hospitalizations with the use of polysubstance and unspecified psychoactive substances were more frequent among children and youth.
- Alcohol and opioid-related injury hospitalizations were more frequent among older adults.

Studies have reported that the odds of experiencing an intentional injury when consuming substances are much greater than of experiencing an unintentional injury.[4,5] In addition, compared to when not using any substances, using alcohol alone or with other drugs increases the likelihood of an intentional injury by 4 to 18 times.[4,5] Alcohol- and cannabis-related injuries have been consistently studied over a number of years.[5-9] In more recent years, research has also found a positive association between opioid use and injuries.[10-12]

We analyzed trends in injury hospitalizations in Canada that co-occurred with a

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substance use diagnosis from 2010/11 to 2020/21 (each fiscal year lasts from 1 April to 31 March). We describe substance-related injury hospitalizations by age group, sex, injury intent and substance type. Analyzing trends using national hospitalization data provides a better understanding of the burden and pattern of injuries, allowing for greater focus on prevention.

Methods

Data source and case definition

This study utilized data from the Discharge Abstract Database (DAD), a national database managed by the Canadian Institute for Health Information (CIHI). The DAD collects administrative, clinical and demographic information on hospital discharges, from all provinces and territories except Quebec. Our study focussed on acute care inpatient discharge records. We excluded injuries due to the adverse effects of drugs or surgical or medical errors. We also excluded any uncertain or secondary diagnoses. Uncertain diagnoses are those that are suspect or questionable; secondary diagnoses are those that did not receive treatment or that did not contribute significantly to the episode of care.[13]

The DAD uses the *International Classification of Diseases, 10th Revision* (ICD-10) codes to classify reported diagnoses and interventions. These codes classify injuries, conditions and situations that may be risk factors to health.[13]
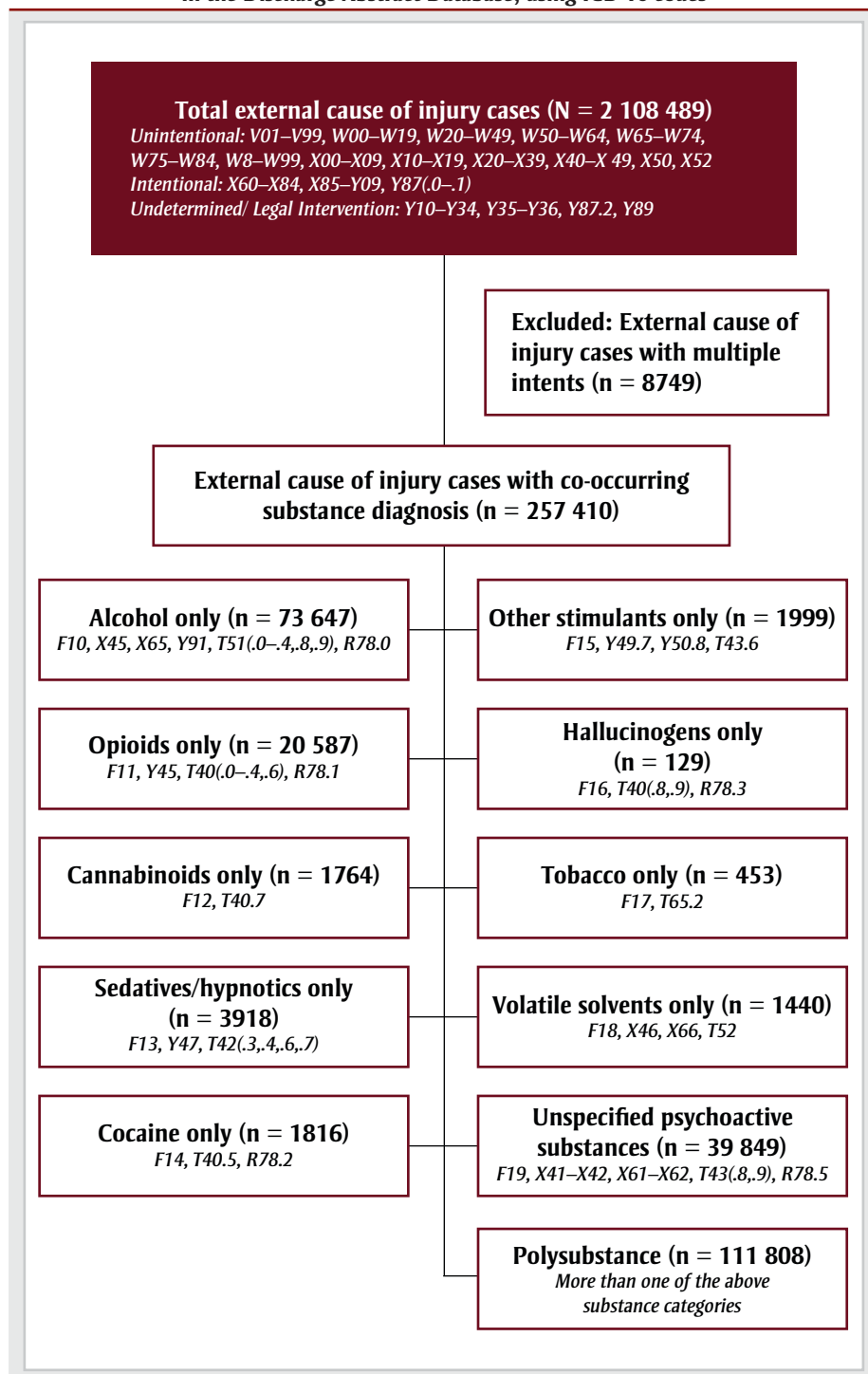
Case identification

We first identified all injury-related hospitalizations in the DAD by searching all 25 diagnosis fields for external cause of injury codes. An injury hospitalization is defined as any entry in the DAD where one of the external causes of injury (codes as listed in Chapter 20 of the ICD-10[13]) has been recorded. The framework for selecting and grouping external cause of injury codes is based on methodology used by CIHI and the US Centers for Disease Control and Prevention.[14] ICD-10 codes used to classify external cause of injuries have been grouped by intent: unintentional; intentional (self-harm, assault, self-inflicted injury); legal intervention (injuries inflicted by the police or other law-enforcing agents in the course of arresting lawbreakers or maintaining

order) or undetermined intent. We excluded entries where the intent overlapped (0.4% of injury hospitalizations) to prevent misclassification.

See Figure 1 for a visual representation of the process we used in this study to identify cases in the DAD.

We applied substance diagnostic codes to the extracted injury cases to identify injury hospitalizations that had a co-occurring substance diagnostic code for the episode of care. Throughout this article, we refer to substance-related injury hospitalizations as injury hospitalizations that have a co-occurring substance

FIGURE 1
Process of selecting substance-related injury hospitalization cases in the Discharge Abstract Database, using ICD-10 codes

Total external cause of injury cases (N = 2 108 489)
Unintentional: V01–V99, W00–W19, W20–W49, W50–W64, W65–W74, W75–W84, W8–W99, X00–X09, X10–X19, X20–X39, X40–X 49, X50, X52
Intentional: X60–X84, X85–Y09, Y87(.0–.1)
Undetermined/ Legal Intervention: Y10–Y34, Y35–Y36, Y87.2, Y89

Excluded: External cause of injury cases with multiple intents (n = 8749)

External cause of injury cases with co-occurring substance diagnosis (n = 257 410)

Alcohol only (n = 73 647)
F10, X45, X65, Y91, T51(.0–.4,.8,.9), R78.0

Other stimulants only (n = 1999)
F15, Y49.7, Y50.8, T43.6

Opioids only (n = 20 587)
F11, Y45, T40(.0–.4,.6), R78.1

Hallucinogens only (n = 129)
F16, T40(.8,.9), R78.3

Cannabinoids only (n = 1764)
F12, T40.7

Tobacco only (n = 453)
F17, T65.2

Sedatives/hypnotics only (n = 3918)
F13, Y47, T42(.3,.4,.6,.7)

Volatile solvents only (n = 1440)
F18, X46, X66, T52

Cocaine only (n = 1816)
F14, T40.5, R78.2

Unspecified psychoactive substances (n = 39 849)
F19, X41–X42, X61–X62, T43(.8,.9), R78.5

Polysubstance (n = 111 808)
More than one of the above substance categories

Abbreviation: ICD-10, *International Classification of Diseases, 10th Revision.*

diagnostic code recorded for the episode of care. A hospitalization with both an injury and a substance diagnostic code does not necessarily mean that the substance was a direct cause of the injury; causality should not be assumed.

The substance groups we identify in this study are alcohol, opioids, cannabinoids, sedatives or hypnotics, cocaine, other stimulants (including caffeine), hallucinogens, tobacco, volatile solvents, unspecified psychoactive substance and polysubstance (see Figure 1). The term "polysubstance" refers to multiple substance group codes (e.g. cannabinoids and alcohol) recorded for a patient during the episode of care.

Statistical analyses

We analyzed substance-related injury hospitalizations that occurred over an 11-year period between 2010/11 and 2020/21. The primary variables analyzed were age group, sex (male and female), fiscal year, external cause of injury and substance type. Results were disaggregated by sex, but because of low counts for the "other" category, we could only present data for males and females. Gender was not a variable available in the DAD at the time of this analysis.

We calculated age-specific rates per 100 000 population using Statistics Canada population estimates over the 11-year period. Age-standardized rates per 100 000 were directly standardized to the 2011 Canadian population. Since the DAD captures all hospitalization records in Canada (excluding Quebec), confidence intervals (CIs) did not need to be calculated as there is no real level of uncertainty around the estimates.

We quantified annual trends in age-standardized rates using annual percent change (APC) and average annual percent change (AAPC).[15] Age-standardized rates that changed significantly over the time period are identified by an APC or AAPC that differs significantly from zero (α = 0.05).

We used SAS EG version 7.1 (SAS Institute Inc., Cary, NC, US) for all descriptive analyses and to calculate age-specific rates. We used Joinpoint Regression Program version 4.7.0.0 (SEERStat, NCI, Bethesda, MD, US) to analyse injury and substance use trends using age-standardized rates, by sex and fiscal year. The Joinpoint

software fits the simplest Joinpoint regression model using the permutation test; this allows the identification of inflection points within the series with multiple weighted segments. We calculated 95% CIs for each segment to highlight the random error around the modelled APC.[15]

Results

Overview of substance-related injury hospitalizations

Between 2010/11 and 2020/21, there were 2 099 740 acute inpatient hospitalizations for injuries of any external cause in Canada (excluding Quebec). Females accounted for 52.4% (n = 1 100 808) of these injuries, of which 11.2% (n = 123 642) were substance related. Of the 998 932 injury hospitalizations of males, 13.4% (n = 133 768) had a substance-related diagnosis.

Poisoning injuries overall made up 5.1% of unintentional injury hospitalizations and 59.0% of intentional injury hospitalizations.

Of the total substance-related injury hospitalizations (n = 257 410), 53.5% were

classified as unintentional injuries, 40.2% as intentional injuries and 6.3% as legal interventions or undetermined-intent injuries. A larger proportion of males than of females were hospitalized for unintentional substance-related injuries, while females made up a higher proportion of intentional substance-related injury hospitalizations.

The substance groups most commonly reported along with injury hospitalizations were polysubstance (males: 20.6%; females: 22.9%), alcohol (males: 19.4%; females: 9.2%) and unspecified psychoactive substances (males: 5.9%; females: 9.6%). Alcohol, opioids, sedatives, unspecified psychoactive substances and polysubstance together made up over 90% of substance-related injury hospitalizations for each age group (see Figure 2). The substances most frequently consumed concurrently with another substance were sedatives (45.1%), opioids (42.4%) and alcohol (28.3%).

Polysubstance use most frequently co-occurred with injury hospitalizations in younger age groups, among whom most

FIGURE 2
Substance-related[a] injury hospitalizations, by substance category[b,c] and age group, 2010/11 to 2020/21, Canada (excluding Quebec)
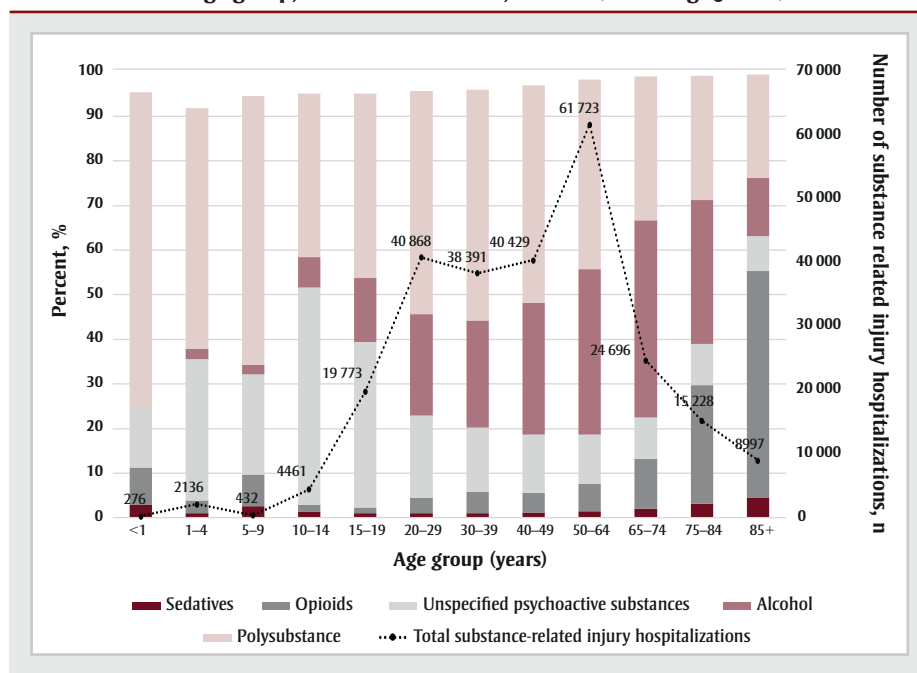
Source: Discharge Abstract Database, 2010/11–2020/21.

[a] Only the top 5 substance categories are shown. Hallucinogens, cocaine, cannabinoids, stimulants, tobacco and volatile substances account for the remaining proportion, but counts are too low to report.

[b] "Unspecified psychoactive substances" includes psychoactive substances other than those categories listed in this study as well as substances that may not be known.

[c] "Polysubstance" includes cases where more than one substance group is reported for a patient in an episode of care.

of the injuries were unintentional. Unspecified psychoactive substance-related injury hospitalizations were also common among youth, among whom they were unintentional for 88.7% of those aged 10 to 14 years and for 87.7% of those aged 15 to 19 years.

Alcohol use most frequently co-occurred with injury hospitalizations among older adults aged 65 to 74 years and 75 to 84 years, with 93.5% and 96.4%, respectively, of these injuries being unintentional. For those aged 85 years plus, opioid use most frequently co-occurred with injury hospitalizations, and 98.5% of these injuries were unintentional.

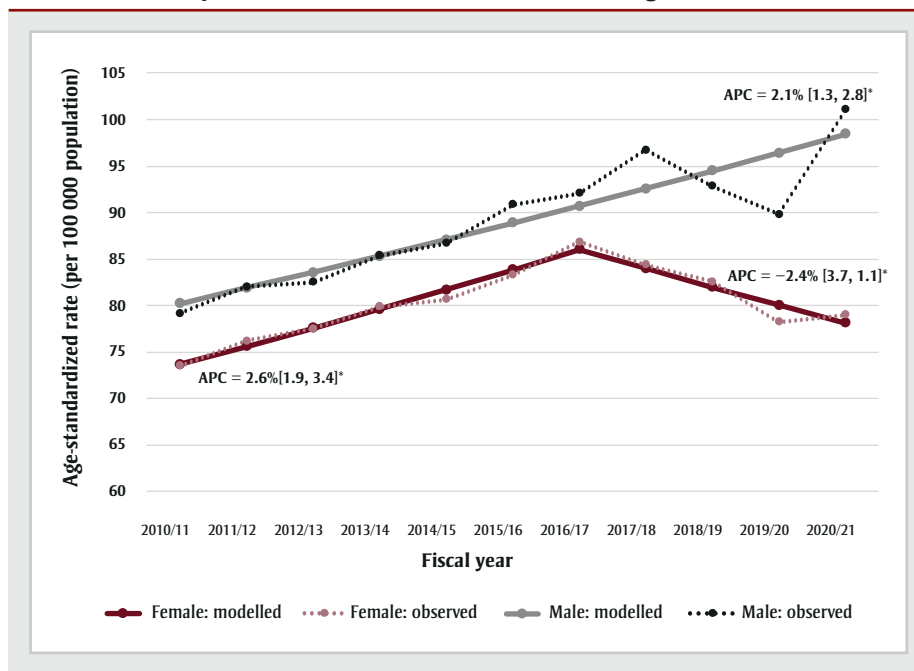### Trends in substance-related injury hospitalizations

From 2010/11 to 2020/21, age-standardized rates of substance-related injury hospitalizations of males increased significantly, by 2.1%. Among females, age-standardized rates of substance-related injury hospitalizations increased significantly from 2010/11 to 2016/17, by 2.6%, and then decreased significantly from 2016/17 to 2020/21, by 2.4% (see Figure 3), resulting in an overall significant increase of 0.6% from 2010/11 to 2020/21. In comparison, rates of total injury hospitalizations decreased significantly during this period.

For males, age-standardized rates of substance-related injury hospitalizations involving polysubstance, alcohol, opioids, stimulants and cannabinoids significantly increased between 2010/11 and 2020/21. For females, rates of injury hospitalizations involving alcohol, unspecified psychoactive substances, opioids, stimulants and cannabinoids significantly increased (see Table 1). For males only sedatives and volatile solvents showed significantly declining trends and for females only sedatives showed declining trends over this period.

Substance-related injury hospitalizations across age groups

Among males, intentional substance-related injury hospitalizations peaked at age 20 to 29 years. Among females aged 15 to 19 years, the peak in intentional substance-related injury hospitalizations was about three times that of males in the same age group (see Figure 4).

FIGURE 3
Age-standardized substance-related injury hospitalization rates per 100 000 population,[a] by sex, 2010/11 to 2020/21, Canada (excluding Quebec)

Source: Discharge Abstract Database, 2010/11–2020/21.

Abbreviation: APC, annual percent change.

[a] Age-standardized rates/100 000 population. Rates are standardized using the 2011 Canadian population (excluding Quebec).

*$p \leq 0.05$

TABLE 1
Prevalence and average annual percent change in substance-related injury hospitalizations, by substance type and sex, 2010/11 to 2020/21, Canada (excluding Quebec)

Substance type	Prevalence, n (%)	AAPC (95% CI), %	
		Males	**Females**
Polysubstance	111 808 (43.4)	+3.3 (2.1, 4.6)*	+0.0 (0.6, 0.7)
Alcohol	73 647 (28.6)	+0.9 (0.1, 1.7)*	+0.9 (0.1, 1.7)*
Unspecified psychoactive substances	39 849 (15.5)	+0.3 (−0.6, 1.3)	+1.7 (0.3, 3.2)*
Opioids	20 587 (8.0)	+3.4 (1.8, 5.1)*	+1.0 (0.3, 1.7)*
Sedatives	3918 (1.5)	−5.3 (−7.0, −3.4)*	−7.7 (−10.0, −5.3)*
Stimulants	1999 (0.8)	+21.8 (18.3, 25.4)*	+18.4 (12.9, 24.3)*
Cocaine	1816 (0.7)	+1.2 (−2.0, 4.5)	−3.6 (−7.9, 0.9)
Cannabinoids	1764 (0.7)	+6.2 (3.7, 8.7)*	+7.6 (4.6, 10.6)*
Volatile solvents	1440 (0.6)	−5.8 (−7.8, −3.7)*	+0.2 (−3.1, 3.6)
Tobacco	453 (0.2)	+1.8 (−7.0, 11.5)	−3.9 (−13.4, 6.5)
Hallucinogens	129 (0.1)	+0.2 (−6.2, 7.0)	–

Source: Discharge Abstract Database, 2010/11–2020/21.

Abbreviations: AAPC, average annual percent change; CI, confidence interval.

* $p \leq 0.05$.

Substance-related injury hospitalizations, by injury intent, age group and sex, age-specific rates/100 000 population[a,b], 2010/11 to 2020/21, Canada (excluding Quebec)

Intentional substance-related injury hospitalizations

Unintentional substance-related injury hospitalizations
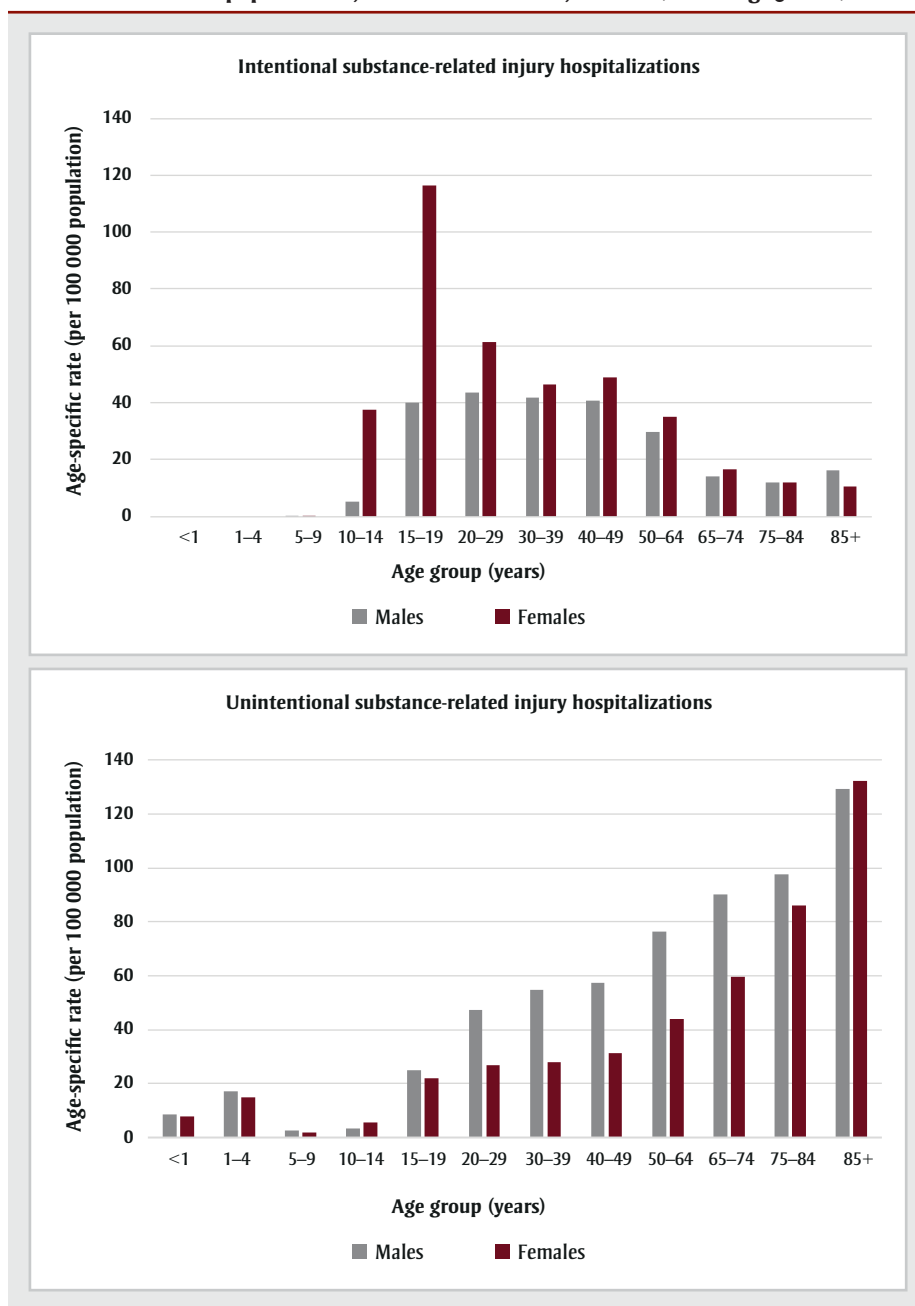
Source: Discharge Abstract Database, 2010/11–2020/21.

[a] Age-specific rates per 100 000 population were calculated using Statistics Canada population estimates (excluding Quebec) for the period of 2010/11–2020/21.

[b] Rates based on counts between 1 and 5 are not reported.

The peak in unintentional substance-related injury hospitalizations occurred for both men and women at age 85 years plus. Overall, across all age groups, unintentional substance-related injury hospitalizations were more frequent among males, whereas intentional substance-related injury hospitalizations were more frequent among females.

Falls (65.8%) and motor vehicle collisions (11.4%) were the two most frequent external causes of unintentional injury hospitalizations between 2010/11 and 2020/21. The age-specific rates of total unintentional injury hospitalizations increased with age and were highest for those aged 85 years plus (men: 5315.4/100 000; women: 7112.2/100 000).

Age-specific rates of substance-related fall injury hospitalizations were highest for those aged 85 years and older, at a rate of 87.4/100 000 for men and 93.2/100 000 for women. Age-specific rates of substance-related motor vehicle collision injury hospitalizations were highest among those aged 20 to 29 years, with a hospitalization rate of 7.2/100 000 for men and 3.2/100 000 for women. Alcohol use co-occurred most frequently with fall (65.9%) and motor vehicle collision injuries (63.0%).

Age-specific rates of total intentional injury hospitalizations were slightly higher for males than females, except for females aged 10 to 14 years and 15 to 19 years, among whom intentional injuries were substantially higher. The age-specific rates of total intentional injuries peaked for men aged 20 to 29 years (139.6/100 000) and for girls aged 15 to 19 years (244.5/100 000).

Substance-related assault injury hospitalizations were recorded more frequently for males, and substance-related self-inflicted injury hospitalizations for females. Substance-related assault injuries peaked at 30 to 39 years at a rate of 9.9/100 000 for men and 3.2/100 000 for women. Substance-related self-inflicted injuries peaked among males and females aged 15 to 19 years at a rate of 35.8 and 114.4/100 000, respectively.

Among assault-related injury hospitalizations, alcohol use accounted for 68.8% of substance-related hospitalizations; among self-inflicted injury hospitalizations, poly-substance use accounted for 60.1% of substance-related injury hospitalizations.

Discussion

This study shows the recent trends in substance-related injury hospitalizations in Canada across age groups (<1 to ≥85 years). Our results reveal that unintentional injuries accounted for more than half of all substance-related injury hospitalizations from 2010/11 to 2020/21. During this period, there was a significant increase in substance-related injury hospitalizations overall, with stimulants, opioids, cannabinoids and alcohol showing a significant increase among both males and females.

Unintentional substance-related injury hospitalizations increased with age, while intentional substance-related injuries occurred

more frequently among adolescents and young adults (age 15–19 and 20–29 years). Males had higher rates of unintentional substance-related injury hospitalizations related to falls and motor vehicle collisions than did females. Females had higher rates of self-inflicted substance-related intentional injury hospitalizations, while males had higher rates of assault injuries.

We found that polysubstance was the most frequently reported substance in almost all the age groups. Zuckermann et al.[16] observed an increase in use of more than one substance among Canadian high school students between 2013/14 and 2017/18. The Canadian Institute for Health Information reported that cannabis, unknown substances (including mixed substances) and alcohol were the three substance groups most commonly indicated with hospital stays for harms caused by substance use by youth aged 10 to 24 years,[17] which is in line with our findings.

Consuming multiple substances simultaneously has been attributed with increased adverse health outcomes and adds additional treatment complexity for health care providers.[18] This may explain the high rates of injury hospitalizations co-occurring with polysubstance use diagnoses in our study.

Our results indicate that injury hospitalizations co-occurring with opioid use were most prevalent among older adults aged 85 years plus, whereas previous studies observed that adults aged 65 years plus had the second highest prevalence of opioid use (11.3%) after adults aged 25 to 64 years (12.1%).[19,20] This difference in results may be due to factors such as age, pre-existing comorbidities and injury severity that require additional interventions or treatments.

Our findings show an overall increase in injury hospitalizations of both males and females co-occurring with substance use since 2010/11. There is little Canadian surveillance reporting on overall trends in substance-related hospitalizations or injury hospitalizations with substance use. Previous Canadian surveillance reports indicate that hospitalizations for harms due to any substance use increased from 2007 to 2014[21] and from 2017 to 2020.[22] US surveillance shows that the prevalence of

substance use disorders among hospitalizations has increased from 2014 to 2018 by about 57%.[23]

The high prevalence of alcohol use in Canada that other studies report[20,21,24] aligns with our study results. We found alcohol to be the second most frequently reported substance associated with injury hospitalizations and that approximately 28% of all substance-related injuries involve only alcohol. Beverage alcohol is legal and readily accessible in Canada,[21] which likely explains the high prevalence of alcohol-related injury hospitalizations that we observed. Any stigma surrounding alcohol use is likely less apparent than for other substances, and individuals may be less apprehensive about seeking medical attention for injuries related to alcohol than for illegal substances.

We found that cannabinoids account for less than 1% of all substance-related injury hospitalizations, which is low relative to the proportion of the Canadian and North American population using cannabis.[20,25,26] Trends in the prevalence of cannabis use in Canada, prior to legalization in 2018, remained stable among youth and increased among adults.[27,28] After legalization, cannabis use by youth aged 15 to 17 years decreased, while use increased slightly among adults aged 18 years and older.[26] Prior to legalization, individuals may have chosen not to seek medical care while under the influence of cannabis to avoid legal repercussions.[29,30] Yet, despite being commonly considered less harmful than other psychoactive substances, cannabis can have adverse effects, especially in terms of effects on psychomotor skills.[31,32] Other countries have reported an increase in cannabis hospitalizations after legalization;[31] our results, in contrast, show increasing cannabis hospitalizations since 2010/11, with no significant changes after legalization in Canada.

Globally, the annual prevalence of illicit drug use was highest for stimulants, opioids and cocaine.[25] In Canada, overall use of illegal drugs (including cocaine, ecstasy, methamphetamines, hallucinogens and heroin) and stimulants has increased over the last several years, while use of psychoactive pharmaceuticals, sedatives and opioids has remained unchanged.[19,20,24,33] Although self-reported opioid pain reliever use in Canada has remained relatively stable since 2011,[19,20] our results show a

significant increase in opioid-related injury hospitalizations over the study period. This may be due to the effects of consuming opioids contaminated with, for example, fentanyl or other synthetic opioids. Fentanyl and other synthetic opioids are very potent, and when consumed unknowingly or in combination with other substances, increase the toxicity of the substance.[18,34] In addition, stigma or apprehension about the legal ramifications of use of illegal substances may influence an individual's decision to seek medical care.

Our results show that patterns in the rates of substance-related unintentional and intentional injury hospitalizations differ across age groups. In the case of intentional substance-related injury hospitalizations, a notable peak was observed among adolescents and young adults, particularly females aged 15 to 19 years. The most frequent external cause of injury among adolescents and young adults are those that are self-inflicted. Higher rates of self-inflicted injury hospitalizations, emergency department visits and suicide mortality among youth are well documented.[35,36,37] Lethality in self-inflicted injuries is higher among males than females, which may explain the higher rates of substance-related intentional injury hospitalizations among females than among males, as our study did not capture deaths that occur pre-admission to hospital.[38]

Polysubstance use co-occurred most frequently with self-inflicted injuries, whereas alcohol use co-occurred more frequently with assault injuries. Polysubstance was most frequently identified with hospitalizations for substance harms among those aged 10 to 24 years,[17] which aligns with the age groups most frequently hospitalized for substance-related self-inflicted injuries in our study. The prevalence of self-reported past-year alcohol use in Canada was highest among those aged 25 to 34 years,[21,39] which aligns with the peak in substance-related assault injuries among those aged 20 to 29 years and 30 to 39 years we found.

We found that substance-related unintentional injuries increased consistently with age, and that falls, the most frequent external cause of unintentional injuries, also increased with age. This aligns with recent Canadian surveillance that reported

that fall injury hospitalizations increase with age and are most frequent among those aged 80 years plus.[3] Certain psychotropic medications taken alone or with other medications or substances, such as alcohol, are associated with higher risk of falls in older adults.[11,40,41] The side-effects of some of these medications result in drowsiness, dizziness and hypotension, which can increase the risk of falls.[41] In addition, older adults may have comorbidities and frailties that increase the severity of injury after a fall.[41]

We also found that alcohol was the substance most frequently co-occurring with motor vehicle injury hospitalizations. Impaired driving continues to be one of the leading factors in motor vehicle collisions in Canada, with over 85 000 incidents of police-reported impaired driving reported in 2019.[42,43] Males (77%) and young adults aged 20 to 34 years (44%) are most frequently charged with alcohol- and drug-impaired driving;[43] this may explain the observed peak in unintentional substance-related motor vehicle collision injuries for those aged 20 to 29 years and the higher rates in men than in women.

Since the start of the COVID-19 pandemic, patterns of hospitalizations have changed in Canada, with fewer overall hospitalizations.[44] Still, the number of substance-related hospitalizations increased by 5% between March and September 2020 compared with the same period in 2019 (n = 76 948 vs. 80 954).[44] These patterns likely reflect changes in human behaviour as a result of widespread lockdowns to curb the spread of COVID-19.[45-47] Because of the impact of the pandemic on hospitalizations during 2020/21, results for this fiscal year should be interpreted with caution.[47]

Limitations

The DAD excludes hospitalization data from Quebec, which accounts for approximately 23% of the Canadian population.[48] Furthermore, these results only include injuries resulting in acute care hospitalizations, and not deaths or emergency department visits.

Several substance-related ICD-10 codes are categorized under mental and behavioural disorders, and for diagnosis, rely on a categorical approach based on self-reported or clinically observable symptoms.[49,50] Substance diagnostic codes are only reported in cases where the substance

was a significant contributor in the overall diagnosis or episode of care, which may lead to an underrepresentation in the number of injuries that had a co-occurring substance diagnosis. As a result, there is also potential for under- or over-reporting of substance diagnostic codes, as health care providers may have an implicit bias that would influence whether they consider a substance as significantly contributing towards a patient's episode of care.

An additional limitation, inherent to administrative data, is the inability to determine temporality between substance and injury diagnostic codes in a single episode of care, which means that causality cannot be assumed. Although our study provides an overview of injury hospitalizations with co-occurring substance use diagnoses, the exact relationship between injuries and substances cannot be interpreted.

Conclusion

Injuries with a co-occurring substance diagnosis have accounted for 12% of total injury hospitalizations over the last 11 years. Our results highlight demographic groups that have higher rates of substance-related injury hospitalizations, and therefore would benefit from targeted prevention efforts. Given the evolving opioid epidemic, continued alcohol use and the increased prevalence of polysubstance use, understanding the relationship between substance consumption and injuries is essential in order to implement public health policy and programs for prevention.

This study is part of a larger project that focusses on substance-related injury hospitalizations prior to and during the COVID-19 pandemic.

Acknowledgements

Conflicts of interest

The authors declare that they have no conflicts of interest.

Authors' contributions and statement

ST, SRM and WT conceptualized the project and methodology.

ST conducted the analysis and led the writing of the manuscript.

All authors provided feedback on the draft and reviewed and approved the final manuscript.

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

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Evidence synthesis

Scoping review of adult-oriented outdoor play publications in Canada

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Abstract

Introduction: Since 2015, there has been growing interest in Canada and beyond on the benefits of outdoor play for physical, emotional, social and environmental health, well-being and development, for adults as well as children and youth.

Methods: This scoping review aims to answer the question, "How, and in what context, is adult-oriented outdoor play being studied in Canada?" We conducted an electronic search for peer-reviewed articles on outdoor play published in English or French after September 2015 by authors from Canadian institutions or about Canadian adults. The 224 retrieved articles were organized according to eight priorities: health, well-being and development; outdoor play environments; safety and outdoor play; cross-sectoral connections; equity, diversity and inclusion; professional development; Indigenous Peoples and land-based outdoor play; and COVID-19. We tallied the study designs and measurement methods used.

Results: The most common priority was outdoor play environments; the least common were COVID-19 and Indigenous Peoples and land-based outdoor play. Cross-sectional studies were the most common; no rapid reviews were identified. Sample sizes varied from one auto-ethnographic reflection to 147 000 zoo visitor datapoints. More studies used subjective than objective measurement methods. Environmental health was the most common outcome and mental/emotional development was the least.

Conclusion: There has been a staggering amount of articles published on adult-oriented outdoor play in Canada since 2015. Knowledge gaps remain in the relationship between outdoor play and adult mental/emotional development; the connections between environmental health and Indigenous cultures and traditions; and how to balance promoting outdoor unstructured play with protecting and preserving natural spaces.

Highlights

- We identified 224 Canadian articles on adult-oriented outdoor play.
- The most common priority was outdoor play environments; the least common were COVID-19 and Indigenous Peoples and land-based outdoor play.
- This scoping review highlights the staggering amount of articles published on adult-oriented outdoor play in Canada since 2015, identifies gaps in knowledge and provides recommendations for future work.

Introduction

The *Position Statement on Active Outdoor Play* (Position Statement)[1] highlighted the many benefits of outdoor play on children's physical, mental, emotional, social and environmental health, development and well-being.[2,3] The Position Statement served to galvanize the outdoor play sector and bring together stakeholders with overlapping interests in outdoor play and children's health and well-being from the education, community, health, environment, parks, wildlife, ecology, law and Indigenous rights sectors, among others.[1]

The Position Statement also led to the formation of Outdoor Play Canada,[4] a network of thought leaders working together to promote, protect and preserve access to play in nature and the outdoors for people of all ages living in Canada. Seven years later, Outdoor Play Canada launched the *Outdoor Play in Canada: 2021 State of the Sector Report* (State of the Sector Report)[5] to reinvigorate the momentum set off by the Position Statement, to reflect on efforts achieved since its release, and to identify a common vision for the outdoor play sector.

This scoping review is part of that larger State of the Sector Report.[5] We sought to determine the volume of published outdoor play research by authors from Canadian institutions or about a Canadian population since the release of the Position Statement[1] and identify where existing evidence is concentrated and where further knowledge generation is required. We categorized all included outdoor play articles according to eight of the nine priorities identified in the State of the Sector Report[5] ("the common vision") to identify where there is substantial knowledge and evidence to inform practice and

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policy and where knowledge gaps remain. We did not include the "research and support data collection on outdoor play" priority because all published research papers align with this priority.

In this scoping review, we used the definition of outdoor play developed in the *Play, Learn and Teach Outdoors Network (PLaTO-Net) Terminology, Taxonomy, Ontology Global Harmonization Project*,[6] that outdoor play is "a form of play that takes place outdoors" and play is "voluntary engagement in activity that is fun and/or rewarding and usually driven by intrinsic motivation." We also adhered to the Ryan and Deci[7,p.56] definition of intrinsic motivation as "doing an activity for its inherent satisfaction rather than for some separable consequence" (e.g. cracking thin ice puddles, making art for art's sake).

As these broad definitions do not limit play to children, we did not limit the scope of this review to this age group. We identified 416 published articles in our initial search in March 2021 and 447 articles in a second search in March 2022. This was a staggering increase in the number of publications from the original 49 articles (not exclusively Canadian authors or populations) used to inform the Position Statement. Given the number of articles identified, we separated the included articles into two: literature on children's and youth's outdoor play and on adult-oriented outdoor play. This scoping review focusses on adult-oriented outdoor play and aims to determine how, and in what context, adult-oriented outdoor play is being studied in Canada.

Methods

The methods for this systematic scoping review have been described in detail in an article on child- and youth-oriented outdoor play.[8] Briefly, we followed the Preferred Reporting Items for Systematic Reviews and Meta-analysis Extension for Scoping Review (PRISMA-ScR) guidelines[9] (checklist available on request from the authors). We also used the Arksey and O'Malley[10] framework and completed the following six steps: (1) identifying the research question; (2) identifying relevant studies; (3) selecting eligible studies; (4) charting the data; (5) collating, summarizing and reporting of results; and (6) consulting with relevant stakeholders.

Search strategy

We conducted an electronic search, led by KB, first in March 2021 and then again in March 2022, via Ovid MEDLINE, EBSCO Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Scopus. A description of the full search strategy and the search terms used have been published elsewhere[7] and are also available at https://osf.io/xyrcb.

Study inclusion criteria

We used the population, concept and context framework[11] to shape our research question and guide the development of the inclusion criteria. Included articles were

- written by authors from Canadian institutions or examined a Canadian population;
- in either of the two official languages in Canada (English and French); and
- published between the release of the Position Statement, in September 2015, and March 2022.

We based our definition of outdoor play on the definition developed in the PLaTO-Net Terminology, Taxonomy, Ontology Global Harmonization Project,[6] which does not limit play to children; as such we did not place any limits on participant age.

Study selection

Articles that met the inclusion criteria were downloaded and imported into Covidence (Veritas Health Innovation, Melbourne, AU). Following de-duplication, two reviewers (LDL and KB) worked independently to screen the titles and abstracts (level 1 screening) of included articles using the population, concept and context framework.[11] For full-text screening (level 2 screening), at least two of three reviewers (LDL, KB and NS) had to agree on final inclusion, resolving any conflicts through discussion to achieve consensus.

Data extraction

Three reviewers met weekly during the extraction phase to discuss any uncertainties and ensure standardization of the extraction protocol and to agree upon any amendments to the data extraction form (adapted from de Lannoy et al.[8]), for example, if new outcomes had emerged.

The following data were extracted from each article using the Covidence extraction template: title, country, population (children/youth < 18 years; adults ≥ 18 years; or both); study design; measurement of outdoor play; and outcomes associated with outdoor play. The outcomes associated with outdoor play included the following:

- cognitive development ("the process by which human beings acquire, organize and learn to use knowledge");[12,p.317]

- cognitive health ("the ability to clearly think, learn and remember");[13]

- environmental health ("the interconnections between people and their environment by which human health and a balanced, nonpolluted environment are sustained or degraded");[14,p.995]

- general well-being ("the combination of feeling good and functioning well");[15]

- mental development ("the progressive changes in mental processes due to maturation, learning and experience") and emotional development ("gradual increase in the capacity to experience, express, and interpret the full range of emotions and in the ability to cope with them appropriately")[16]

- mental/emotional health ("the state of psychological and emotional well-being");[17]

- physical development (advancements and growth of the body, including the brain, muscles and senses, and the refinements of motor skills);[18,19]

- physical health ("the body's physical state and how well it works,"[20,p.381] and "taking into consideration everything from the absence of disease to fitness level");[21]

- quality of life ("an individual's perception of their position in life in the context of the culture in which they live and in relation to their goals, expectations, standards and concerns"[22,p.1403]);

- skills development (an "ability and capacity acquired … to smoothly and adaptively carry out complex activities or … functions"[23,p.5]); and

- social health ("that dimension of an individual's well-being that concerns how [they] get along with other people, how other people react to [them] and how [they] interact with social institutions and societal mores").[24,p.75]

After data extraction, the template containing the extracted data was downloaded and expanded upon to synthesize themes related to study design and measurement of outdoor play.

We organized retrieved studies by design into the following categories: literature review, systematic review, meta-analysis, scoping review, rapid review, commentary, randomized controlled trial (RCT), non-RCT, longitudinal study, cross-sectional study or mixed methods study according to established definitions.[25]

Measurement of outdoor play was categorized as objective or subjective. Objective measurements included use of a device (e.g. accelerometer, Global Positioning System); observations (e.g. system of observing outdoor play); or environmental assessment (e.g. examination of neighbourhood correlates of outdoor play). Subjective measurements included proxy report (e.g. parent reporting on their child's behaviour), self-report (e.g. an individual reporting on their own behaviour) and narrative (e.g. single-person retelling of an experience). In addition, we extracted themes related to the priorities identified in the State of the Sector Report[5] (see Table 1), as this scoping review was conducted as part of that report.

Data synthesis

Because of the large number of articles meeting the inclusion criteria following level 2 screening (n = 447), the data were separated into two datasets according to age (children/youth < 18 years; adults ≥18 years). If an article included both children/youth and adults, it was included in both datasets.

We organized the articles according to the priorities identified in the State of the Sector Report (see Table 1), recognizing that many articles align with more than one priority. We then counted the articles categorized according to each priority, each type of study design and measurements of outdoor play.

Stakeholder engagement

The various components of the State of the Sector Report, including the scoping reviews used to identify the outdoor play research published since the release of the Position Statement, were discussed during a series of four meetings by a 63-person national cross-sectoral consultation group. In addition, at the launch of the State of the Sector Report at the 2021 Breath of Fresh Air Summit, stakeholders discussed how this scoping review could identify a base of knowledge on equity, diversity and inclusion efforts in the field of outdoor play.

More information on the process of developing the State of the Sector Report is available on the Outdoor Play Canada website (www.outdoorplaycanada.ca/ssr).

Results

Study selection

Our search of Canadian-focussed peer-reviewed outdoor play publications retrieved 4327 results. A total of 591 duplicates were removed, resulting in 3736 articles sent to level 1 screening. After removal of irrelevant articles (n = 2979), 757 articles underwent level 2 screening. At this point, 310 articles were excluded because they did not measure or focus on outdoor play (n = 156; 50%); they were published before September 2015 (n = 77; 25%); they did not study a Canadian population or were not written by an author from a Canadian institution (n = 60; 19%); they were not considered to be journal articles (e.g. they were conference proceedings, etc.; n = 12; 4%); the full-text could not be located (n = 4; 1%); or they were not published in either English or French (n = 1; <1%). For the full review, 447 articles were deemed relevant; 223 articles that focussed solely on children/youth underwent a separate scoping review,[8] and 224 articles that focussed on adult-oriented outdoor play were included in this scoping review.

See Figure 1 for a visual representation of the screening process.

Study characteristics

An overview of the characteristics of each included study is shown in Supplementary Table 1 (https://osf.io/8n32x). By definition, all studies focussed on adults 18 years and older (some also included children/families) and were written by authors from Canadian institutions or were works that studied a Canadian population. Sixteen studies included data from both Canadian and international populations,[28-43] and in one, a Canadian research team analyzed data exclusively from international populations.[42] Sample sizes varied substantially and ranged from an auto-ethnographic reflection by one individual involved in a community gardening project[45] to 147 000 data points on zoo visitors over 16 years.[46]

Outdoor play themes

A central aim of this scoping review was to identify how many of the included articles align with each of the priorities identified in the State of the Sector Report, recognizing that many would align with more than one. We sorted included articles according to one or more of the following priorities, in order, from highest to lowest number of included studies: outdoor play environments (n = 165); health, well-being and development (n = 163); cross-sectoral connections (n = 66); professional development (n = 40); safety and outdoor play (n = 37); equity, diversity and inclusion (n = 36); Indigenous Peoples and land-based outdoor play (n = 16); and COVID-19 (n = 10). As previously mentioned, by the nature of their being published, all studies could be included in the "research and support data collection on outdoor play" priority; as a result, we did not use this priority when categorizing the articles.

Outdoor play study design

Cross-sectional studies were the most common study design across the State of the Sector Report (see Table 2). No rapid reviews were identified. There were no commentaries in the Indigenous Peoples and land-based outdoor play and COVID-19 priorities; no meta-analyses in the cross-sectoral connections, equity, diversity and inclusion, professional development, safety and outdoor play, Indigenous Peoples and land-based outdoor play or COVID-19 priorities; no mixed-methods studies in the COVID-19 priority; no non-RCT interventions in the equity, diversity and inclusion, Indigenous Peoples and land-based outdoor play, and COVID-19 priorities; no RCTs in the outdoor play environments, equity, diversity and inclusion, Indigenous Peoples and land-based outdoor play and COVID-19 priorities; no scoping reviews in the safety and outdoor play, professional development and COVID-19 priorities; and no systematic reviews in the professional development and COVID-19 priorities.
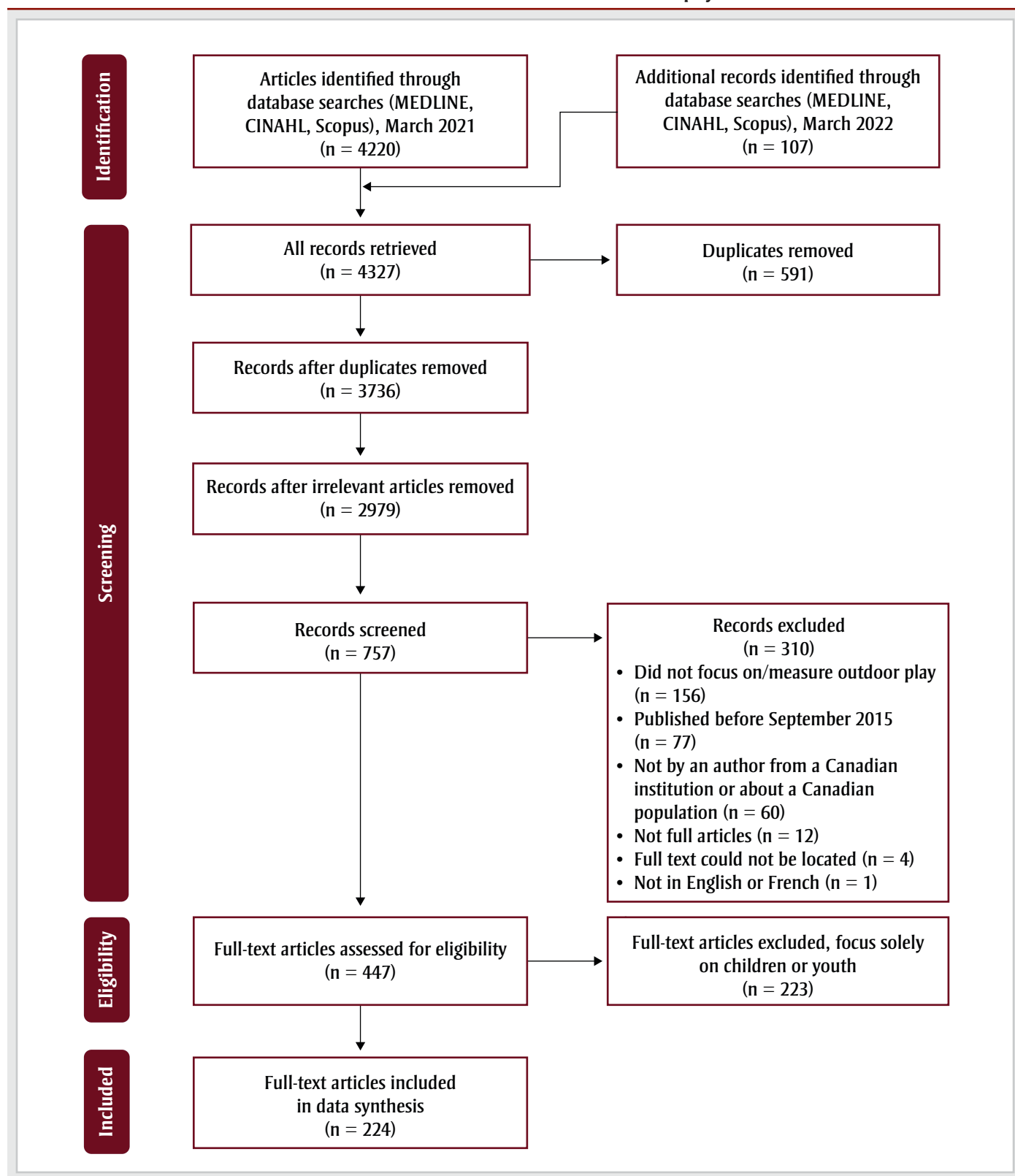
TABLE 1
Description of the State of the Sector Report[a] priorities

Priority[b]	Brief description	Number of action items and examples
Promote, protect, preserve and invest in outdoor play environments (Outdoor play environments)	This priority is intended to be inclusive of all outdoor spaces where outdoor play may occur—built environments (e.g. playgrounds, streets) and existing natural spaces. It highlights synchronicities between outdoor play and sustainability efforts (e.g. development of sustainable cities and communities).	15 action items E.g. Accept a shared responsibility for connection and access to the Land, where "Land" includes peoples, cultures, languages and knowledge.
Promote the health, well-being and developmental benefits of outdoor play (Health, well-being and development)	This priority is intended to recognize the importance of outdoor play for physical, mental, emotional and social development of children and the health and well-being of people of all ages, while providing specific actions for how this information may be promoted across sectors.	7 action items E.g. Promote an understanding of the value and benefit of play for all ages.
Expand and enable cross-sectoral connections/collaborations (Cross-sectoral connections)	This priority recognizes that outdoor play initiatives, programs and projects are found across many sectors. To develop and promote outdoor play priorities, we need to promote connections and collaborations across sectors so that we work together, learn from each other and amplify each other's work.	6 action items E.g. Develop cross-sectoral connections and identify other stakeholders who will help fuel the development of measurement tools.
Increase and improve professional development opportunities in outdoor play (Professional development)	This priority recognizes the need to increase and improve professional development opportunities in outdoor play for educators (e.g. early childhood educators, elementary and secondary school educators) as well as for those across all sectors involved in outdoor play (parents, coaches, health professionals, built environment professionals, students). This is crucial to help shift mindsets and provide tools to advocate for and promote outdoor play.	15 action items E.g. Work with colleges and universities to make sure that training on outdoor play is available in early childhood education programs.
Reframe views on safety and outdoor play (Safety and outdoor play)	This priority focusses on the need to reframe the ways liability and safety are applied to outdoor play opportunities to improve the balance between protecting against injury and promoting beneficial play opportunities.	10 action items E.g. Take an assets-based approach; base decisions surrounding outdoor play on assets rather than on liabilities.
Advocate for equity, diversity and inclusion in outdoor play (Equity, diversity and inclusion)	This priority is grounded in and builds upon the UN Convention on the Rights of the Child, which recognizes "the right of the child to rest and leisure, to engage in play and recreational activities appropriate to the age of the child and to participate freely in cultural life and the arts."[26]	9 action items E.g. Ensure that diverse groups, including Indigenous Peoples, and children and youth, are at outdoor play leadership tables.
Ensure that outdoor play initiatives are Land-based and represent the diverse cultures, languages and perspectives of Indigenous Peoples of North America (Indigenous Peoples and land-based outdoor play)	This priority recognizes that Indigenous Peoples have lived on and played in connection with the Land we now call Canada since time immemorial, and that supporting, learning about and engaging in Indigenous-led land-based outdoor play provides an opportunity to build trusting and respectful relationships between Indigenous Peoples and non-Indigenous people, move towards reconciliation and raise the next generation of environmental stewards.	7 action items E.g. Focus on creating ethical and safe spaces to support Indigenous and western worldviews coming together respectfully and in a balanced way. Find ways to support these respectful partnerships.
Leverage engagement opportunities with the outdoors during and after COVID-19 (COVID-19)	This priority highlights how the COVID-19 pandemic led to a rediscovery of the outdoors for physical and mental health, for enjoyment, fun and relaxation. This rediscovery has great potential to be an accelerator for outdoor play efforts.	6 action items E.g. Leverage the current opportunity (the pandemic) to push the importance of outdoor play and recognize the advantages it brings. Preserve neighbourhood changes that have encouraged and facilitated spontaneous outdoor play.
Research and support data collection on outdoor play (Research and data collection)	This priority focuses on gaps in knowledge related to outdoor play, and the research and data collection efforts that are needed to address those gaps. It also recognizes that research and knowledge on outdoor play needs to be made accessible to governments, policy makers, educators, community organizations and the private sector.	10 action items E.g. Create valid and reliable outdoor play measurement tools and resources and promote the use of these tools to achieve greater consistency and reproducibility across research groups.

[a] *Outdoor Play in Canada: 2021 State of the Sector Report.*[5]

[b] The short name of each priority as used in this manuscript is shown in parentheses.

FIGURE 1
PRISMA-ScR flow diagram[a] of the identification, screening, eligibility
and inclusion of studies of adult-oriented outdoor play

TABLE 2
Articles organized according to the State of the Sector Report[a] priorities, by study design (n = 224)

Study design	Articles per priority, % (n)[b]							
	Outdoor play environments (n = 165)	Health, well-being and development (n = 163)	Cross-sectoral connections (n = 66)	Professional development (n = 40)	Safety and outdoor play (n = 37)	Equity, diversity and inclusion (n = 36)	Indigenous Peoples and land-based outdoor play (n = 16)	COVID-19 (n = 10)
Commentary	4.8 (8)	6.1 (10)	3.0 (2)	5.0 (2)	2.7 (1)	2.8 (1)	0	0
Cross-sectional study	58.2 (96)	55.8 (91)	53.0 (35)	60.0 (24)	56.8 (21)	58.3 (21)	43.8 (7)	80.0 (8)
Literature review	15.2 (25)	11.0 (18)	15.2 (10)	15.0 (6)	21.6 (8)	19.4 (7)	31.3 (5)	10.0 (1)
Longitudinal study	6.7 (11)	6.7 (11)	12.1 (8)	5.0 (2)	2.7 (1)	5.6 (2)	6.3 (1)	10.0 (1)
Meta-analysis	0.6 (1)	0.6 (1)	0	0	0	0	0	0
Mixed methods	10.3 (17)	13.5 (22)	18.2 (12)	15.0 (6)	10.8 (4)	16.7 (6)	12.5 (2)	0
Non-RCT intervention	4.8 (8)	5.5 (9)	3.0 (2)	5.0 (2)	5.4 (2)	0	0	0
RCT	0	0.6 (1)	1.5 (1)	2.5 (1)	2.7 (1)	0	0	0
Rapid review	0	0	0	0	0	0	0	0
Scoping review	2.4 (4)	3.1 (5)	1.5 (1)	0	0	2.8 (1)	6.3 (1)	0
Systematic review	4.8 (8)	4.3 (7)	3.0 (2)	0	2.7 (1)	8.3 (3)	12.5 (2)	0

Abbreviation: RCT, randomized controlled trial.

[a] *Outdoor Play in Canada: 2021 State of the Sector Report.*[5]

[b] Percentage of the total number of articles within each State of the Sector Report priority, with count in parentheses.

Measurement of outdoor play

Articles were also grouped and tallied according to measurement of outdoor play and further subdivided into objective and subjective measures (see Table 3). Across all State of the Sector Report priorities, subjective measures were more common than objective measures.

The most common method of subjective measurement was narrative, except in studies within the outdoor play environments and COVID-19 priorities, which used self-reports more often. Proxy reporting was the least common subjective method of measurement, except for the COVID-19 priority, where narrative was the least common subjective method of measurement.

Observation was the most common objective method of measurement across priorities, tying with devices as the most common measure within the professional development and COVID-19 priorities. Devices alone were the most common objective method of measurement for the safety and outdoor play priority.

Environmental assessment was the least used objective method of measurement, except for studies within the equity, diversity and inclusion priority, where none of the studies used devices as their objective method of measurement.

Commentary themes

Commentaries were grouped into three main themes: outdoor play and climate change/ecological impacts; outdoor play as a method or facilitator of learning; and outdoor play and physical and/or mental well-being (see Table 4). Across State of the Sector Report priorities, outdoor play and physical and/or mental well-being was the most common commentary theme. Outdoor play as a method or facilitator of learning was the least common theme and, alongside the theme on outdoor play and climate change/ecological impacts, was not found in the cross-sectoral connections, professional development, safety and outdoor play, equity, diversity and inclusion, Indigenous Peoples and land-based outdoor play or COVID-19 priorities.

Outcomes

Within each of the State of the Sector Report priorities, articles were categorized and tallied according to outcome (see Table 5). Environmental health was the most common outcome for half of the priorities, namely outdoor play environments, cross-sectoral connections, professional development (tied as most common with skills development) and Indigenous Peoples and land-based outdoor play.

In contrast, mental/emotional development was not identified as an outcome in any of the priorities. Cognitive health as an outcome was not found within the safety and outdoor play or COVID-19 priorities. Cognitive development, physical development, quality of life and skills development were other outcomes not found within the COVID-19 priority.

Discussion

As for our scoping review on children's and youth's outdoor play,[8] the number of articles published on adult-oriented outdoor play in Canada over the past 7 years and included in this review is remarkable compared to other reviews on Canadian leisure research from past years.[47] The COVID-19 pandemic led to a pattern of reengaging with the outdoors for safe social gatherings, the health benefit and, more simply, as "something to do" in the face of pandemic-related restrictions.[48] This reengagement may have contributed to the surge in outdoor play publications in 2020, as did the increase in the number of researchers who, in accordance with health-related guidelines put in place to decrease transmission of SARS-CoV-2, were unable to spend time in the lab or field and instead focussed on writing.[49]

Despite this surge, we observed areas where further research is required, namely

TABLE 3
Articles organized according to the State of the Sector Report[a] priorities, by measures of outdoor play (N = 224)

Measures	Articles per priority, % (n)[b]							
	Outdoor play environments (n = 165)	Health, well-being and development (n = 163)	Cross-sectoral connections (n = 66)	Professional development (n = 40)	Safety and outdoor play (n = 37)	Equity, diversity and inclusion (n = 36)	Indigenous Peoples and land-based outdoor play (n = 16)	COVID-19 (n = 10)
Subjective measures								
Narrative	41.2 (68)	50.9 (83)	63.6 (42)	55.0 (22)	45.9 (17)	52.8 (19)	56.3 (9)	0
Proxy report	5.5 (9)	6.7 (11)	4.5 (3)	2.5 (1)	10.8 (4)	2.8 (1)	0	20.0 (2)
Self-report	44.2 (73)	47.2 (77)	47.0 (31)	47.5 (19)	32.4 (12)	41.7 (15)	31.3 (5)	60.0 (6)
Objective measures								
Device	8.5 (14)	7.4 (12)	4.5 (3)	7.5 (3)	10.8 (4)	0	6.3 (1)	10.0 (1)
Environmental assessment	7.9 (13)	3.7 (6)	3.0 (2)	0	0	5.6 (2)	0	0
Observations	11.5 (19)	10.4 (17)	9.1 (6)	7.5 (3)	8.1 (3)	11.1 (4)	12.5 (2)	10.0 (1)

[a] *Outdoor Play in Canada: 2021 State of the Sector Report.*[5]

[b] Percentage of the total number of articles within each State of the Sector Report priority, with count in parentheses.

on Indigenous and land-based outdoor play as well as outcomes related to adult-oriented mental/emotional development.

Outdoor play priorities

We included all ages in the scoping review to adhere to the PLaTO-Net definition of outdoor play.[6] We subsequently decided to separate the data according to age (children/youth and adults) because of the large number of articles retrieved based on our inclusion criteria and because we surmised that adult-oriented outdoor play would explore different themes and outcomes and may be measured and expressed differently from children's and youth's outdoor play. Accordingly, the

outdoor play environments priority was the more common focus of studies on adult-oriented outdoor play, whereas health, well-being and development was the primary focus in the scoping review on children's and youth's outdoor play.[8] Similarly, environmental health (e.g. pro-environmental leisure activity, behaviour and/or stewardship), was the most common outcome studies of adult-oriented outdoor play examined, while in children and youth this was physical health (see Supplementary Table 2; https://osf.io/46yfx).

Of concern is that the Indigenous Peoples and land-based outdoor play priority continues to be among the least common

(n = 16), second only to COVID-19 (n = 10), despite recognized connections between the environment, environmental health and Indigenous cultures and traditions[44,50-52] For example, in the article by Mikraszewicz and Richmond in 2019,[50] the authors present the reflections of Elders and youth canoeing the length of the Pic River on the ways the journey fostered and was pivotal to promoting cultural identity, traditional knowledge sharing and land stewardship. The State of the Sector Report[5] identifies seven action items (see Table 1) to support the Indigenous Peoples and land-based outdoor play priority, help build trusting relationships between local Indigenous and non-Indigenous people, address the

TABLE 4
Articles organized according to State of the Sector Report[a] priorities, by commentary theme (N = 224)

Commentary themes	Articles per priority, % (n)[b]							
	Outdoor play environments (n = 165)	Health, well-being and development (n = 163)	Cross-sectoral connections (n = 66)	Professional development (n = 40)	Safety and outdoor play (n = 37)	Equity, diversity and inclusion (n = 36)	Indigenous Peoples and land-based outdoor play (n = 16)	COVID-19 (n = 10)
Outdoor play and climate change/ ecological impacts	1.8 (3)	1.9 (3)	0	0	0	0	0	0
Outdoor play as a method/facilitator of learning	1.2 (2)	1.2 (2)	0	0	0	0	0	0
Outdoor play and physical and/or mental well-being	3.0 (5)	4.3 (7)	3.0 (2)	5.0 (2)	2.7 (1)	2.8 (1)	0	0

[a] *Outdoor Play in Canada: 2021 State of the Sector Report*.[5]

[b] Percentage of the total number of articles within each State of the Sector Report priority, with count in parentheses.

TABLE 5
Articles organized according to the State of the Sector Report[a] priorities, by outcome (N = 224)

Outcome	Articles per priority, % (n)[b]							
	Outdoor play environments (n = 165)	Health, well-being and development (n = 163)	Cross-sectoral connections (n = 66)	Professional development (n = 40)	Safety and outdoor play (n = 37)	Equity, diversity and inclusion (n = 36)	Indigenous Peoples and land-based outdoor play (n = 16)	COVID-19 (n = 10)
Cognitive development	5.5 (9)	8.0 (13)	15.2 (10)	20.0 (8)	5.4 (2)	5.6 (2)	12.5 (2)	0
Cognitive health	6.7 (11)	8.0 (13)	6.1 (4)	7.5 (3)	0	8.3 (3)	12.5 (2)	0
Environmental health	65.5 (108)	42.9 (70)	48.5 (32)	42.5 (17)	35.1 (13)	41.7 (15)	62.5 (10)	20.0 (2)
General well-being	21.8 (36)	29.4 (48)	21.2 (14)	15.0 (6)	27.0 (10)	38.9 (14)	31.3 (5)	40.0 (4)
Mental/emotional development	0	0	0	0	0	0	0	0
Mental/emotional health	23.6 (39)	34.4 (56)	24.2 (16)	12.5 (5)	24.3 (9)	30.6 (11)	43.8 (7)	30.0 (3)
Physical development	4.2 (7)	4.9 (8)	4.5 (3)	10.0 (4)	2.7 (1)	5.6 (2)	0	0
Physical health	27.9 (46)	38.7 (63)	24.2 (16)	12.5 (5)	48.6 (18)	30.6 (11)	12.5 (2)	80.0 (8)
Quality of life	4.2 (7)	5.5 (9)	4.5 (3)	2.5 (1)	2.7 (1)	11.1 (4)	12.5 (2)	0
Skills development	13.9 (23)	15.3 (25)	30.3 (20)	42.5 (17)	24.3 (9)	22.2 (8)	25.0 (4)	0
Social health	34.5 (57)	44.2 (72)	40.9 (27)	27.5 (11)	35.1 (13)	58.3 (21)	50.0 (8)	30.0 (3)

[a] *Outdoor Play in Canada: 2021 State of the Sector Report.*[5]

[b] Percentage of the total number of articles within each State of the Sector Report priority, with count in parentheses.

Truth and Reconciliation Commission's Calls to Action,[53] and raise the next generation of environmental stewards. Addressing these actions is one approach the outdoor play sector can take to promote the recognition of Indigenous knowledge as integral to advancing outdoor play environments.

Outdoor play outcomes

As with the scoping review of children's and youth's outdoor play,[8] the least commonly measured outcome for adult-oriented outdoor play was mental/emotional development; in fact, our search through three health-centred databases of peer-reviewed articles did not retrieve any articles that explored this outcome. However, we identified many articles that explored mental/emotional health (n = 59).

A similar pattern was observed for articles examining the effect of adult outdoor play on physical development and physical health, with very few articles identified for physical development (n = 8) and many more for physical health (n = 73). What is curious is that the number of articles on cognitive development and cognitive health was the same (n = 15, each). This suggests that while recognition and interest are growing in the area of cognitive development and outdoor play in adult populations, the same is not true

for mental/emotional and physical development, highlighting a major gap and opportunity for future research.

A common thread through articles that explored cognitive development was a focus on outdoor educational programs with opportunities for learning for both students and practitioners. These studies often explored how child-led outdoor learning challenges traditional pedagogical approaches.[54-60] In a similar vein, in Leather et al.,[61] co-authors from Canada and the United Kingdom challenged conventional postsecondary pedagogy and showed how play may serve to promote creativity, wellness and graduate employability among adult learners.

Although the benefits of outdoor play for adult learners and practitioners have historically received little attention, this is beginning to change. In Scotland, for example, outdoor play programs are reported to expand practitioner teaching and learning opportunities and support their sense of resilience and well-being.[62] Outdoor play as a pedagogical approach is discussed in the professional development priority and represents the need to increase and improve opportunities for high-quality professional development in outdoor play. It is therefore encouraging that there is a growing body of evidence

that may be used to support the action items within this priority and the notion of outdoor play as an avenue for lifelong learning.

Measurement of outdoor play

The results of this scoping review show that adult outdoor play typically focusses on outdoor recreation and leisure, although some articles discuss adult outdoor play in the context of co-play with children.[63-66] Accordingly, outdoor play was often measured through narrative interviews with recreation and leisure participants. For example, Neumann and Mason[67] allowed interviewed facility managers to stray from the pre-prepared interview questions in order to more effectively describe the unique or specific ways in which they were able to sustainably resolve conflicts between cross-country skiers and fat bikers sharing recreational trails. In other papers in this scoping review, this form of interviewing, which allows participants the space to describe their experiences across time in relation to the topic of study, is often described as "storytelling."[68,69]

Although subjective measures, such as these narrative interviews, were the most common method of measurement (see Table 3), as was observed for children's

and youth's outdoor play,[8] fewer studies examining adult-oriented play used a combination of subjective and objective methods of measurement. Using a combination of measures to assess children's and youth's outdoor play may be necessary as their play is less structured and more spontaneous than adults' outdoor play and therefore more difficult to assess. But it is also plausible that the field of adult play is underdeveloped and less rigorously studied because play is typically considered an activity that is important for children and youth at various developmental stages.

When several methods were used to measure adults' outdoor play, objective measures were often used to assess physical activity and subjective measures to capture the experience and emotion associated with the activity. For example, in a study of the impact on visitor usage of converting an urban trail into a skate way during the winter, McGavock et al.[70] measured trail use and users' physical activity using objective measures and the impact on mental health with subjective measures. Both physical and emotional/mental elements are critical components of play for adults as well as children, as per the PLaTO-Net definition.[6] This reinforces the State of the Sector Report[5] action item on the need to create valid and reliable outdoor play measurement tools to gather complete and consistent data across studies.

Strengths and limitations

Major strengths of this scoping review on adult-oriented outdoor play include its adherence to best practices for conducting scoping reviews, with the use of the PRISMA-ScR guidelines[9] and the Arksey and O'Malley[10] framework. Further, as our search included all peer-reviewed literature, regardless of type of study or article, we were able to identify and document the vastness and diversity of the literature published in Canada on the topic.

Our exclusion of articles in languages other than English or French, a potential limitation, resulted in the removal of only one study. Our focus on published studies by authors from Canadian institutions or that examined a Canadian population only limits the generalizability of our findings beyond Canada. Indeed, it also provides insight for Canadian outdoor play advocates, practitioners, researchers and organizations on the knowledge available to

support the actions within the State of the Sector Report,[5] and where further knowledge generation is needed to take relevant action.

Future directions

Adult-oriented outdoor play environments, with the focus on the environmental impacts of outdoor recreation and leisure (see Table 1), is a topic that is gaining interest partly because of the growth in outdoor pursuits during the COVID-19 pandemic,[30] recognition of Indigenous knowledge as integral to advancing this topic,[50-52] as well as the burgeoning concerns of governments and researchers alike over the effects of climate change and the need to protect natural spaces.[71] This was much less of a focus in the articles included in the scoping review on children's and youth's outdoor play,[8] despite children's tendencies to wander beyond designated paths and trails while playing outdoors.[55] Identifying how to balance promoting unstructured outdoor play—and the curiosity and environmental stewardship that comes from it for both children and adults—with protecting and preserving natural spaces is a clear gap in the literature and warrants further investigation.

While Canadians nationwide were seen to re-engage with the outdoors during the COVID-19 pandemic, the pandemic also revealed that access to the outdoors and outdoor spaces is not equitably distributed.[72] At the launch of the State of the Sector Report at the 2021 Breath of Fresh Air Summit in October 2021, several stakeholders emphasized the importance of establishing, as a first step, a base of knowledge on equity, diversity and inclusion efforts in the field of outdoor play. Our search retrieved 36 articles on this priority, including a recent scoping review on the relationship between nature and immigrants' integration and well-being in Canada.[73] This and the other articles identified may help showcase current obstacles and achieved successes and inform future efforts in advancing equity, diversity and inclusion in the outdoor play sector.

Conclusion

We retrieved 224 articles published since 2015 and written by authors from Canadian institutions or about Canadian adults in response to the question, "How, and in

what context, is adult-oriented outdoor play being studied in Canada?" The articles covered all State of the Sector Report[5] priority areas. The most common focus was outdoor play environments, and the most common outcome environmental health. The least common priorities were COVID-19, likely because of the relative recency of the start of the pandemic, and Indigenous Peoples and land-based outdoor play. This is a concern given the recognized connections between the environment, environmental health and Indigenous cultures and traditions. Moreover, we did not identify any articles that looked at mental/emotional development as an outcome, highlighting a major knowledge gap.

This scoping review calls attention to the encouraging and staggering increase in adult-oriented outdoor play research in Canada over the last 7 years; identifies gaps in knowledge; and proposes areas for future work to ensure the promotion, protection and preservation of access to play in nature and the outdoors for all people living in Canada.

Conflict of interest

The authors have no conflicts of interest to report.

Authors' contributions and statement

Conceptualization of the scoping review – LDL, KB and MST

Data curation, formal analysis and investigation – LDL, KB and NS

Methodology – LDL and KB

Writing of the original draft – LDL

Review and editing of the draft – LDL, KB, NS and MST

Funding acquisition – LDL and MST

Project administration – LDL and MST

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Release notice

Congenital Anomalies in Canada Data Tool: latest update on prevalence rates and trends over 15 years (2006–2020)

Chantal Nelson, PhD; Jennifer Lye, MPH; Neetu Shukla, MPH; Hongbo Liang, MD, PhD; Wei Luo, MSc

Tweet this article

The Canadian Congenital Anomalies Surveillance System (CCASS) team of the Public Health Agency of Canada (PHAC) is pleased to announce the release of the latest Congenital Anomalies in Canada Data Tool. The interactive Data Tool, located on the PHAC Infobase website, includes the latest information on the prevalence rates and temporal trends for 38 select congenital anomalies (grouped into 12 categories) in Canada. Data are derived from the Discharge Abstract Database of the Canadian Institute for Health Information, which includes data from all provinces and territories except Quebec. Data include a follow-up period of one year after birth.

The website includes the following tabs: "Data Tool," "About Congenital Anomalies" and "Technical Appendix." The Data Tool has been modified from previous versions and includes updated information with trends over 15 years of data (from 2006 to 2020), new features such as jurisdictional maps, and more data stratifications by province/territory, infant sex and maternal age.

This resource is a collaborative effort between PHAC, the Canadian Perinatal Surveillance System's External Advisory Committee and the Canadian Congenital Anomalies Surveillance Provincial and Territorial Network.

To access the latest Congenital Anomalies in Canada Data Tool, visit https://health-infobase.canada.ca/congenital-anomalies/.

Author reference:
Public Health Agency of Canada, Ottawa, Ontario, Canada

Call for Papers: Social Prescribing in Canada

Guest Editors: Sandra Allison (Island Health Authority), Kiffer Card (Simon Fraser University), Kate Mulligan (University of Toronto)

HPCDP Journal Editors: Robert Geneau and Margaret de Groh (Public Health Agency of Canada)

Social prescribing (SP) is a practical tool for addressing the social determinants of health through supported referrals to community services. This globally spreading intervention aims to promote health and prevent chronic disease by supporting individual and community self-determination and connecting participants to nonclinical supports in their communities, such as food and income support, parks and walking groups, arts and cultural activities or friendly visiting.[1]

Global evidence demonstrates that SP can support individual and population health, build the evidence base on the impacts of social interventions for health promotion and chronic disease prevention and integrate health and social care at the community level.[2] However, while SP practices continue to scale and spread across Canada, and knowledge mobilization is underway through the new Canadian Institute for Social Prescribing,[3] there is relatively little published literature on this novel intervention in Canadian contexts and by Canadian researchers, practitioners and participants.

The objective of this special issue is to identify and share the most current research and practice on SP by and for residents of Canada, particularly those facing inequities in access to health and its social and structural determinants. *Health Promotion and Chronic Disease Prevention in Canada: Research, Policy and Practice* therefore seeks relevant qualitative and quantitative research articles, as well as commentaries, that present new findings, synthesize existing evidence or imagine new ways forward on (for example)

- applications of SP, including those for specific populations or specific types of social interventions;
- policies and systems changes relevant to SP uptake;
- expertise and experiences of SP actors, including participants (patients), health care workers, community organizations and caregivers;
- training, workforce development, collaboration and knowledge mobilization for SP;
- technology, data tracking, evaluation and evidence building in SP; and
- understanding of SP through theoretical frameworks and systems trends.

International submissions will be considered if they include Canadian data, results (e.g. as part of multi-country studies or global comparisons) and/or evidence-based discussion of implications for community or population health in Canada.

Consult the Journal's website for information on article types and detailed submission guidelines for authors. Kindly refer to this call for papers in your cover letter.

All manuscripts should be submitted using the Journal's ScholarOne Manuscripts online system. Pre-submission inquiries and questions about suitability or scope can be directed to HPCDP.Journal-Revue.PSPMC@phac-aspc.gc.ca.

Submission deadline: July 31, 2023.

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With thanks to our 2022 peer reviewers

We are grateful to the following individuals for their significant contribution to *Health Promotion and Chronic Disease Prevention in Canada* as peer reviewers in 2022. Their expertise ensures the quality of our journal and promotes the sharing of new knowledge among peers in Canada and internationally.

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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 2022 and 2023:

Auger N, **Nelson C**, Brousseau É, et al. Extended risk of mortality in children with inborn errors of metabolism: a longitudinal cohort study. J Pediatr. 2023;252:16-21.e2. https://doi.org/10.1016/j.jpeds.2022.08.053

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