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Special Issue: Exploring substance use in Canada: Trends and emerging issues in public health

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Commentary

Problematic substance use or problematic substance use policies?

Tim Stockwell, PhD (1,2); Cecilia Benoit, PhD (1,3); Kiffer Card, PhD (1); Adam Sherk, PhD (1)

Abstract

This special issue on substance use issues comes at a critical time for Canadian health policy makers and researchers. Most attention is currently focussed on the opioid crisis and the potential impacts of cannabis legalization. However, our most widely used and harmful substances continue to be alcohol and nicotine. Our policies to reduce harms from these substances are failing. While alcohol control policies are being gradually abandoned, opportunities to maximize the harm reduction potential of new, alternative and safer nicotine delivery devices are not being grasped. More generally, a greater focus is needed on harm reduction strategies that are informed by the experience of marginalized people with severe substance use–related problems so as to not exacerbate health inequities.

In order to better inform policy responses, we recommend innovative approaches to monitoring and surveillance that maximize the use of multiple data sources, such as those used in the Canadian Substance Use Costs and Harms (CSUCH) project. Greater attention to precision in defining patterns of risky use and harms is also needed to support policies that more accurately reflect and respond to actual levels of substance use–related harm in Canadian society.

Keywords: *substance use, alcohol, cannabis, tobacco, smoking, harm reduction, surveillance, surveys, public health, health inequities*

Highlights

- Substance use in Canada cost $46 billion in 2017, with the great majority of these costs resulting from the use of tobacco and alcohol.
- Substance use–related costs, harms and rates of use have been increasing in Canada over the past decades for both legal and illegal substances, including those for cannabis.
- Canadian policies to address our most harmful substances, i.e. alcohol, cannabis and tobacco, are largely failing, despite significant opportunities to improve polices on pricing, taxation and marketing of legal substances.
- Canada's monitoring and surveillance efforts can be improved by developing more discerning measures of risk and maximizing the use of multiple data sources.

Introduction

Substance use costs the Canadian economy an estimated $46 billion per year in direct health care expenditures, lost productivity and expenses related to enforcing its Criminal Code. The great majority of these costs result from alcohol and tobacco use.[1] The Canadian Drugs and Substances Strategy (CDSS) is the federal government's official response to these rising costs and societal harms. The CDSS focusses on optimizing four activities—prevention, treatment, harm reduction and enforcement—through increased funding for research and programming. The primary focus of the CDSS, however, is on cannabis, opioids and other illicit substances.

In 2018, Health Canada conducted a broad-based evaluation of the federal government's strategy. This evaluation highlighted many fundamental problems with these four activities. This special issue on problematic substance use in Canada casts further light on the challenges. Aside from conceptualizing problematic substance use for many drugs, legal and illegal, this issue of *Health Promotion and Chronic Disease Prevention in Canada* also describes programs and policies that are failing to adequately address the costs and harms related to substance use.

A key starting point for this commentary is the principle that priorities for substance use policies in Canada need to reflect their potential for reducing related harms. Another is that policies are informed by the experiences of marginalized groups so as not to exacerbate health inequities. We provide examples of Canadian policy directions that are failing to address, and are even exacerbating, harms due to alcohol and tobacco use. In addition, broad system-wide policies addressing some of the social determinants of health at all stages in the lifespan need to be prioritized as they may have benefits across the full range of types of substance use and related harms.

This special issue contains eight articles that variously evaluate policies, describe

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current trends in substance use and examine risk factors. Four articles focus on alcohol policies, three on patterns of harm from cannabis use and one on potential protective factors against substance use among youth. While many important substances and relevant concerns are not captured here (e.g. stigma, marginalized populations, social determinants), these articles present salient and timely perspectives on some of the biggest challenges facing Canada right now. Indeed, with the legalization of cannabis in 2018, there has been a flurry of studies aiming to understand what this means for the prevalence of cannabis (especially among youth) and future patterns of substance use, related harms and possible benefits. This interest in cannabis has further sidelined studies on alcohol and nicotine, despite these continuing to be the greatest contributors to substance use–related costs and harms.

The authors of these papers have also provided a number of recommendations for next steps and future directions to support policy- and decision-makers. These include the need for (1) continued monitoring and surveillance of substance use and substance use–related harms; (2) legislative and regulatory mechanisms to reduce the harms arising from substance use, such as excise taxes and minimum unit pricing for legalized drugs; and (3) enhanced education and programming for youth, families and communities in Canada.

We take the opportunity here to dive a bit deeper into these three broad areas.

Monitoring and surveillance

Canada has a strong system of monitoring and surveillance in place; however, there are avenues for improvement. Foundational for monitoring substance use and related harms are national substance use surveys, administered by Statistics Canada and Health Canada. These provide a picture of substance use, although delays in data release mean there are difficulties in identifying emerging trends. Programs such as the Canadian Community Epidemiology Network on Drug Use help to fill these gaps in sentinel surveillance by connecting community partners across Canada and focussing on identifying emerging trends and potential problems with safe supply.

The Statistics Canada and Health Canada surveys support broader studies of substance use, such as the Canadian Substance Use Costs and Harms (CSUCH) project, a national study of the economic cost of substance use. CSUCH compares costs and harms related to eight categories.[1] The overall economic cost of substance use across health care, lost productivity, criminal justice and other direct cost domains was estimated at $46 billion in 2017. Accounting for more than three-quarters of the total cost are the three legal drugs: alcohol ($16.6 billion), tobacco ($12.3 billion) and cannabis ($3.2 billion). Among illicit substances, only opioids ($5.9 billion) and cocaine ($3.7 billion) make up more than 5% of the total cost.

Monitoring efforts may be prioritized using two criteria: overall population-level harm, where alcohol and tobacco have by far the largest contribution, and significant emerging health concerns, such as the opioid crisis.

Several articles in this special issue contribute toward providing baseline knowledge of cannabis poisoning and/or injury harms over the years leading up to legalization. Maloney-Hall et al.[2] found that rates of hospital-based cannabis use disorders more than doubled from 2006 to 2015. Champagne et al.[3] found increases in cannabis-related poisonings and injuries in the lead up to legalization among both adults and youth, while Cheng et al.[4] reported that the majority of poisonings related to cannabis occurred alongside alcohol co-use. Continued monitoring of cannabis harms, with the concurrent use of other substances, is clearly a priority post legalization. We recommend this is accompanied with more precise definitions of patterns of cannabis use and related harms, including the quantification of amounts used. Alcohol-related harms are mostly dose-related and it is insufficient to only record use patterns in terms of frequency.[5] Ignoring the amount of cannabis consumed per occasion could lead to an underestimation of health consequences.[6]

Monitoring of substance use in Canada should continue to be a focus, with improvements in data collection. For example, despite particular concerns, national surveys currently do not collect information on substance use in the territories. Survey questions should collect information on use and harms, and also on emerging harm reduction opportunities, such as substituting nicotine vaping for tobacco smoking or, potentially, cannabis for the use of alcohol and other substances.

Legislative and policy mechanisms

Three of the papers in this special issue of the Journal highlight specific opportunities for Canadian governments to use policies related to alcohol to improve public health outcomes. Paradis et al.[7] show that regulations to restrict the content of alcohol promotions in traditional media need to be extended to modern social media. In particular, they show that bars frequented by students in four Canadian cities routinely allow posts on their social media accounts that violate existing regulations. Stockwell et al.[8] identify alternative alcohol price and tax policies that could save hundreds of Canadian lives and prevent thousands of hospital admissions each year. They also estimate that failures over the past 25 years to adjust alcohol excise taxes for inflation have cost the federal government about $11 billion. Sherk[9] shows that the revenues currently received by federal government fall short by one-third of the estimated national economic costs generated by alcohol.

The Canadian Alcohol Policy Evaluation (CAPE) project[10,11] paints a broader picture of regulatory failure regarding alcohol and public health on the part of Canadian governments. Applying more than 200 indicators across 11 evidence-based policy domains, the CAPE project gave failing grades to provincial and territorial governments for their implementation of most alcohol policies. While many strong practices were identified, there is a trend for provincial and territorial governments to introduce policies that worsen public health outcomes from alcohol, such as the "buck a beer" program and sales in grocery stores (as described by, e.g. Myran et al., 2019).[12] Van der Maas et al.[13] demonstrated the viability and potential value of a Canadian arm of the International Alcohol Control study to monitor and evaluate alcohol policies longitudinally.

Central to a modern public health approach to alcohol policy is the principle that the more alcohol is consumed by a population, the greater the overall risk to that population's health and safety.[14] With growing evidence for effective policies to reduce population alcohol consumption, it would be timely to apply lessons learned

from alcohol policy to our other legal drugs. In this issue, three papers focus on trends in and/or levels of cannabis-related harms as tracked in Canadian surveillance systems. Maloney-Hall et al.[2] show that between 2006 and 2015, rates of cannabis-related hospitalizations doubled. Almost half of these were identified as "mental and behavioural disorders" including "psychotic disorders," which tripled in number. Champagne et al.[3] report a 30% increase in emergency room presentations for cannabis-related poisonings or injuries between 2015 and 2018. Elsewhere, analyses of Canadian substance use self-report surveys conducted for the CSUCH project confirm parallel increases in rates of cannabis use between 2007 and 2017.[1] These trends highlight the need for more effective cannabis policies such as those identified for alcohol in the CAPE studies in such domains as pricing and taxation, availability and controls on marketing.

Enhanced education and programming for marginalized groups

Strong population-wide policies need to be tempered in order to help reduce harms to people with severe substance-use problems, many of whom are also marginalized and stigmatized. Managed alcohol programs are a uniquely Canadian harm reduction approach designed to limit harms experienced by unstably housed people, who in many parts of Canada, are overrepresented by Indigenous peoples. They involve the provision of accommodation coupled with regular administration of alcohol in a safe environment.[15] Work is underway to explore whether substituting cannabis for alcohol further reduces harms for this population.[16] In relation to nicotine, we need to maximize the harm reduction potential of alternative, safer methods of use in order to further reduce the continuing tragic epidemic of tobacco-related lung diseases. In 2018, the United States National Academies of Science, Medicine and Engineering concluded that e-cigarettes are "far less harmful" than regular tobacco cigarettes.[17] Smoking dried cannabis leaves, especially in combination with tobacco, also poses serious risks of lung disease.[18] Policies that restrict access to vaping equipment and supplies for heavy smokers, especially for low-income and marginalized groups, risk losing the tremendous potential benefits from this new technology for reduction of the almost 50 000 deaths estimated each year from smoking-related lung disease.[1]

Community-based harm reduction approaches are also recommended for substance-using pregnant and parenting women, who are overrepresented by low-income Indigenous women. These programs need to be assessed so that providers carefully weigh the interests and concerns of parents and the welfare of their unborn and dependent children. Benoit et al.[19] found health and social care service providers, even when embracing harm reduction principles, tended to view any substance use by women who were pregnant or had recently become parents as problematic/morally wrong. By contrast, new parents, even when holding abstinence as the ideal, recognized the autonomy of women to judge substance use risk for themselves. Participants also called attention to social structural factors (unstable housing, food insecurity, violence, etc.) that increase harms associated with such substance use.[20] Harm reduction programs aiming to provide nonjudgmental care for marginalized women and their families need to measure "success" from multiple perspectives in order to assess the quality and impact of care, improve services and apply this learning to future program development.[21]

The study by Enns and Orpana[22] of factors such as resilience and autonomy that may protect youth from harmful substance use is a timely reminder that prevention needs to focus on strengths and not just vulnerabilities.

Conclusions

We conclude that our current substance use policies are largely failing or at least failing to reach their potential, especially for our traditional legal drugs. Canada needs to strengthen monitoring and surveillance and augment this with modelling approaches such as those applied in the CSUCH national monitoring project to achieve more comprehensive and accurate estimates of patterns of substance use and related harms.[1] Underpinning our policy responses should be the principle of prioritizing strategies to deal with those substances that cause the greatest harm while also developing harm reduction strategies for marginalized, heavy-using populations. In monitoring and surveillance activities we should not conflate all substance use with substance use–related harms. We need more precise definitions and measures of the specific patterns of use that pose the greatest harm while acknowledging the right of citizens to access psychoactive substances and participate in the process of implementing harm reductions strategies.

In closing, the editors would like to thank the authors for the exceptional work they have invested in these studies and the editorial team at *Health Promotion and Chronic Disease Prevention in Canada* for putting together this special issue.

Conflicts of interest

TS, CB, KC and AS were Guest Editors for this issue of the HPCDP Journal, but removed themselves from the editorial decision-making associated with this manuscript.

Statement

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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At-a-glance

The alcohol deficit: Canadian government revenue and societal costs from alcohol

Adam Sherk, PhD

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Abstract

This summary article compares government revenue from the sale and distribution of alcohol to the societal costs caused by alcohol use for the year 2014. Statistics Canada data reported government revenue of $10.9 billion; however, this was offset by net societal costs of $14.6 billion, as reported by Canada's national substance use surveillance system, the Canadian Substance Use Costs and Harms project. The societal costs include health care, economic loss of production, criminal justice and other direct costs. Though revenue from alcohol sales has been described as a benefit to public coffers, accounting that includes costs incurred shows that all provinces and territories in Canada are running an alcohol deficit, totalling $3.7 billion nationally.

Keywords: *alcohol use, costs, societal costs, Canadian Substance Use Costs and Harms, alcohol deficit*

Highlights

- Canada runs an alcohol deficit of about $3.7 billion per year, when accounting considers both government revenue and societal costs from established sources.
- Government revenue totalled $10.9 billion in 2014, but this was more than offset by societal costs of $14.6 billion, as reported by the Canadian Substance Use Costs and Harms project.
- Societal costs include health care, lost productivity, criminal justice and other direct costs.
- Among provinces and on a per capita basis, Alberta had the lowest government revenue and the highest alcohol deficit.

Introduction

Canadian government revenue generated from the sale and distribution of alcohol has been described as a boon to public coffers, as this revenue may then be redirected towards health care and education. Indeed, a look at the public accounts makes it clear that the sale of alcohol is lucrative, providing significant revenues to federal and provincial governments.[1] However, as more than 75% of Canadian adults drank alcohol in the past year,[2] these revenues are balanced against substantial and growing costs[3] due to population-wide exposure to alcohol. These societal costs include health care, lost productivity, criminal justice and other direct costs.

Government revenues generated from the sale of alcoholic beverages, in the form of federal excise tax, net income from provincial liquor authorities and sales tax (such as harmonized sakes tax [HST], provincial sales tax [PST] and goods and services tax [GST]) have been recorded by Statistics Canada for some time.[1] However, Canada was without a national substance use surveillance system for more than a decade until the completion of the Canadian Substance Use Costs and Harms (CSUCH) project in 2018.[3] CSUCH details a comprehensive accounting of the societal costs associated with eight different psychoactive substances, including alcohol. At $14.6 billion, alcohol was the most costly substance in Canada in 2014, with costs higher than tobacco ($12.0 billion) and far higher than opioids ($3.5 billion) and cannabis ($2.8 billion).[3]

This summary article answers the following question: When considering net revenue and net societal costs, do Canadian governments run an alcohol surplus or an alcohol deficit?

Methods

The conceptual framework used by the data sources described next is a counterfactual scenario wherein population exposure to alcohol use is, and has always been, zero. Neither source, nor this summary article, takes the stance that alcohol use should be zero: this is simply a means of accounting government revenue and societal costs caused, or attributed, to alcohol.

Provincial/territorial level data on net income of liquor authorities and government revenue from the sale of alcohol were from Statistics Canada's CANSIM database for fiscal year 2014/15.[1] Downloaded data had a greater level of granularity than that presented in this article; I used the existing table heading "net income of liquor authorities" and row stub heading "federal excise tax and customs duties." I grouped all other taxes and revenue categories into "sales tax and other revenue."

CSUCH presents economic costs incurred by society in 19 categories across four domains (health care, economic loss of production, criminal justice and other

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direct costs). Provincial/territorial data for 2014 in these four cost categories were from the CSUCH online visualization tool (https://csuch.ca/explore-the-data/) on 4 December 2019. Detailed methodology regarding each of the domains, as well as for the CSUCH project, is described elsewhere.[3,4] The CSUCH project underestimated health care costs in the province of Quebec due to the lack of data availability in certain categories in that province.

For each province and territory as well as Canada as a whole, total net deficits/surpluses were calculated as the difference between net revenue and net costs. I use the terms "net revenue" and "net costs" as costs (when discussing net revenue) and savings (when discussing net costs) have already been accounted for. For example, the net revenue category "net income from liquor authorities" has already had product costs, administrative expenses and employee salaries deducted from gross sales. In terms of health care costs, low doses of alcohol may have a slightly protective effect on some health conditions, such as diabetes[5], and ischemic heart disease in women[6]; the cost savings of this on the health care system have already been included in the "net cost" figures. Per capita figures were calculated using provincial populations on 1 July 2014.[7]

Results

Significant government revenue—a total of nearly $10.9 billion—was generated from the sale of alcohol in 2014 (see Table 1). However, this is more than balanced by the outlay of $14.6 billion caused by alcohol consumption, resulting in an annual national government deficit of about $3.7 billion in 2014.

Among revenue categories, net income from liquor authorities was the largest national contributor at $5.7 billion (52%), followed by sales tax and other revenue at $3.7 billion (34%) and federal excise tax at $1.5 billion (14%). Net income from liquor authorities was the largest component of government revenue in all jurisdictions except Prince Edward Island and Quebec, where sales tax and other revenue was the largest category.

Examination of costs incurred show that economic loss of production contributed the highest proportion of alcohol-caused costs at $5.9 billion (40%), followed by costs incurred by the health care system at $4.2 billion (29%), criminal justice outlays at $3.2 billion (22%) and other direct costs at $1.34 billion (9%). Note that the CSUCH project underestimated health care costs in Quebec due to lack of data availability in several health care categories.[3]

Examination of per capita government revenue, costs and deficits shows significant regional differences (see Table 2). Of all the provinces, Alberta has the lowest per capita revenue at $272 per person (pp) and the highest per capita costs at $587 pp, leading to a per person deficit ($315 pp) more than double that of the next highest province and almost six times the national average. Quebec has the lowest per capita deficit; however, as noted health care costs were not fully accounted for. Newfoundland and Labrador ($52 pp), Nova Scotia ($58 pp), Prince Edward Island ($70 pp), New Brunswick ($104 pp) and Ontario ($105 pp) had per capita deficits below the national average ($106 pp). Deficits in the territories were substantially higher than this national average.

TABLE 1
Government alcohol net revenue, net costs and net deficit, by jurisdiction and Canada, 2014

Jurisdiction	Net revenues (fiscal year 2014/15), $ million				Net costs (2014), $ million					Total net surplus/deficit, $ million
	Net income from liquor authorities	Federal excise tax	Sales tax[a] and other revenue	Total net revenue	Health care	Economic loss of production	Criminal justice	Other direct	Total net cost	
Newfoundland and Labrador	160.7	30.1	57.9	248.7	(86.8)	(119.5)	(48.9)	(20.8)	(276.0)	(27.3)
Prince Edward Island	19.7	6.7	30.3	56.7	(26.2)	(19.7)	(15.0)	(6.0)	(66.9)	(10.2)
Nova Scotia	228.0	41.9	102.9	372.7	(144.8)	(168.1)	(89.0)	(24.8)	(426.7)	(54.0)
New Brunswick	166.1	27.4	54.3	247.8	(102.5)	(120.5)	(76.3)	(27.1)	(326.4)	(78.6)
Quebec[b]	1 032.7	331.8	1 080.9	2 445.3	(598.9)	(983.3)	(708.5)	(298.2)	(2 588.9)	(143.6)
Ontario	1 817.4	549.2	1 552.0	3 918.6	(1 473.6)	(2 118.0)	(1 258.0)	(494.7)	(5 344.3)	(1 425.7)
Manitoba	281.6	56.4	93.6	431.5	(186.2)	(224.2)	(105.3)	(61.8)	(577.5)	(146.0)
Saskatchewan	244.2	53.8	93.4	391.4	(179.8)	(235.6)	(107.3)	(40.2)	(562.9)	(171.5)
Alberta	765.8	218.4	127.0	1 111.2	(709.3)	(1 109.6)	(387.2)	(189.7)	(2 395.8)	(1 284.6)
British Columbia	935.2	222.2	463.9	1 621.3	(673.2)	(744.3)	(349.0)	(169.0)	(1 935.5)	(314.2)
Yukon	9.2	2.7	6.1	17.9	(15.2)	(20.3)	(3.3)	(1.9)	(40.7)	(22.8)
Northwest Territories	25.0	3.1	2.4	30.5	(17.6)	(30.6)	(3.6)	(4.0)	(55.8)	(25.3)
Nunavut	1.2	0.3	0.3	1.7	(16.1)	(22.5)	(2.7)	(2.0)	(43.3)	(41.6)
Canada	5 686.9	1 543.9	3 664.8	10 895.5	(4 230.2)	(5 916.4)	(3 154.2)	(1 340.3)	(14 641.1)	(3 745.6)

Note: Numbers in parentheses are negative.

[a] Provincial sales tax (PST), harmonized sales tax (HST) or goods and services tax (GST).

[b] According to *Canadian Substance Use Costs and Harms: 2007–2014*,[3] health care costs in Quebec are not fully enumerated due to data access issues; these costs are therefore underestimates.

TABLE 2
Per capita net revenue, net cost and net deficit, by jurisdiction and Canada, 2014

Jurisdiction	Per person, $		
	Net government revenue	Net cost	Net surplus or deficit
Newfoundland and Labrador	471.0	(522.6)	(51.6)
Prince Edward Island	393.3	(463.7)	(70.4)
Nova Scotia	397.2	(454.6)	(57.5)
New Brunswick	326.5	(430.1)	(103.6)
Quebec [a]	300.0	(317.6)	(17.6)
Ontario	287.8	(392.5)	(104.7)
Manitoba	337.4	(451.5)	(114.1)
Saskatchewan	351.6	(505.8)	(154.1)
Alberta	272.1	(586.7)	(314.6)
British Columbia	344.4	(411.2)	(66.7)
Yukon	483.0	(1 095.9)	(613.0)
Northwest Territories	695.3	(1 271.5)	(576.2)
Nunavut	48.5	(1 203.7)	(1 155.2)
Canada	307.5	(413.2)	(105.7)

Note: Numbers in parentheses are negative.

[a] According to *Canadian Substance Use Costs and Harms: 2007–2014*,[3] health care costs in Quebec are not fully enumerated due to data access issues; these costs are therefore underestimates.

Discussion

An accounting of government revenue, as well as societal costs, associated with alcohol sales and alcohol use in Canada shows that alcohol surpluses are a misconception. In all 13 jurisdictions, societal costs are higher than government revenue, resulting in an "alcohol deficit" of $3.7 billion in Canada during 2014.

This summary article has limitations, as the data sources used to estimate government revenue and societal cost include incomplete accounting and are likely to be underestimated. Alcohol-producing businesses and individuals working in alcohol commerce pay corporate and personal income tax to federal or provincial governments. This could be considered indirect government revenue resulting from alcohol use in Canada. On the other hand, as noted above, the conceptual framework of this study is a counterfactual scenario with zero population exposure to alcohol. This study does not recommend this scenario, only its use for scenario-based accounting. In this counterfactual scenario, entrepreneurs and corporations would enter other sectors of the economy, as opposed to the alcohol industry. The overall economic effect of this diversion of energy and capital away from the production and sale of alcohol to other sectors is difficult to determine.

The societal costs of alcohol use captured in CSUCH may be significantly underestimated, as some cost categories could not be enumerated due to methodological or data restraints. For example, CSUCH does not include the cost of human pain and suffering experienced by individuals and those in their social networks linked to alcohol-caused health conditions. Nor does it include economic loss of production due to incarceration, the life course cost of fetal alcohol spectrum disorder and private treatment costs. [3]

Conclusion

Societal costs, including health care, economic loss of production, criminal justice and other direct costs, were substantially higher than government alcohol-related revenue in all provinces and territories in 2014. Nationally, government revenue of $10.9 billion is below the societal cost of $14.6 billion estimated by the CSUCH study, resulting in an annual, ongoing alcohol deficit of $3.7 billion. It is clear we are robbing Peter to pay Paul.

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Conflicts of interest

AS was a Guest Editor for this issue of the HPCDP Journal, but removed himself from the editorial decision-making associated with this manuscript.

Author's contributions and statement

AS was responsible for all portions of the article.

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

What popular bars post on social media platforms: a case for improved alcohol advertising regulation

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This article has been peer reviewed.

Abstract

Introduction: The aim of this study was to document the scope of violations of the Canadian Radio-television and Telecommunications Commission (CRTC) "Code for Broadcast Advertising of Alcoholic Beverages" (CRTC Code) by drinking venues posting alcohol-related content on social media platforms, and to assess whether CRTC Code violations by drinking venues relate to their popularity among university students and to students' drinking behaviours.

Methods: In phase 1 of the study, a probability sample of 477 students from four Canadian universities responded to a questionnaire about their drinking and preferred drinking venues. In phase 2, a probability sample of 78 students assessed the compliance of drinking venues' social media posts with the 17 CRTC Code guidelines. We pooled both datasets and linked them by drinking venues.

Results: Popular drinking venues were overwhelmingly posting alcohol-related content that contravenes the CRTC Code. Adjusted effect estimates show that a decrease in the mean level of compliance with the CRTC Code was significantly associated with a 1% increase in popularity score of drinking venues (t-test, $p < .001$). With regard to drinking behaviours, a 1% increase in the overall mean level of compliance with the CRTC Code was associated with 0.458 fewer drinking days per week during a semester (t-test, $p = .01$), 0.294 fewer drinks per occasion (t-test, $p = .048$) and a lesser likelihood of consuming alcohol when attending a drinking venue (t-test, $p = .001$).

Conclusion: The results of this study serve as a reminder to territorial and provincial regulatory agencies to review their practices to ensure that alcohol advertising guidelines are applied and enforced consistently. More importantly, these results call for the adoption of federal legislation with a public health mandate that would apply to all media, including print, television and radio, digital and social.

Keywords: *advertising, alcoholic beverages, social media, students, universities*

Highlights

- According to Canadian university students surveyed, popular drinking venues are overwhelmingly posting alcohol-related content on Facebook and Instagram that contravenes the CRTC "Code for Broadcast Advertising of Alcoholic Beverages" (CRTC Code).
- The heaviest drinkers tend to prefer drinking venues that post images that violate several CRTC Code guidelines.
- The current self-regulatory system fails Canadian youth by not taking action when a great number of alcohol portrayals and promotions support a culture of excessive drinking.
- The federal government should adopt new legislation that would apply to all media, include mandatory preclearance of alcohol advertisements and administrative and deterrence systems for infringements on marketing restrictions.

Introduction

To reduce the harmful use of alcohol, particularly by young people, the World Health Organization (WHO) recommends limiting the impact of alcohol marketing by setting up regulatory frameworks.[1] This recommendation is supported by accumulating evidence that alcohol advertisements increase the likelihood of young people starting to drink and the amount they drink both overall and on any one occasion.[2-6]

In Canada, alcohol marketing and advertising is regulated at both the federal and provincial levels. At the federal level, all radio and television advertising must comply with the Canadian Radio-television and Telecommunications Commission's (CRTC) "Code for Broadcast Advertising of Alcoholic Beverages" (the "CRTC Code")[7] and advertisers must obtain pre-clearance for all broadcast ads from broadcasters.[8] In addition, provinces and territories have implemented restrictions on alcohol advertising similar to those outlined in the CRTC Code, and provincially-licensed alcohol retailers are similarly restricted in how they can promote alcohol in their establishments. With digital media overtaking other traditional media channels such as television, radio and the press,[9,10] several provinces, including British Columbia, Ontario, Quebec and Nova

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Scotia, have adopted restrictions on alcohol advertising and marketing that apply to both broadcast and nonbroadcast ads, including web advertising.

Although the CRTC developed the Code, it issued a public notice in 1996 saying it was "no longer necessary to involve itself in the pre-clearance process" and that, instead, it was encouraging self-regulation by the industry and broadcasters, and relying on provincial regulations.[11] Since then, very few CRTC Code violations have been recorded.[8] However, this may simply correspond to what experts have been claiming for years: that allowing industry self-regulation results in a loss of policy control over alcohol marketing and advertising.[12] Indeed, since 1997, consumers, groups or agencies who have a concern about the content of a specific alcoholic beverage advertisement must submit a complaint through the Ad Standards (Advertising Standards Canada [ASC]) website for the Standards Council to evaluate whether the advertisement violates the CRTC Code or not.[13] If the complaint focusses on spirits, before directing it to the Council, Ad Standards' staff must take an additional step, making a preliminary determination whether there has been an infraction of one or more provisions of the Spirits Canada "Code of Responsible Advertising and Marketing." In this context, that there has only been a small number of reported violations may not be evidence of an advertising landscape promoting safe and responsible alcohol use. Instead, it might only reflect a self-regulatory system in which a CRTC Code violation can only be recorded if a complaint is submitted by the public and then receives an adverse evaluation from an industry-backed council.

An additional concern is that the apparent loss of control over alcohol marketing and advertising may be even more pronounced online. Social media has become a key platform for alcohol brands, one that makes it possible for advertisers to spread messages via consumers and involve them in the production of marketing content.[14] While it offers new possibilities for interaction between alcoholic beverage companies and their potential consumers, it also allows drinking venues to distribute alcohol-related marketing messages on a mass scale. A recent UK study found that drinking venues regularly post on social media platforms, and that it is not uncommon for venues to present images associating alcohol with social success, sexual attractiveness and intoxication.[15]

Given that virtually all Canadians aged 15 to 24 use social networking sites[16] and that almost all youth are likely to be exposed to alcohol-related content on social media platforms,[17] Canadian youth may routinely be exposed to alcohol marketing and advertising that violates the CRTC Code. From a public health perspective, this is concerning because exposure to alcohol marketing is associated with measures of early life drinking, youth alcohol use, binge drinking and other negative consequences.[18-20] Moreover, the highest proportion of heavy drinking for both sexes in Canada is among those aged 18 to 34 years. In this age group, 33.5% of males and 23.8% of females are heavy drinkers.[21] Among young people who attend postsecondary institutions, preliminary results based on the 2018 pilot phase of the Canadian Postsecondary Education Alcohol and Drug Use National Survey (CPADS) showed that 64% of male drinkers reported having five or more drinks and 61% of female drinkers reported having four or more drinks on one occasion in the past 30 days.[*]

The aim of this study was to get a better sense of the extent to which Canadian youth might be exposed to alcohol marketing and advertising that "promote[s] the general consumption of alcoholic beverages"[11] or that "contribute[s] to the negative health and societal effects relating to excessive or inappropriate alcohol consumption."[11] Our study focussed on university students, a key audience for alcohol advertising on social media platforms. It aimed to measure the scope of CRTC Code violations on social media platforms by drinking venues and to assess whether there is an association between these venues' CRTC Code violations and their popularity, as well as the students' drinking behaviours.

Methods

Survey design, sampling and data collection

Following ethical approvals for the project,[†] we used a cross-sectional survey design to collect data during the winter and fall semesters of 2017 from convenience samples of students from four different Canadian universities (University of Victoria, Queen's University, Bishop's University and Dalhousie University), in two separate phases described below. A diagram of the study is presented in Figure 1.

Phase 1

Using recruitment flyers posted both online and around campus, as well as the presence of a research coordinator at a booth space in a high-traffic area on university property, we gathered convenience samples of students who were fluent in English, who were at least 19 years of age and who had frequented a drinking venue at least once a month over the course of the previous semester, for a total of 477 students. These students were invited to fill out an online questionnaire that included questions about (1) the frequency of their drinking ("Over this semester, how many days per week have you usually drunk alcohol?"); (2) the average quantity they consumed on a single occasion ("On a day when you drank alcohol, how many standard drinks did you usually have?"); and (3) the frequency of their drinking when attending drinking venues ("How often when you go out to a bar/pub/club do you drink alcohol?"). The possible responses were (1) never, (2) sometimes, (3) half of the times, (4) most of the times and (5) all the times. Students were also asked about their favourite and second favourite drinking venues ("Which bar/pub/club do you frequent most/second most often, i.e. your favourite/second favourite bar?"). Participating students were offered $10 gift cards as compensation for their time, and at the University of Victoria, students recruited through the Psychology Research Participation System were awarded 0.5 course credits.

Moving from phase 1 to phase 2

Based on data collected in phase 1, we identified the most popular local drinking venues on each campus by assigning 2 points to a venue each time it was named as a favourite drinking venue and 1 point when it was named as a second favourite. The initial goal was to identify the 16 most popular drinking venues on each campus, but at Dalhousie University

[*] Data available from the corresponding author.

[†] Dalhousie University Research Ethics Board (2017-4273); Bishop's University Research Ethics Board (101576); Queen's University Health Sciences Research Ethics Board (6021533); University of Victoria Human Research Ethics Board (16-384).

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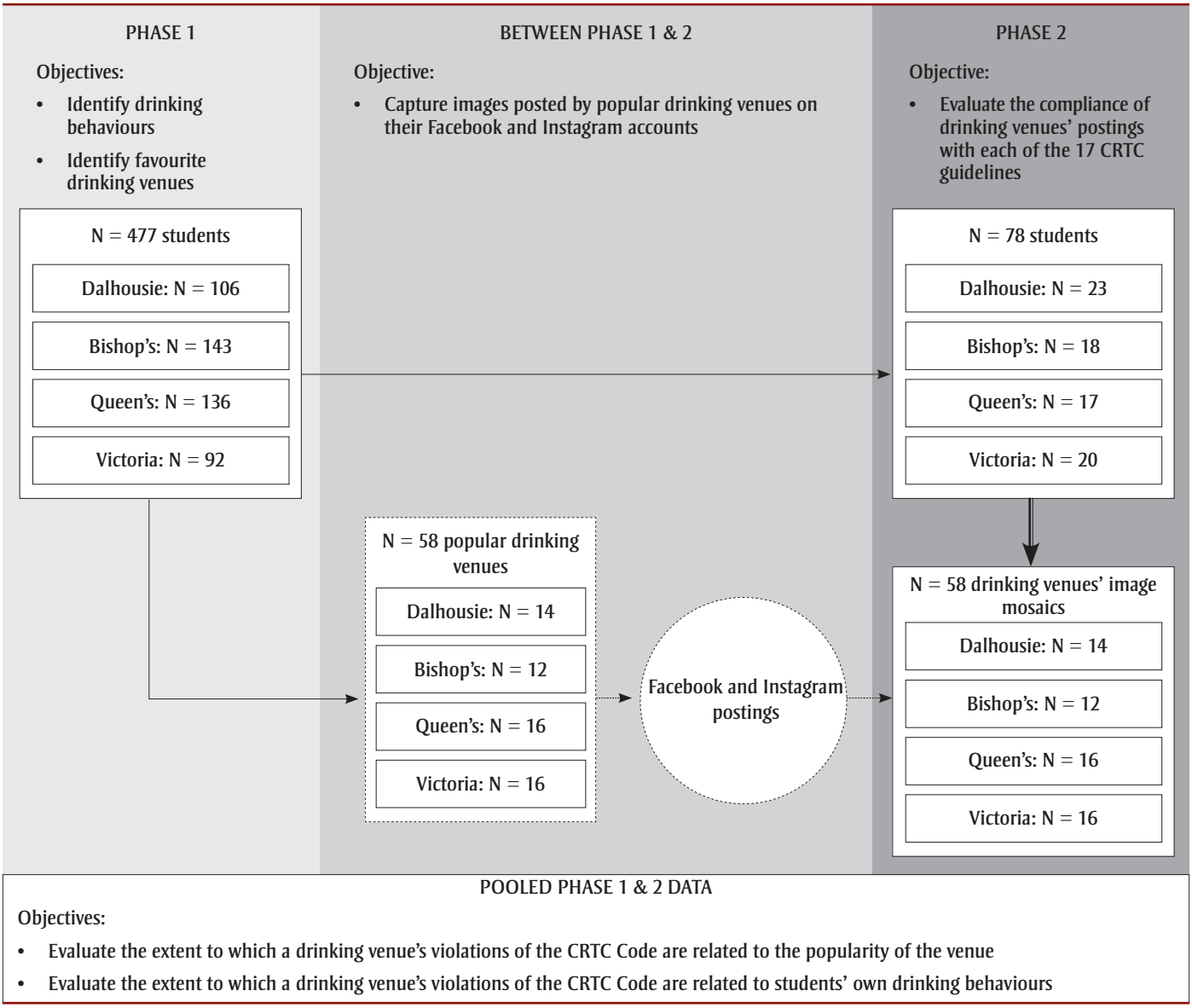
FIGURE 1
Design of study on the relationships of social media alcohol advertising by drinking venues, the popularity of those venues, and university students' drinking behaviours, Canada, 2017



and Bishop's University, students' responses only allowed for the identification of 14 and 12 venues, respectively, for a grand total of 58 popular local drinking venues across the four campuses.

Next, two members of our research team visited the Facebook and Instagram accounts—the two most popular social media platforms among Canadian youth aged 18 to 34[22]—of the 58 popular drinking venues. They selected up to 20 postings that captured a variety of images for each of the campuses' local drinking venues; preference was given to images that provided the opportunity to analyze compliance with six key themes of the CRTC Code as determined by the ASC.[13,‡] These images were further evaluated by two other research team members for compliance with the 17 CRTC Code guidelines.[7,§] An example of a question asked by investigators to evaluate image compliance is: "Do any of these images attempt to influence nondrinkers of any age to drink or to purchase alcoholic beverages?" We used a five-point Likert scale to collect the responses (1 = definitely, 2 = probably, 3 = unsure, 4 = probably not, 5 = definitely not), where a higher score indicated greater compliance with the CRTC Code. For each venue, we selected the nine images that received the lowest score, and consequently appeared most to conflict with the CRTC Code, and arranged them into three-by-three mosaics (Figure 2).

‡ The ASC has grouped the clauses of the CRTC Code under six key themes: (1) "Advertising must not encourage the general consumption of alcohol"; (2) "Advertising must not promote the irresponsible or illegal use of alcohol"; (3) "Advertising must not associate alcohol with social or personal achievement"; (4) "Advertising must not be directed to persons under the legal drinking age"; (5) "Advertising must not associate alcohol with the use of motor vehicles or with activities requiring a significant degree of skill or care"; and (6) "Contest and promotion requirements."[13,p.4]

§ Individual guidelines may be viewed at https://crtc.gc.ca/eng/television/publicit/codesalco.htm

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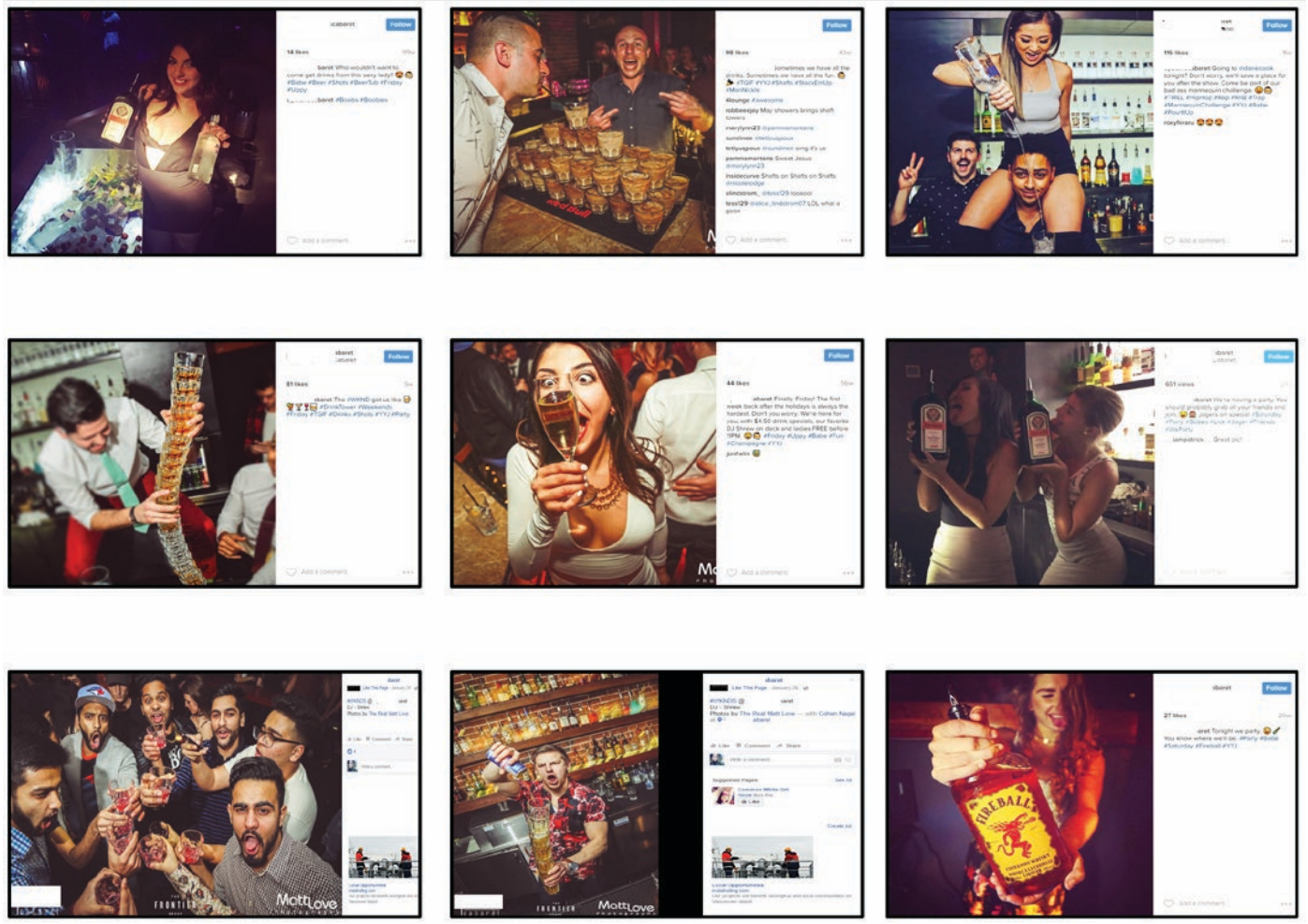
FIGURE 2
Picture mosaic created from alcohol-related images posted to social media by drinking venues, ranked by investigators as conflicting most with the CRTC Code guidelines



This allowed us to create, for each university, a unique booklet containing between 12 and 16 picture mosaics, one for each popular local drinking venue.

Phase 2

From the students who in phase 1 had indicated interest in being contacted again, we recruited a group of 78 students (20 at the University of Victoria, 17 at Queen's University, 18 at Bishop's University and 23 at Dalhousie University) via email to rate popular drinking venues' postings against the CRTC Code guidelines. The participating students were invited to a room where they were provided with their campus booklet. By using the same rating procedure described earlier, students were instructed to evaluate each drinking venue's picture mosaic for compliance with the CRTC Code. The exercise was repeated between 12 and 16 times, depending on how many popular local drinking venues had been identified at a particular campus. It took between one and two hours for students to complete the evaluation. A $30 gift card was offered to participants to thank them for their time.

Analyses

First, we performed descriptive analyses. Based on phase 1 data, we used ANOVA and chi-square tests to examine the sample characteristics and identify potential confounding effects of sociodemographic variables that should be adjusted for in multivariate regression analyses. Once the CRTC Code rating executed by students in phase 2 was completed, we confirmed modest interrater reliability by a Spearmen correlation analysis (0.52), a Fleiss' kappa coefficient of 0.21[23] and a mean percent agreement of 61% (0 = rated definitely noncompliant, probably noncompliant or unsure; 1 = rated probably compliant or definitely compliant). Then, based on students' mean rating scores of each drinking venue's mosaic obtained in phase 2, we calculated a measure of compliance with each of the 17 CRTC Code guidelines across all drinking venues.

Second, we connected both phase 1 and phase 2 databases by linking data on the drinking venues, which were uniquely identified in each phase: phase 1 data included students' favourite drinking venues and their drinking behaviours, and phase 2 data included students' mean rating scores of each drinking venue's mosaic for each CRTC Code guideline. From these pooled data, we performed two series of multivariate regressions[24] and adjusted both for potential confounding effects of

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age, education, year of study, study subject and campus site.

For the first series, we examined the association between the extent to which drinking venues' Facebook and Instagram postings violate the CRTC Code (in their original metrics) and drinking venues' popularity (natural log-transformed) so as to estimate changes in mean compliance scores associated with a 1% change in popularity. For the second series, we examined the association between students' drinking behaviours (i.e. frequency of drinking, average quantity consumed in a single occasion and frequency of drinking when attending drinking venues) in their original metrics, and the extent to which the drinking venues they tend to prefer posted images on social media platforms that violate the CRTC Code (natural log-transformed).

For both analyses, we used the natural logarithm of the independent variables. We performed the log transformations to account for the non-normal distribution of the variables and reduce the effects of extreme values, and because they were only performed on the independent variables, they did not significantly affect the nature of the relationships under study. All statistical analyses were conducted using SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA, 2011).

All significance tests assumed 2–tailed p-values ($p < .05$). The adjusted effect estimates and corresponding 95% confidence intervals (CIs) are reported.

Results

Phase 1

The descriptive results presented in Table 1 indicate that the mean age of sample participants was 20.8 years and that the vast majority were undergraduates (90.8%). These characteristics varied significantly between the four universities, with Bishop's

TABLE 1
Characteristics of phase 1 sample of students from four Canadian universities

Characteristics	Queen's University		Dalhousie University		Bishop's University		University of Victoria		Total	
	N	M/%[a]	N	M/%[a]	N	M/%[a]	N	M/%[a]	N	M/%[a]
Age										
Mean	136	20.40	106	21.81	143	19.75	92	21.74	477	20.78
SD		2.15		5.14		2.44		3.03		3.38
Min		17.00		18.00		17.00		19.00		17.00
Max		35.00		54.00		33.00		34.00		54.00
T-test p		.002		.877		<.001		ref		<.001[b]
Education level										
Undergraduate	127	93.38	88	83.02	137	95.80	81	88.04	433	90.78
Graduate	9	6.62	18	16.98	6	4.20	11	11.96	44	9.22
χ^2 p		.168		.321		.032		ref		.006[b]
Alcohol drinking days per week										
Mean	136	1.80	106	1.83	143	2.14	92	1.86	477	1.92
SD		1.34		1.45		1.59		1.54		1.48
Min		0		0		0		0		0
Max		7		7		7		7		7
T-test p		.771		.900		.1589		ref		.212[b]
Usual number of alcoholic drinks per occasion										
Mean	136	3.34	106	2.61	143	3.07	92	3.90	477	3.21
SD		3.52		3.53		3.02		2.88		3.28
Min		0		0		0		0		0
Max		30		26		13		15		30
T-test p		.205		.006		.057		ref		.044[b]
Alcohol drinking frequency when attending a drinking venue										
Mean	136	3.31	106	3.41	143	3.30	92	3.80	477	3.42
SD		1.39		1.34		1.31		1.32		1.35
Min		1		1		1		1		1
Max		5		5		5		5		5
T-test p		.006		.037		.005		ref		.022[b]

Abbreviations: Max, maximum; Min, minimum; ref, reference group; SD, standard deviation.

[a] M = mean of age, drinking days weekly, usual number of drinks per occasion and drinking frequency at drinking venues; % of undergraduates and graduates.

[b] Across all sites T-test or χ^2 test p.

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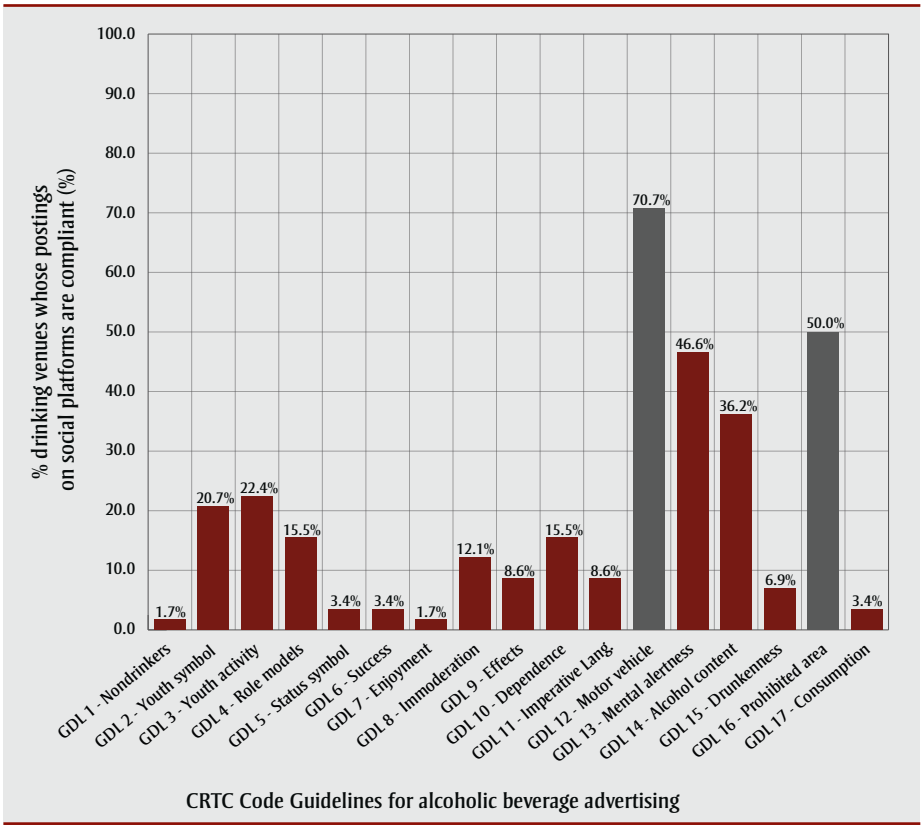
students being younger (t-test, $p < .01$) and more likely to be undergraduates (chi-square, $p > .01$). On average, students reported drinking alcohol 1.92 days per week. The average number of alcoholic drinks per occasion was 3.20 and varied significantly across sites (t-test, $p = .044$) with students from the University of Victoria reporting a greater number of alcoholic drinks per occasion than students from Dalhousie University. Regarding the frequency of drinking alcohol when going out to a bar, a pub or a club, students' average response was 3.42 (meaning more than "half of the times") and varied significantly across campuses (t-test, $p = .022$) with students from the University of Victoria reporting drinking more often than their counterparts at the other campuses.

Phase 2

Drinking venues' compliance with the CRTC Code, according to students

Figure 3 presents, for each CRTC Code guideline, the percentage of drinking venues rated by phase 2 students as being probably or definitely compliant, i.e. to whom students gave an average score of 4.0 or higher. For example, for guideline 12, according to which commercial messages for alcoholic beverages shall not "introduce the product in such a way or at such a time that it may be associated with the operation of any vehicle or conveyance requiring skill,"[7] students' evaluations indicated that 71% (42/58) of drinking venues posted images on social media platforms that probably or definitely complied with this particular CRTC Code guideline. In the same vein, students' evaluations showed that 50% of venues (29/58) posted images that probably or definitely adhered to guideline 16, according to which postings shall not "portray persons with any such product in situations in which the consumption of alcohol is prohibited."[7] However, for the remaining 15 guidelines, students evaluated that no more than 46.6% (27/58) and as little as 1.7% (1/58) of drinking venues posted images on social media platforms that adhere to the CRTC Code.

FIGURE 3
Percentage of drinking venues with postings on social media platforms rated by students as being compliant with CRTC Code[a] guidelines



Abbreviations: CRTC, Canadian Radio-television and Telecommunications Commission; GDL, guideline; Lang., language.
[a] CRTC Code for Broadcast Advertising of Alcoholic Beverages.[7]

Pooled phase 1 and phase 2

Tables 2 and 3 present results based on pooling data from phase 1, in which students indicated their drinking behaviours and their favourite drinking venues, with data from phase 2, in which a subgroup of students evaluated the compliance of drinking venues' postings with each of the 17 CRTC guidelines.

Drinking venues' compliance with the CRTC Code and popularity among students

In Table 2, adjusted effect estimates show that a lower mean level of compliance with the CRTC Code was significantly associated with a 1% higher popularity score of drinking venues (adjusted estimate: −.158, 95% CI: −.219 to −.097; t-test, $p < .001$). More specifically, a lower mean level of compliance with the CRTC Code guideline 1 (t-test, $p < .001$), guideline 2 (t-test, $p < .001$), guideline 3 (t-test, $p = .002$), guideline 5 (t-test, $p = .036$), guideline 6 (t-test, $p = .003$), guideline 7 (t-test, $p = .004$), guideline 15 (t-test, $p = .017$) and guideline 17 (t-test, $p = .002$) was significantly associated with a drinking venue's popularity. Put differently, there was a significant association between students' preferences for certain drinking venues and these venues' propensity to post images on social media platforms that violate the CRTC Code in general and eight specific guidelines in particular.

Drinking venues' compliance with the CRTC Code, and student drinking behaviours

Table 3 presents the association between CRTC Code compliance by drinking venues and students' drinking behaviours during the semester. Adjusted effect estimates indicate that a 1% higher overall mean level of compliance with the CRTC Code was significantly associated with 0.458 fewer drinking days per week during a semester (95% CI: −0.806 to −0.111; t-test, $p = .01$), 0.294 fewer drinks per occasion (95% CI: −0.584 to −0.003; t-test, $p = .048$) and a lesser likelihood of consuming alcohol when attending a drinking venue (adjusted estimate: −0.302; 95% CI: −0.471 to −0.133; t-test, $p < .001$). Overall, these results indicate that the lightest drinkers preferred drinking venues whose images posted on social media platforms complied with the CRTC Code, or contrariwise, that the heaviest drinkers tended to prefer drinking venues whose images posted on

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TABLE 2
Changes in mean levels of compliance with the CRTC Code[a] guidelines according to 1% higher score in drinking venues' popularity

CRTC	N	Mean	Unadjusted effect estimate[b]			Adjusted effect estimate[b,c]		
			Estimate	95% CI	T-test *p*	Estimate	95% CI	T-test *p*
Mean CRTC Code score	986	3.156	−0.093	−0.143 to −0.043	< .001	−0.158	−0.219 to −0.097	< **.001**
GDL 1 - Nondrinkers	58	2.935	−0.171	−0.281 to −0.061	.003	−0.263	−0.380 to −0.147	< **.001**
GDL 2 - Youth symbol	58	3.390	−0.166	−0.309 to −0.023	.024	−0.283	−0.429 to −0.138	< **.001**
GDL 3 - Youth activity	58	3.478	−0.116	−0.258 to 0.026	.108	−0.230	−0.373 to −0.087	**.002**
GDL 4 - Role models	58	3.428	−0.033	−0.157 to 0.092	.602	−0.070	−0.208 to 0.069	.317
GDL 5 - Status symbol	58	2.693	−0.146	−0.304 to 0.012	.069	−0.179	−0.347 to −0.012	**.036**
GDL 6 - Success	58	2.804	−0.203	−0.333 to −0.073	.003	−0.213	−0.349 to −0.076	**.003**
GDL 7 - Enjoyment	58	2.434	−0.191	−0.327 to −0.055	.007	−0.210	−0.352 to −0.069	**.004**
GDL 8 - Immoderation	58	2.720	−0.145	−0.356 to 0.067	.176	−0.184	−0.428 to 0.061	.138
GDL 9 - Effects	58	3.135	+0.038	−0.119 to 0.194	.632	+0.048	−0.117 to 0.214	.559
GDL 10 - Dependence	58	3.185	−0.080	−0.259 to 0.098	.370	−0.087	−0.289 to 0.115	.391
GDL 11 - Imperative language	58	3.009	−0.077	−0.244 to 0.091	.363	−0.015	−0.210 to 0.180	.875
GDL 12 - Motor vehicle	58	4.223	+0.077	−0.054 to 0.209	.243	+0.004	−0.122 to 0.130	.948
GDL 13 - Mental alertness	58	3.987	+0.025	−0.108 to 0.158	.706	−0.045	−0.189 to 0.100	.537
GDL 14 - Alcohol content	58	3.563	−0.007	−0.175 to 0.162	.936	−0.115	−0.292 to 0.063	.202
GDL 15 - Drunkenness	58	2.651	−0.251	−0.438 to −0.064	.01	−0.259	−0.471 to 0.048	**.017**
GDL 16 - Prohibited area	58	4.009	+0.029	−0.090 to 0.148	.625	−0.080	−0.181 to 0.021	.119
GDL 17 - Consumption	58	2.002	−0.170	−0.354 to 0.013	.068	−0.264	−0.425 to −0.103	**.002**

Abbreviations: CI, confidence interval; CRTC, Canadian Radio-television and Telecommunications Commission; GDL, guideline.
Note: Bolded type indicates statistically significant effect.
[a] CRTC Code for Broadcast Advertising of Alcoholic Beverages.[7]
[b] The effect estimates were interpreted as change in mean CRTC scores due to a 1% increase in popularity scores, since the independent measure was natural log–transformed.
[c] Adjusted for age, education, year of study, study subject and site.

social media platforms were less compliant with the CRTC Code.

Discussion

Twelve years ago, it was suggested that to enhance public health and safety, Canadian policy should aim to support and improve the current self-regulatory system and eventually ban both broadcast and nonbroadcast alcohol ads.[25] Although there have been doubts as to whether a total ban on alcohol marketing on social platforms would succeed,[26] at least two countries have taken steps in that direction. In 2015, the Finnish parliament adopted a law that restricts any alcohol-related web content that is intended to be shared by consumers. In Sweden, a new law will forbid commercial advertising on social media to be used to market alcohol products.[14] According to Lindeman and Hellman,[27] these initiatives are bringing to light that proper enforcement requires persistent monitoring and regional collaboration for enforcing policies on social media advertising, something that Canada might want to explore.

Strengths and limitations

This innovative study contributes to research on web alcohol advertising first by documenting the scope of CRTC Code violations by drinking venues posting alcohol-related content on social media platforms. A central result of this study is that, from the point of view of the average Canadian university student, popular drinking venues are overwhelmingly posting alcohol-related content that contravenes the CRTC Code and supports a culture of excessive drinking. In Nova Scotia, Quebec, Ontario and British Columbia, i.e. four provinces where regulatory agencies have restrictions on web alcohol advertising, drinking venues tend to post images that associate alcohol with immoderate consumption, the enjoyment of activities and events, social status, personal success and achievements. Contrary

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TABLE 3
Change in university students' drinking behaviours in a semester according to 1% higher scores in drinking venues' compliance with CRTC Code

		Alcohol drinking days per week	Usual number of alcoholic drinks per occasion	Alcohol drinking frequency when attending a drinking venue
	N	986	986	986
	Estimate	−0.355	−0.282	−0.417
Unadjusted effect estimate[a]	95% CI	−0.769 to 0.059	−0.610 to 0.456	−0.614 to −0.220
	T-test *p*	.093	.092	< .001
	Estimate	−0.458	−0.294	−0.302
Adjusted effect estimate[a,b]	95% CI	−0.806 to −0.111	−0.584 to −0.003	−0.471 to −0.133
	T-test *p*	**.01**	**.048**	**.001**

Abbreviations: CI, confidence interval; CRTC, Canadian Radio-television and Telecommunications Commission.

Note: Bolded type indicates statistically significant effect.

[a] The effect estimates (95% CI) were interpreted as one unit change in drinking measures due to a 1% increase in compliance scores with CRTC Code guidelines.

[b] Adjusted for age, education, year of study, study subject and site.

to the intent of the CRTC Code guidelines, students also found it common for drinking venues to post scenes in which alcohol is consumed or images that attempt to influence nondrinkers to drink.

These results are in line with the general findings in the literature showing that self-regulatory marketing codes fail to prevent the dissemination of content that circumvents the spirit of marketing code guidelines, in particular those concerning social or sexual success enhancement and protection of youth.[28,29] Our results, like those of others,[30] suggest that self-regulatory systems that govern alcohol marketing practices are not meeting their intended goal of protecting vulnerable populations. Clearly, the current self-regulated system fails Canadian youth by not taking action when a great number of alcohol portrayals and promotions support a culture of excessive drinking. Furthermore, because of the clear relationship between sexist and demeaning (to women) alcohol advertising and sexual victimization,[31] this unregulated environment may be especially risky for young women.

Second, by pooling results from phase 1 with those from phase 2, we obtained additional results worth emphasizing. There was a significant association between drinking venues' propensity to post images on social media platforms that do not comply with the CRTC Code and students' preferences for these venues. This association may illustrate that by posting noncompliant content, drinking venues manage to attract the attention of students and bring them in. Obviously, in a competitive environment where there are no legal consequences to posting content that contravenes the self-regulatory CRTC Code, drinking venues seeking to attract students will be tempted to post images that normalize and trivialize excessive or inappropriate alcohol consumption.

Finally, our study brought to light the extent to which CRTC Code violations relate to drinking behaviours. University students who drink more tend to prefer venues whose images posted on social media platforms violate several CRTC Code guidelines. This might be a result of natural selection, whereby the heaviest drinkers attend venues that post images indicating they may meet others who drink like them. However, given that increases in student alcohol consumption match decreases in compliance with the CRTC Code, we must acknowledge that posting images that promote excessive drinking may contribute to normalizing the behaviour. Once again, this may have more severe repercussions for young women than for young men, as women who say they sometimes or often consume more alcohol than they should are twice as likely to be victims of completed, attempted or suspected sexual assaults than those who only sporadically or never use alcohol.[32]

Besides the usual challenges associated with cohort studies, which do not allow for establishing causality, this study has a few limitations. First, the process by which we selected the images, that is, ranking their compliance with the CRTC Code and then selecting the least compliant images to put in the mosaics, means that they cannot be considered representative of all alcohol-related posts on Facebook and Instagram. Though this could be considered a limitation, any deviation from the guidelines can be considered cause for concern.

Second, because of its innovative nature, this study lacks standardized measures. Notably, to allow students to evaluate the alcohol-related content posted by drinking venues on social media platforms, we had to develop a survey adapted from the CRTC Code. While we are unaware of previous studies that have adapted the CRTC Code in this manner, we would argue that the instrument has face validity, since each item asking about compliance used precise wording from the Code itself. We note, however, that interrater reliability between student raters was only modest, indicating some subjective component in applying the CRTC Code as it stands to digital images from bars.

Third, by focussing specifically on drinking venues considered popular in four campus towns, the generalizability of the present findings is limited. Nonetheless, the fact that similar results were obtained across all four towns is indicative that bars in other university cities and towns in Canada are also likely to employ social media to encourage student drinking.

Conclusion

This study contributes to the broader consensus that there is reason for concern regarding the use of social media as a platform for marketing alcohol. An important result of this study is the insight

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it provides about university students, a key audience for alcohol advertising on social media platforms. More specifically, we were able to demonstrate the scope of CRTC Code violations on social media platforms by asking students from four Canadian universities to rate alcohol portrayal and promotions posted online by popular drinking venues. We further assessed whether the extent to which drinking venues violate the CRTC Code is related to the popularity of the venues and students' own drinking behaviours.

These results serve as a reminder to territorial and provincial regulatory agencies to review their practices to ensure that alcohol advertising guidelines are applied and enforced consistently. More importantly, these results call for the adoption of federal legislation with a public health mandate, as currently exists for cannabis and unhealthy food for children, that would apply to all media, including print, television and radio, digital and social. This new legislation should include advertising restrictions such as mandatory preclearance of alcohol advertisements and effective administrative and deterrence systems, independent of the industry, for infringements on marketing restrictions.

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Conflicts of interest

The authors declare no conflict of interest. Tim Stockwell received research funds and travel expenses from both the Swedish (Systembolaget) and Finnish (ALKO) government retail alcohol monopolies for the conduct of research into the impacts of their policies on alcohol consumption and related harm.

TS was a Guest Editor for this issue of the HPCDP Journal, but removed himself from the peer review process and editorial decision-making associated with this manuscript.

Authors' contributions and statement

CP conceptualized the manuscript, interpreted the data and drafted the paper. JZ built the database, planned and performed analyses and drafted the methodology section. TS helped to conceptualize the study. The authors were all involved in revising of the paper and the approval of the final manuscript for submission.

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Original quantitative research

How many alcohol-attributable deaths and hospital admissions could be prevented by alternative pricing and taxation policies? Modelling impacts on alcohol consumption, revenues and related harms in Canada

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This article has been peer reviewed.

Abstract

Introduction: In 2017 Canada increased alcohol excise taxes for the first time in over three decades. In this article, we describe a model to estimate various effects of additional tax and price policies that are predicted to improve health outcomes.

Methods: We obtained alcohol sales and taxation data for 2016/17 for all Canadian jurisdictions from Statistics Canada and product-level sales data for British Columbia. We modelled effects of alternative price and tax policies—revenue-neutral taxes, inflation-adjusted taxes and minimum unit prices (MUPs)—on consumption, revenues and harms. We used published price elasticities to estimate impacts on consumption and revenue and the International Model for Alcohol Harms and Policies (InterMAHP) to estimate impacts on alcohol-attributable mortality and morbidity.

Results: Other things being equal, revenue-neutral alcohol volumetric taxes (AVT) would have minimal influence on overall alcohol consumption and related harms. Inflation-adjusted AVT would result in 3.83% less consumption, 329 fewer deaths and 3762 fewer hospital admissions. A MUP of $1.75 per standard drink (equal to 17.05 mL ethanol) would have reduced consumption by 8.68% in 2016, which in turn would have reduced the number of deaths by 732 and the number of hospitalizations by 8329 that year. Indexing alcohol excise taxes between 1991/92 and 2016/17 would have resulted in the federal government gaining approximately $10.97 billion. We estimated this could have prevented 4000–5400 deaths and 43 000–56 000 hospitalizations.

Conclusions: Improved public health outcomes would be made possible by (1) increasing alcohol excise tax rates across all beverages to compensate for past failures to index rates, and (2) setting a MUP of at least $1.75 per standard drink. While reducing alcohol-caused harms, these tax policies would have the added benefit of increasing federal government revenues.

Keywords: *alcohol policy, minimum unit pricing, taxation, International Model for Alcohol Harms and Policies, InterMAHP, mortality, morbidity, policy modeling*

Highlights

- We modelled the impacts of alternative pricing and taxation policies on alcohol harms for Canada in 2016.
- A minimum unit price (MUP) of $1.75 per standard drink would have reduced the number of deaths across Canada in 2016 by 732 and hospitalizations by 8329.
- Compensating for past failures to adjust alcohol excise tax rates with inflation would have decreased the annual number of deaths by 329 and hospitalizations by 3762.
- Indexing alcohol excise taxes between 1991 and 2017 would have resulted in the federal government gaining approximately $10.97 billion.
- Excise taxes calculated per unit of alcohol, adjusted for inflation and combined with an MUP, would have significantly reduced alcohol consumption, and consequently alcohol-attributable deaths and hospitalizations.

Introduction

Alcohol consumption in Canada was associated with approximately 15 000 preventable deaths, 90 000 preventable hospital admissions and 245 000 potential years of life lost in 2014.[1] The collective impact of alcohol use on health care, crime and lost productivity was estimated at $14.6 billion, higher than the costs of tobacco use and the costs of all other psychoactive substances combined, including opioids and cannabis.[1]

In 2016/17, the reference fiscal year we use in this paper, Canada collected $1.6 billion from excise taxes on alcohol,

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and $634 million from goods and services tax (GST) applied to alcohol.[2]

Alcohol excise taxes have a significant but, in most countries, substantially untapped potential to improve public health and safety outcomes.[3] In most countries, excise taxes are applied to the wholesale price of alcohol and then multiplied by profit margins and sales taxes. Thus, the effects of excise taxes on final prices can be considerable. Pricing and taxation strategies are considered among the most effective at reducing alcohol consumption and related harms.[4,5] In a much-cited systematic review that included 1003 observations from 112 studies covering more than 30 countries, Wagenaar et al. concluded that, on average, a 10% increase in alcohol prices results in a 4.4% reduction in consumption.[6] The same research group also estimated significant impacts of price changes on alcohol-related morbidity and mortality.[7]

Thomas et al.[3] outlined elements of taxation and pricing strategies with strong theoretical and empirical support for their impacts on consumption and related harms. Giesbrecht et al.[8] and Wettlaufer et al.[9] operationalized these and assessed the implementation of ideal pricing and taxing strategies that achieve the following objectives:

- Taxes are applied comprehensively across all beverage types at a rate per unit of pure alcohol, often referred to as an alcohol volumetric tax (AVT). These generally result in drinks with higher alcohol content (both by strength and volume) being more expensive than less hazardous, lower alcohol content drinks;
- Tax rates are applied per unit of alcohol (e.g. per litre of ethanol or standard drink) and indexed to inflation to ensure that their real values do not erode over time;
- "Floor" or minimum prices are set, also at a rate per unit of pure alcohol, to restrict the availability of cheap and high strength alcohol.

In many countries, excise tax rates and pricing do not follow these principles. For example, it is common for wine excise taxes to be set per litre of beverage rather than per litre of ethanol. This means that high strength alcohol products have the same tax per litre as lower strength products.[10] Many countries have *ad valorem* (value-based) excise tax rates (i.e. set as a per cent of wholesale price and unrelated to alcohol content) that favour cheap, high strength beverages. Many jurisdictions do not routinely adjust volumetric excise tax rates with the cost of living. As a result, these tax rates decline in value and hence effectiveness over time.[3] This was the case for Canada between 1985 and 2017.[11,12] The only revisions made in that time were to compensate for introducing a 6% GST in 1991[13] and then reducing this to 5% in 2006[14,15].

Another common shortcoming is the practice of applying much higher excise tax rates to products above a particular percentage alcohol content by volume. For example, excise taxes in Canada increase for products above 7% alcohol by volume (ABV); as a consequence, most ciders and coolers have exactly 7% ABV, maximizing the amount of alcohol sold to consumers for the least price. An excise tax that increases continuously and gradually according to the strength of alcoholic drinks should minimize such clustering of relatively strong, low-priced drinks.

While all excise tax rates in Canada are volumetric (volume-based) rather than value-based, they are only "alcohol volumetric" for spirits with ABV greater than 7%. Most Canadian provinces and territories also impose some kind of minimum price on alcohol sales from liquor stores and/or bars and restaurants.[3] However, these vary greatly in value, comprehensiveness and how they are applied.[16] For example, some provinces or territories fail to apply minimum prices to all beverage types; set low minimum prices that potentially affect very few products; calculate minimum prices by product volume rather than pure ethanol (i.e. they do not set minimum prices per standard drink or unit); or do not index minimum price rates with inflation.[3]

Given the strong evidence for the effectiveness of minimum pricing as a public health measure,[17-19] Wettlaufer et al.[9] recommended that the federal government encourage a standard national minimum price of at least $1.71 per standard drink (equal to 17.05 mL ethanol), that is, a minimum unit price (MUP).

In this paper, we take advantage of access to unique, detailed datasets from a provincial government alcohol distributor that provide product-level data on prices, alcohol content and sales volumes. These were integrated with other national datasets to help model the effects of excise tax reforms on government revenues, per capita alcohol consumption and alcohol-related harms. We approximated per capita alcohol consumption changes based on published alcohol price elasticity data, and estimated impacts of alcohol consumption changes on health harms using an open access Internet-based modelling tool, the International Model for Alcohol Harms and Policies (InterMAHP).[20] Specifically, we modelled the following policy scenarios for the fiscal year 2016/17:

Scenario 1: Revenue-neutral Canadian excise taxes calculated at "uniform" versus "stratified" rates by beverage type and quality class; rates set per litre of pure ethanol while maintaining the tax burden on, and revenues from, alcohol sales constant.

Scenario 2: Higher inflation-adjusted alcohol excise tax rates calculated to compensate for the absence of adjustments for inflation between the fiscal years 1991/92 and 2016/17.

Scenario 3: MUPs set at either $1.50 or $1.75 per standard drink applied to all alcohol beverages.

Methods

Overall analytic strategy

For each of the selected tax and price policy scenarios, we proceeded through the following four basic steps:

1. We estimated the impact of the policy scenario on the prices of all alcoholic beverages in the Canadian market by beverage type (beers and ciders, wines, spirits) and by three price ("quality") categories (low, medium, high).
2. We estimated how the price changes would affect the consumption of each product in the Canadian market by applying a matrix of price elasticities for each beverage type and quality category as well as cross-price elasticities between each of these categories.
3. We estimated how the changes in consumption from Step 2 would affect

federal government excise taxation revenues.

4. We estimated how the changes in consumption from Step 2 would affect alcohol-attributable morbidity and mortality in Canada using the InterMAHP.[20]

The degree to which the consumption of alcohol responds to changes in price (i.e. the price elasticity of alcoholic beverages)—which is determined by its starting price[21]—is foundational to the strategy. There is a very wide distribution of alcohol prices in all developed markets, and consumers usually respond differently to price changes to cheap products than they do to expensive ones.

An added complication is that Canadian excise taxes vary substantially by beverage type and by the strength of drinks within these beverage types. In the case of beer, the level of taxation applied also depends on the volume of output of an individual brewery with lower rates applied to smaller producers. To model how price and tax policies would affect consumption overall, we estimated the distribution of alcohol sales by price for each beverage and quality category. To achieve this, we sought comprehensive individual product sales and price data from a provincial government alcohol monopoly. We estimated the distribution of prices per unit (standard drink) of pure alcohol from three samples of such data for the province of British Columbia (BC) and then applied this to national data reported by Statistics Canada on alcohol sales volumes.

Our modelling approach assumes the principle of *ceteris paribus*, that is, "all else being equal." Our estimated changes in consumption, revenue and harms assume all other relevant policies, social and economic changes are held constant.

Further details on each of the four methodological steps are provided below, followed by additional details specific to each of the selected tax and price policy scenarios.

Step 1: Estimation of scenario impacts on alcohol prices

We first estimated the exact contributions of excise taxes to the final price of each alcohol product in a detailed price and sales volume dataset from BC. This was necessary in order to estimate how changes to taxation rates would affect the price and, then, the sales volumes of each product, so as to estimate the overall impact of tax changes on total alcohol consumption. We assumed a conservative pass-through of 100% from a tax increase to a price increase.[22]

For the scenarios involving changes in excise taxes, it was necessary to estimate how a specific change in excise tax would change the retail price of each beverage category at each point along the wide distribution of prices within that category of alcoholic beverage. We started with three samples of comprehensive individual product data provided by the BC Liquor Distribution Branch. These comprised reported prices, ethanol contents and sales volumes, one from 2014 (April to August) and two from 2016 (April and May), covering 10466 individual alcohol products. We analyzed these samples separately to test for consistency in estimates of the distributions of the key variables of interest.

Prices of all products were converted to a price per standard drink (equal to 17.05 mL pure alcohol). We calculated the proportion of those prices made up by excise taxes in the target year of 2016 on the basis of beverage type, strength and (in the case of beer) individual brewery. These excise tax price components for each beverage were then adjusted according to each excise tax scenario estimating, in turn, the change in the retail price of each product. Both the retail price per standard drink and the value of excise taxes paid on all individual beverages were then expressed as proportions of the total value of all beverages sold within that category (by beverage type and quality). This meant that the distribution of sales volumes (litres of pure alcohol) could be expressed independently of absolute price levels and of the identity of individual products in a category. These distributions were then adjusted to fit national data on the total volume and value of the sales of alcoholic beverages in Canada by beverage type for the calendar year 2016.

Following Gruenewald et al.,[21] products in each beverage category were divided into low, medium and high quality groups (terciles) by price per unit of ethanol. Prices per standard drink after the application of sales tax varied between $0.69 for a cheap wine and $1617.23 for the most expensive spirits (Table 1).

We applied excise tax rates for beer, wine, spirits and coolers for that year to estimate as closely as possible the precise excise tax collected in BC from each individual product. As these were determined solely by percentage alcohol content by volume and container size for wine and spirits and were available in the price dataset, estimating these rates for these beverages was straightforward. However, federal excise tax rates on beer vary according to the annual volume produced by individual breweries, with lower excise tax rates for smaller producers. For example, rates for regular strength beers

TABLE 1
Summary statistics from the British Columbia product-level dataset, 2016

Beverage type	Quality	Price per standard drink ($ incl. taxes)				Number of products (*n*)	Per cent of volume sold, by beverage (%)	
		Min.	Average	Median	Max.		Litres of beverage	Litres of ethanol / pure alcohol
Beer	Low	0.79	1.30	1.22	1.53	218	31.4	33.3
	Medium	1.53	1.69	1.55	1.84	243	33.4	33.3
	High	1.84	2.97	2.37	59.42	1640	35.2	33.3
Wine	Low	0.69	1.23	1.19	1.47	230	33.7	33.3
	Medium	1.47	2.02	1.85	2.51	879	33.2	33.3
	High	2.51	16.54	5.10	965.09	5128	33.1	33.3
Spirits	Low	0.91	1.37	1.28	1.44	181	31.2	33.3
	Medium	1.44	1.50	1.35	1.56	156	31.7	33.3
	High	1.56	11.67	3.13	1617.23	1392	37.2	33.3
Total		0.69	10.51	3.06	1617.23	10 067	N/A	N/A

Abbreviations: max., maximum; min., minimum.

(>2.5% ABV) produced by domestic breweries in 2016 rose from $3.122 per 100 litres for the first 200 000 litres produced to $31.22 per 100 litres for all production above 7.5 million litres. We therefore estimated effective average beer excise tax rates for each individual brewery. To determine these rates, we fit logistic curves of recorded sales by brewery against effective tax rates within constraints set by 2016 data on market coverage by beverage type and total BC excise tax revenues collected. This enabled us to calculate excise taxes levied on each individual product and then calculate the total amount of excise taxes collected from each beverage category. We did this by multiplying the taxes levied on each individual product by sales volumes and then scaling these estimates to known national alcohol market parameters (e.g. total litres of ethanol, litres of beverages and dollar values by beverage types and jurisdiction from Statistics Canada) using both geographical and temporal scaling (e.g. provincial-to-national and quarterly-to-yearly, respectively). We obtained national alcohol market parameters from officially recorded sales[23] and excise tax revenues[2] using reported excise tax rates for the 2016/17 fiscal year.[12]

Assumed MUPs of $1.50 or $1.75 for Scenario 3 led to a more straightforward process for calculating price changes. Prices of all products in each price dataset that were below a new minimum per standard drink were simply adjusted upwards to reflect the new assumed minimum. We used this conservative approach because evidence shows that an increase in minimum prices can also cause increases in the price of products above the new minimum price.[18]

Step 2: Estimating effects of price changes on alcohol consumption

Any change in the way alcohol is taxed or priced affects the level of its consumption. The extent of consumption change in response to a price change is measured by its price elasticity. Price elasticity estimates the percentage change in consumption for a 1% change in price. Also, any change in consumption of any one beverage (e.g. wine) affects levels of consumption of other competing alcoholic beverages (e.g. spirits and beer). These "cross-price elasticities" are also influenced strongly by beverage quality (indexed by the relative prices of different beverages of the same type).[21] We estimated a matrix of such elasticities by applying alcohol price and cross-price elasticities reported for Canada,[18,24] with modifications by quality tercile following estimates made for Sweden.[21]

Gruenewald et al. performed a unique analysis of detailed price and sales data provided by the Swedish government alcohol retail sales monopoly, Systembolaget, before and after a sudden change in the way alcohol prices were calculated.[21] In broad terms, they analyzed the market for a "complex good," such as alcohol with thousands of unique products arranged along a price-quality "spectrum" (the full price range over which competing products vary[25]). "Quality classes" are represented along this spectrum by relative prices in which relatively lower cost goods represent lower quality goods, relatively higher priced goods represent higher quality goods, and so on.[26,27]

Defining "low," "medium" and "high" quality class beverages by beverage type, as above, Gruenewald et al.[21] examined the effect of a substantial increase in value-based taxes on wine and spirits and a per unit liquid volume tax for all alcoholic beverages on alcohol sales. They found that consumers did substitute between beverage quality classes and demonstrated that price elasticities related to price increases on lower quality goods were much greater than price elasticities related to price increases on high quality goods.[21] The many more options for quality substitutions available among high quality products enabled consumers of these products to substitute to lower quality products when faced with higher prices; these options are not always available to consumers of lower quality products. Not surprisingly, studies of tax pass-throughs have demonstrated that the alcohol industry knows this well; in the face of tax increases, prices on costly products are disproportionately increased over those of less costly products.[28,29]

Following on this work, we defined three "own-price" (beer, wine and spirits) and two "cross-price" elasticities between quality classes for each beverage type (e.g. beer and wine, beer and spirits). "Own-price" elasticity is an estimate of how changes to the price of a particular product affect sales. "Cross-price" elasticity is an estimate of how sales of product are affected by changes in price of a *different* product. We then anchored these ratios by requiring that the overall own-price elasticities matched those estimated for Canada by Hill-McManus et al.[24] We then used the resulting matrix of price elasticities to estimate how the mean price per litre of all beverage categories (by type and quality) would affect consumption. The resulting elasticity matrix is shown in Table 2.

To estimate the impacts of price changes on overall consumption, we first assigned all products to low, medium and high quality categories (terciles) based on their price per standard drink, and determined average price per litre of beverage in each category. We then compared how these mean prices would change in each scenario and applied the appropriate price elasticities shown in Table 2 to estimate changes in consumption. We assumed elasticities would work independently, that is, the total change in consumption

TABLE 2
Ratios of alcohol price elasticities by beverage type and quality or price per litre of ethanol

Beverage category	Effects of beverages of …	Beer	Wine	Spirits	Coolers	Ciders
Own-price elasticities	Equal quality	−0.591	−0.415	−0.436	−0.362	−0.362
Within-beverage cross-price elasticities	Lower quality	0.250	0.240	0.168	0.153	0.153
	Higher quality	0.417	0.080	−0.016	0.255	0.255
Cross-beverage price elasticities	Lower quality	0.062	0.075	0.074	0.038	0.038
	Higher quality	−0.078	−0.096	−0.051	−0.048	−0.048

Source: Based on Hill-McManus et al.[24] values for Canada adjusted by Gruenewald et al.[21]

for a given quality category was computed as the simple sum of the changes in consumption expected from the price changes under a given scenario.

Within beverage types, quality categories are equally distributed by sales of ethanol so the change in ethanol consumption by beverage type was computed by a simple mean of the values for each quality category. Total change in ethanol consumption was computed by a weighted mean, where the weights were given by total ethanol sales. This elasticity strategy was applied in all scenarios that report changes in consumption.

Step 3: Estimating impacts of consumption change on federal excise tax revenues

To determine changes in collected tax or revenue resulting from a change in consumption, we estimated changes in consumption for sales of each beverage quality class. We then combined the new sales estimates with the new prices used in each scenario, and summed them all to produce new total sales and tax figures. We then scaled our market coverage parameters to reproduce yearly national figures on the assumption that the distribution of BC alcohol prices was broadly representative of the nation. Because the estimated distribution of prices per standard drink was expressed in terms of percentages of both the total value and volume (in litres of ethanol) of the BC alcohol market, the assumption that this distribution applies to the whole of Canada is independent of the identity of the products sold, the level of overall consumption or the actual prices paid.

Step 4: Estimation of impacts of changes in alcohol consumption on mortality and morbidity under each policy scenario

Applying and developing methods used originally in the World Health Organization (WHO) Global Burden of Disease Study[30] with updated systematic reviews and meta-analyses, we used InterMAHP to estimate the impacts of alcohol consumption changes on alcohol-caused mortality and morbidity. InterMAHP was created to estimate alcohol-attributable fractions for 43 disease and injury types partially attributable to alcohol use.[20] The second version of this resource has a feature that enables calculating changes in rates of harm due to changes in per capita consumption.[20,31] Notable assumptions applied in InterMAHP for these purposes are that (1) a continuous distribution of drinking levels across any population follows a gamma distribution (as demonstrated and described for multiple countries, including Canada, by Kehoe et al.[32]); and (2) change in 100% alcohol-attributable conditions due to a change in per capita consumption can be estimated by an absolute risk function calibrated to the observed incidence of each condition.[31,33]

To perform such estimations, it is first necessary to have reliable estimates of per capita consumption for the population in the year of interest; an estimate of additional unrecorded consumption; and data on numbers of deaths and hospitalizations associated with diagnoses either fully or partially attributable to alcohol use. In the current study, we obtained per capita consumption data for BC and Canada as a whole from Statistics Canada[34] and applied an assumed 10.1% unrecorded alcohol consumption for Canada using the WHO Global Information System on Alcohol and Health (GISAH).[35] Data sourced originally from the Canadian Institute for Health Information (CIHI) on hospitalizations and from Statistics Canada on deaths were provided by the Canadian Substance Use Costs and Harms study[1] for the year 2016 for all Canadian jurisdictions.

All estimates of alcohol-attributable morbidity and mortality and changes in these under each scenario were calculated by applying InterMAHP.[20] When estimating the impacts of changes in per capita consumption on harm, InterMAHP assumes all changes are accrued immediately, even for impacts on long-term chronic illnesses.[20] Population rates for some of these, such as liver cirrhosis, have been shown to respond immediately to changes in population consumption, while others, such as cancers, likely would respond over a longer time. Our methods thus count both the immediate and future effects caused by consumption changes, as if the policies had been implemented far enough in the past for longer-term health benefits to accrue.

Scenario 1: Calculating revenue-neutral alcohol volumetric excise tax rates and structures

In calculating the impacts on alcohol sales and related morbidity and mortality in 2016/17 had Canada implemented revenue-neutral volumetric excise tax rates, we considered two different tax structures: (1a) taxes distributed at a standard "unified" rate by volume of alcohol in each product; and (1b) taxes "stratified" by beverage type by volume of alcohol in each product.

In brief, we adjusted the portion of each product's retail price in 2016/17 due to excise taxes as required by each scenario and then scaled the distribution of taxes to assure revenue neutrality (i.e. produce the same revenue observed in 2016/17) – total alcohol revenues from 1a and beverage-specific revenues for 1b. We constructed an input vector θ of ethanol volumetric excise tax rates whose output would match a vector V of estimated volumetric excise taxes collected for all three scenarios. We defined the distance between our prospective scenario and the existing tax structure as the Euclidean distance to the vector C of estimated excise tax collected under the current structure:

$$d_C(V) = \sum_i (V_i - C_i)^2$$

The composition of these two functions produced a single-valued multivariable function $L(\theta)$ that we could then optimize (i.e. find the minimum value of L). When the input and output vectors were one-dimensional (scenario 1a), we applied the base R uniroot function.[36] When input and output were multidimensional (scenario 1b), we applied simultaneous perturbation stochastic approximation techniques[37] to optimize the loss function.

In each scenario, we estimated ethanol volumetric excise tax rates that replicated, as closely as possible, total excise tax revenues collected under the current structure using the techniques described.

Scenario 1a applied a unified AVT for all beverages, estimated to be $6.705 per litre of ethanol. Scenario 1b involved calculating separate stratified AVT rates to deliver revenue neutrality for each beverage type, estimated at $4.679 for beer, $4.769 for wine and $11.454 for spirits.

Scenario 2: Calculating inflation-adjusted excise tax rates to compensate for the lack of adjustment from 1991/92 to 2016/17

Point estimate for 2016/17

In Scenario 2, we first estimated the change in alcohol consumption and

alcohol-attributable morbidity and mortality that would occur from an increase in excise taxes in 2016/17 that corrected for cumulative inflation from 1991/92 to 2016/17. For this scenario, we applied the same methods used in Scenario 1b for stratified AVTs, but now working with initial excise tax rates adjusted by cumulative inflation from 1991/92 to 2016/17, estimated at 1.5535 for that period or +55.35%.

Cumulative estimate for 1991/91 to 2016/17

We then estimated the cumulative impacts on consumption, revenue and harms of past failures to adjust excise tax rates. We assumed a counterfactual scenario in which excise rates had kept up with inflation from 1991/92 to 2016/17. We applied a compounded inflation rate, acquired from the Bank of Canada, to estimate excise taxes collected at the product level adjusted for inflation since 1991/92. For example, if the rate for a given product was $0.10 per litre of beverage and inflation was +50%, then the rate would be increased to $0.15 per litre of beverage. These new rates produced new prices across all beverage quality groups.

We estimated total excise taxes foregone by the Canadian government resulting from the failure to index these between 1991/92 and 2016/17. We accessed archived and current Statistics Canada data of total alcohol sales (in dollars and litres).[23,33,38-40] Data for total litres of beverage sold were available for all years of study, but revenues were only available from 1993/94 to 2016/17 and excise taxation data were only available from 2004/5 to 2016/17. Revenues were imputed from total litres of beverage sales data, and excise collection was imputed from the Consumer Price Index using non-Bayesian linear regression method as implemented in the R package "mice."[41]

To implement the selected scenario where excise rates would have tracked inflation, we used consumption, price, and excise collection data to create a series of year over year per cent changes from 1991/92. We used these per cent changes to encode the assumed grandly exogenous factors that historically alter changes in price and consumption. Our prospective scenario induces relatively small changes in these factors, determined by the following iterative method.

Given each year's beverage product price, and the proportion of that price that was due to excise taxation, we first increased the amount due to excise taxes by that year's inflation rate. We then assumed that 100% of this inflated amount would be passed onto consumers.[22,42] The resulting price change was then assumed to affect subsequent sales with an elasticity of −0.44,[6] leading to changes in consumption that then affected net revenue; prospective excise collection was then determined as a proportion of net sales. These changes in consumption were then carried over to the following year's prospective excise scenario. Sources of uncertainty were taken both from the Wagenaar et al. estimate of overall alcohol price elasticity and the method of imputation for historical excise duty rates.[6] These uncertainties were then used in Monte Carlo simulations with 10000 draws to construct 95% confidence intervals, that is, a parametric bootstrap.

We estimated cumulative harms incurred from lack of indexing by a simple extrapolation from the preventable hospitalizations and deaths estimated in 2016/17. The 95% confidence interval endpoints were used to estimate the lower and upper bounds on preventable harms in 2017. These harms were projected over the period of 1991/92 to 2016/17 by assuming a linear relationship between population and preventable harms. We then rounded preventable deaths to the hundreds, and preventable hospitalizations to the thousands, to reflect the simplicity of this estimate.

Scenario 3: Estimating effects of an MUP set at $1.50 or $1.75 per standard drink

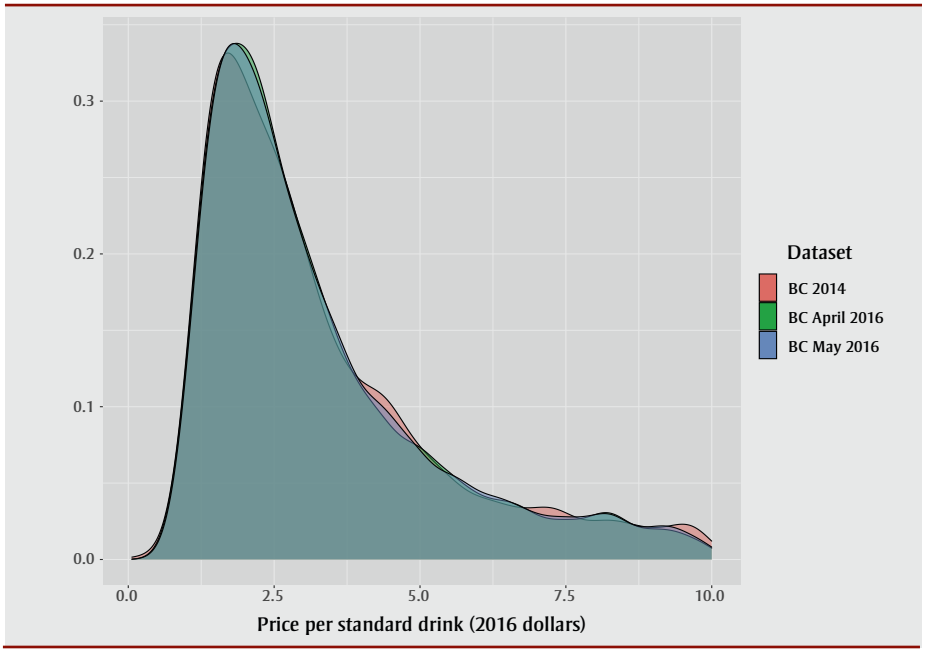
We computed each product's price per standard drink and raised the price of each product that fell below the proposed minimum to the proposed minimum price for all products. This selective price increase changed the mean price per litre of beverage quality classes having at least one product that fell below the threshold. As before, we used these adjusted prices and the elasticities in Table 2 to estimate expected changes in consumption, one for each dataset, and proposed minimum price per standard drink.

Results

Precision of estimated distributions of ethanol sales by prices per standard drink

The distributions of ethanol sales volumes by price paid per standard drink across the three BC product-level prices and sales samples were very similar (Figure 1). We estimated the extent of overlaps between samples using 10 000 bootstrap samples calculated using the overlapping R package.[43] Resulting median estimates and 95% confidence limits demonstrated the

FIGURE 1
Probability distributions of ethanol sales by price per standard drink for three product-level samples from British Columbia (BC), 2014–2016



following overlaps: 89.05% (87.17–90.83%) between the BC 2014 and BC April 2016 prices paid per standard drink; 88.48% (86.76–90.10%) between the BC 2014 and BC May 2016 prices paid per standard drink; and 92.44% (90.90–93.75%) between the BC April 2016 and BC May 2016 prices paid per standard drink.

Scenario 1: Revenue-neutral alcohol volumetric excise tax rates and structures

Based on our simulations, compared to current Canadian taxes[12] the unified AVT (Scenario 1a) would have resulted in a considerable reduction in excise taxes contributed by spirits-based drinks, large increases for beers and small increases for wines (see Table 3). Unexpectedly, it also resulted in a very small 0.13% increase in overall per capita alcohol consumption after taking account of the impacts of price changes across the full price-quality spectrum and across beverage types, own- and cross-price elasticities.

The stratified AVT (Scenario 1b) was designed to generate the same revenue within each beverage type as under the existing system. The overall impact was just a 0.06% reduction in per capita alcohol consumption.

Scenario 2: Inflation-adjusted excise tax rates

Actual alcohol excise taxes collected in 2016/17 totalled $1556.1 million. Had taxes been inflation-adjusted since 1991/92, 55.35% greater tax revenues would have been received in 2016/17 (see Table 4). This amounts to an additional $846.30 million and would have been accompanied by a 3.83% reduction in per capita alcohol consumption. Applying this estimated change in the per capita consumption to national data on partially and fully alcohol-attributable morbidity and mortality using InterMAHP suggested that there would be approximately 3762 fewer hospitalizations and 329 fewer deaths in 2016.

The cumulative effects of the failure to index excise duty rates between 1991/92 and 2016/17 are summarized in Table 5. All told, we estimated that the federal government would have collected between $9.26 billion and $12.71 billion more from excise taxation and the Canadian population would have been consuming between 2.51% and 3.33% less alcohol in 2016/17.

Scenario 3: MUPs set per standard drink of alcohol

The largest impacts of any of the price and tax reforms estimated arose from introducing MUPs (see Table 6). If set at $1.50 per standard drink, per capita alcohol consumption in Canada would have fallen in 2016 by approximately 3.94%. If set at $1.75, consumption would have been reduced by 8.68%. These consumption changes in turn would result in 4.2% and 7.9% reductions in federal taxes collected, with reductions in excise taxes slightly offset by smaller increases in GST. Both types of minimum prices modelled in Scenario 3 resulted in estimated increases in overall expenditure on alcohol, $564.37 million for an MUP of $1.50 and $1.57 billion for an MUP of $1.75.

The 8.68% reduction in consumption from a $1.75 MUP would have resulted in approximately 8329 fewer hospitalizations and 732 fewer deaths in Canada in 2016.

Comparison of policy scenario effects by beverage type and product price/quality

Figure 2 conveys the full effect of different tax policy impacts by beverage type and quality class categories, showing stark differences in effects, especially on consumption of cheaper products. Both the revenue-neutral unified and stratified alcohol volumetric taxation strategies had fairly equal effects across different quality bands for all beverages (Scenarios 1a, 1b). However, the across-the-board increase in excise taxes adjusting for inflation (Scenario 2) appeared to increase consumption of lower quality products while both the MUPs (Scenario 3) resulted in marked decreases in consumption of these products.

Discussion

We estimated the effects on revenue, alcohol consumption and related harms of a variety of recommended pricing and taxation reforms[3,9] by applying a matrix of price elasticities to a large dataset of prices, alcohol contents and sales volumes for over 10 000 products provided by a government monopoly alcohol distributor in a Canadian province. This modelling approach enabled us to simulate the impacts of different tax strategies while accounting for complex interactions related to price changes across different beverage types and "quality" classes of alcoholic beverages.

This approach provides a realistic assessment of tax impacts on sales of this "complex good." Of note, our approach was made possible by the availability of BC price data used to estimate sales volumes distributed across two key variables, price per standard drink and excise taxes paid per standard drink, each expressed as a percentage of total value of the BC alcohol market. These distributions were estimated independently from three separate,

TABLE 3
Estimated effects of two alternative and broadly revenue-neutral alcohol volumetric tax solutions on alcohol consumption and excise tax revenues

Outcome measures		Scenario 1a: Unified AVT	Scenario 1b: Stratified AVT
AVT rate per litre of ethanol ($)	Beer	6.705	4.679
	Wine	6.705	4.769
	Spirits	6.705	11.454
Change in ethanol consumption (%)	Beer	+0.21	+0.18
	Wine	−0.93	−0.46
	Spirits	+1.12	+0.01
	Coolers	−0.33	+0.29
	Ciders	+0.33	+0.23
	Total	+0.13	−0.06
Change in beverage consumption (%)	Total	+0.08	+0.04
Change in excise tax revenues (%)	Total	0.00	+0.55

Abbreviation: AVT, alcohol volumetric tax.

TABLE 4
Estimated effects in 2016/17 of introducing an alcohol volumetric tax adjusted for previous 25 years of inflation

Outcome measures		Estimates
Inflation	1991/92 to 2016/17	1.5535
Change in ethanol consumption (%)	Beer	−0.68
	Wine	−3.15
	Spirits	−8.16
	Coolers	−3.84
	Ciders	+0.26
	Total	−3.83
Estimated lost excise revenue (2016, $ million)	Beer	233.83
	Wine	173.85
	Spirits	397.923
	Coolers	23.05
	Ciders	17.64
	Total	846.30
Change in harm (*n*)	Deaths	−329
	Hospitalizations	−3762

comprehensive samples of BC price data, each comprising more than 10000 products. The distributions estimated were very consistent.

The most striking finding was the superiority of MUPs as a means of reducing consumption and related harms compared with strategies that raise alcohol taxes across the full spectrum of alcohol products. For example, if an MUP of $1.75 per Canadian standard drink had been introduced in 2016, it would have reduced consumption by 8.68%, alcohol-attributable deaths by 732 and hospitalizations by 8329. In contrast, an across-the-board increase in alcohol excise taxes to compensate for inflation since 1997 would have resulted in reductions in consumption of only 3.51%, deaths by 302 and hospitalizations by 3453.

We likely underestimated the extent of the difference in outcomes from across-the-board tax increases versus MUPs because we were unable to take into account the disproportionate rates of alcohol-related harm experienced by people on low incomes consuming alcohol at the same rate as those on higher incomes.[17,44] It is possible, therefore, that under some circumstances, across-the-board tax increases could *increase* the health burden from alcohol consumption as consumers shift to and use more lower quality goods. This will likely particularly affect consumers living at lower income who tend to drink cheaper alcohol, thereby increasing health inequalities in comparison with the reverse effect of introducing MUPs. This situation may arise because, while MUPs precisely target only the cheapest products known to be favoured especially by drinkers living on low incomes, our models predict that an across-the-board tax increase will increase consumption of these cheaper beverages (see Figures 2a to 2c). At the very least, we can conclude that our models found that MUP and across-the-board tax increases had reverse effects on consumption of cheap alcohol, the former decreasing and the latter increasing consumption.

TABLE 5
Estimated uncollected excise revenue and change in consumption

Cumulative outcome measure	Point estimate	95% Confidence intervals
Change in consumption by 2016	−2.91%	−2.51% to −3.33%
Lost excise revenue 1991–2016	$10.97 billion	$9.26 billion to $12.71 billion

The proposed hypothetical tax policy reforms were based on theoretical and empirical evidence that they would yield public health benefits. However, it is hard to predict precise impacts on overall consumption given the complex interrelationships between price changes of different types of alcohol products beverages categorized by beverage and price categories.[21]

In Scenario 1, we estimated the effects of collecting alcohol excise taxes at a rate per litre of ethanol rather than per litre of liquid as is currently the case for most beverages. In theory, this should provide consumers with a price incentive to select lower alcohol content beverages and shift their consumption accordingly. Again, in theory it should be possible to reduce alcohol consumption across the whole population by such a strategy while maintaining revenue neutrality. Our first model established a single unified alcohol volumetric excise tax rate applied to all beverage varieties while achieving the same level of exercise revenue as obtained in 2016/17. In fact, when considering all the complex interrelationships between beverage types and qualities in terms of price elasticities, this resulted in a slight increase in overall consumption (0.13%), because decreased wine consumption was more than compensated by slightly increased consumption of beer and spirits.

Applying unequal adjustments to tax rates for different major categories of alcohol producers would likely create political difficulties, and so we also modelled an alternative policy scenario in which each of the major producers was equally affected/unaffected overall (i.e. the stratified AVT, Scenario 1b). The model that best meets these requirements estimated only a 0.06% reduction in per capita alcohol consumption. While there may be some virtues of directly applying excise taxes at a rate per litre of ethanol rather than per litre of liquid, when applied across the whole complex alcohol market, overall estimated impacts on total consumption and related harms appeared to cancel each other out in our models.

Starkly contrasting outcomes were obtained from Scenario 2 (excise taxes increased to compensate for a failure to index taxes for 25 years) compared with Scenario 3 (a $1.50 MUP). Each resulted in a total change in consumption of approximately −4%, but this reduction occurred in

TABLE 6
Estimated effects of implementing minimum unit prices per standard drink

Outcome		MUP $1.50	MUP $1.75
Change in consumption (%)	Beer	−1.08	−2.21
	Wine	−4.57	−9.61
	Spirits	−6.73	−15.47
	Coolers	−5.15	−11.10
	Ciders	−0.04	−0.46
	Total	−3.94	−8.68
Change in harm (*n*)	Deaths	−339	−732
	Hospitalizations	−3868	−8329
Change in revenue ($ million)	Excise duty	−73.86	−162.95
	Federal sales tax (GST)	6.89	36.47
	Net federal revenue	−66.97	−126.48
Change in expenditure ($ million)	Due to price changes	564.37	1567.60

Abbreviations: GST, goods and services tax; MUP, minimum unit price.

completely different product segments. The two strategies had similar effects on spirit consumption, with all sectors seeing consumption reductions of similar magnitudes. However, opposite patterns of effects were observed for beers and wines. Under an MUP, consumption of cheaper alcohol was reduced and of expensive alcohol was increased. The reverse pattern occurred for the across-the-board tax increase in Scenario 2 (inflation-adjusted AVT).

Scenario 2 also highlighted the extent of lost federal government revenue from a failure to index alcohol tax rates until 2017. The federal alcohol taxes increase in 2006 was introduced purely to compensate for a reduction in federal sales taxes (the GST change from 6% to 5% for all consumer goods), that is, this was a revenue-neutral change and not an adjustment to take inflation into account. We estimated that in 2016 alone the federal government lost $846.30 million by not having adjusted alcohol excise taxes to compensate for inflation in the previous 25 years. Over this period, we estimate that the federal government lost $10.97 billion in excise tax revenues, which resulted in 4000 to 5400 more alcohol-caused deaths and 43000 to 56000 more alcohol-caused hospitalizations by 2016.

These results are broadly consistent with UK[45] and Australian modelling.[46] Meier et al. concluded that both AVT and minimum unit pricing generated greater reductions in harm for a fixed reduction in consumption than would be obtained from a value-based model or the then current mixed model applied in the UK.[45] Byrnes et al. estimated that introducing a revenue-neutral uniform AVT would only reduce per capita consumption by 0.05%, very similar to our estimate of 0.06%, albeit in a different market with a different tax structure.[46]

Limitations

We used geographical and temporal scaling parameters to generalize findings from provincial estimates for BC to the whole of Canada. The BC distribution of product prices and sales volumes may not be fully representative of all other provinces and territories where there are different local sales taxes, transportation costs and regulatory policies. The BC alcohol market is, however, broadly representative of the rest of Canada with its combination of metropolitan, rural and remote populations spread across a large geographical area, though BC per capita consumption is slightly above the national average.[1] Overall any differences are likely to mostly cancel each other out.

Further, because only the distributions of ethanol sales volumes by both price and excise taxes paid per standard drink in BC were calculated as percentages of the total value of the BC alcohol market, extrapolating these distributions to Canada as a whole was independent of the types, brands, volumes and values of individual products sold in BC. In addition, almost identical distributions of these key variables were estimated from three independent samples of BC price data which, in turn, closely resembled reported distributions from Ontario in an earlier study.[24]

Seasonal change in consumption between beverage categories is well documented.[47] The product-level datasets we used were from the spring and summer months when market shares of beer and refreshment beverages tend to be higher. Seasonal variations in total beverage market share were accounted for by temporal scaling parameters, but seasonal variation in individual product sales could not be estimated from the available data.

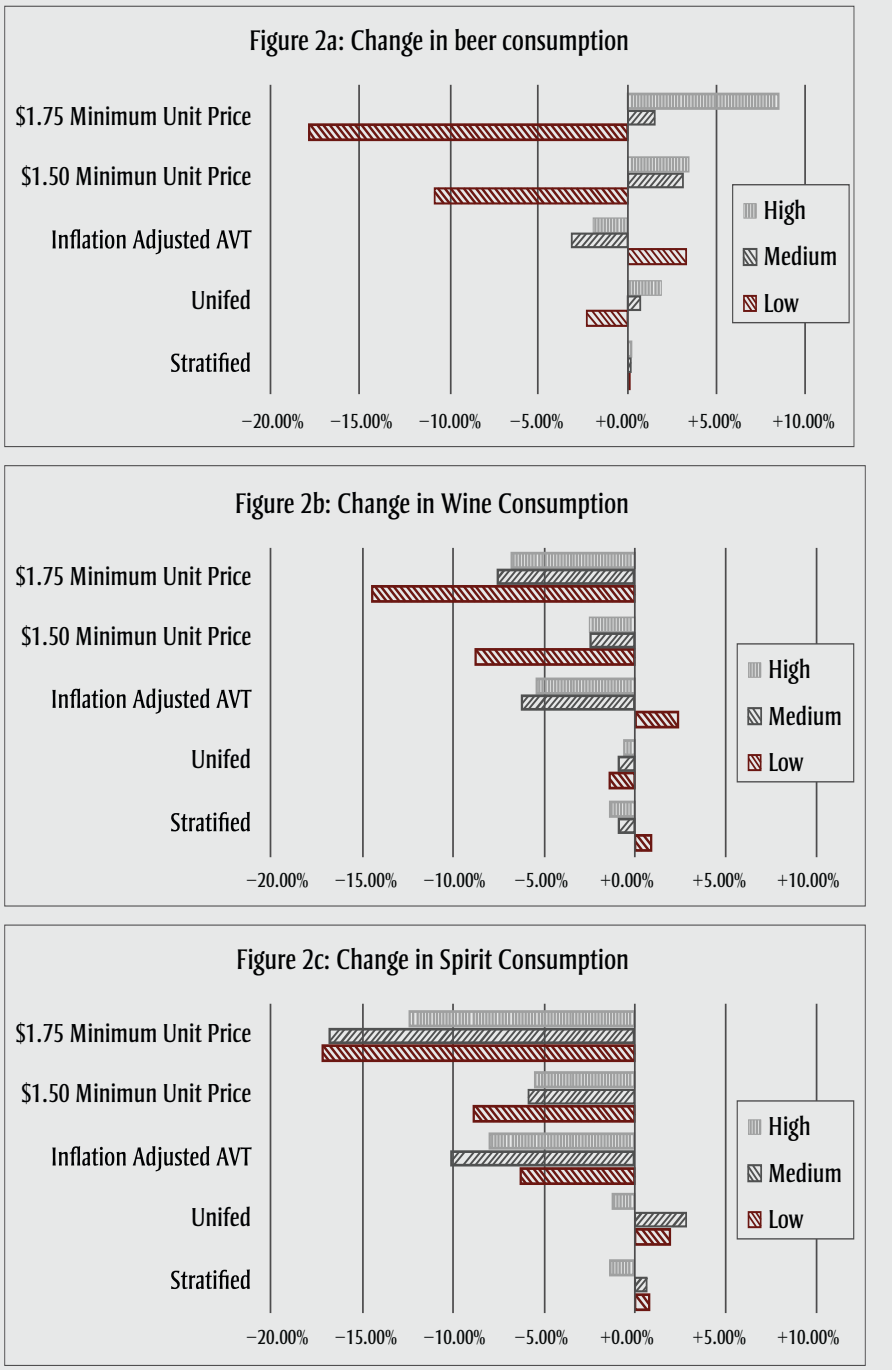
An additional unknown factor would be how manufacturers would respond to tax and minimum price changes. They would likely raise or lower the price they sell their products to the government distributor according to known changes in the final retail price. This would influence the potential to make profit from particular products. For example, 32% of individual cider products were listed as containing exactly 7% ABV, an artificial bright line in excise duty rates that marks an increase in duty collection. These products accounted for 50.8% of total ethanol sales among ciders. With an alcohol volumetric excise taxation, we would expect this type of clustering to disappear and a broader spectrum of strengths to occur. When considering MUP strategies, a majority of the additional revenue is unallocated by our models. One would expect producers to reactively raise the prime cost of their products to meet new MUPs, otherwise all of this unallocated revenue would be collected by government liquor authorities.

Conclusions

While a modelling exercise such as this can never precisely predict the future, it is capable of simultaneously considering a range of empirical inputs and complex interrelationships in order to provide a useful guide to the likely general outcomes of alternative policies. We suggest that the analyses presented in this paper support the following broad conclusions:

- Introducing national minimum pricing has substantial potential to improve public health and safety outcomes while, according to other evidence, reducing health inequalities to

FIGURE 2
Change in consumption by scenario, beverage category (beer, wine, spirits) and quality group (low, medium, high)



Abbreviation: AVT, alcohol volumetric tax.

a greater extent than across-the-board tax increases for all alcoholic products;

- The Canadian government lost substantial revenue over recent decades by not indexing alcohol excise taxes to the cost of living between 1985 and 2017, with attendant negative impacts on public health; and
- Some optimal public health as well as revenue collection benefits could be obtained by combining elements of each of the reforms proposed above, that is, by replacing the federal sales tax on alcohol with an alcohol volumetric excise tax adjusted to compensate for past lost revenues and combining this with a national minimum price, for example, of $1.75 a standard drink.

In addition to the public health benefits, this combination of policies should help reduce health inequalities by reducing alcohol-attributable harms for people living on low incomes while ensuring that the federal government gains additional revenue.

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Conflict of interest

TS, JS and AS have each received travel expenses from Scandinavian government alcohol retail monopolies (Systembolaget and/or Alko) to take part in a project to assess the public health impacts of their policies. TS also received a consulting fee for this work, and AS and JS salary contributions. No conflicts for others to declare.

TS and AS were Guest Editors for this issue of the HPCDP Journal, but removed themselves from the peer review process and editorial decision-making associated with this manuscript.

Authors' contributions and statement

Conceptualization: TS, SC, AS

Analysis and interpretation of data: SC, TS, PG, JS

Writing – original draft: TS, SC, PG

Writing – review and editing: TS, SC, AS, JS, PG

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

Drinking patterns, alcohol-related harm and views on policies: results from a pilot of the International Alcohol Control Study in Canada

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Abstract

Introduction: We conducted a pilot assessment of the feasibility of implementing the International Alcohol Control (IAC) Study in Ontario, Canada, to allow for future comparisons on the impacts of alcohol control policies with a number of countries.

Methods: The IAC Study questionnaire was adapted for use in the province of Ontario, and a split-sample approach was used to collect data. Data were collected by computer-assisted telephone interviewing of 500 participants, with half the sample each answering a subset of the adapted IAC Study survey.

Results: Just over half of the sample (53.6%) reported high frequency drinking (once a week or more frequently), while 6.5% reported heavy typical occasion drinking (8 drinks or more per session). Self-reported rates of alcohol-related harms from one's own and others' drinking were relatively low. Attitudes towards alcohol control varied. A substantial majority supported more police spot checks to detect drinking and driving, while restrictions on the number of alcohol outlets and increases in the price of alcohol were generally opposed.

Conclusion: This pilot study demonstrated that the IAC Study survey can be implemented in Canada with some modifications. Future research should assess how to improve participation rates and the feasibility of implementing the longitudinal aspect of the IAC Study. This survey provides additional insight into alcohol-related behaviours and attitudes towards alcohol control policies, which can be used to develop appropriate public health responses in the Canadian context.

Keywords: *alcohol, policy, Canada, survey instrument, binge-drinking, International Alcohol Control Study, IAC Study*

Highlights

- The estimates of average drinks per months from the International Alcohol Control (IAC) Study were significantly higher than those from the Centre for Addiction and Mental Health (CAMH) Monitor (26.3 vs. 19.4).
- The typical drinking session at a public special event or while camping or staying at a cabin/cottage approximated a binge-drinking session (5+ for men, 4+ for women).
- Only 8.3% of respondents were in favour of a policy of increasing the price of alcohol.
- Those who had purchased alcohol in the past six months from a grocery store showed significantly higher rates of over-drinking (53.5% vs. 40.54%) as compared to those who had not.

Introduction

The majority of adults in Canada consume alcohol,[1] and the production and distribution of alcohol creates thousands of jobs, while governments derive significant tax revenues from alcohol production and sales.

At the same time, alcohol causes or contributes to a large number of conditions, diseases and injuries.[2] According to the Global Burden of Disease Study, in 2016, alcohol was responsible for approximately 350000 disability-adjusted life year (DALYs) and 3.9% of all-cause DALYs in Canada.[3] In the same year, alcohol was the third leading behavioural contributor to the burden of disease globally, and the second leading behavioural contributor in Canada.[3] Alcohol is the largest single contributor to motor vehicle fatalities and was associated with one-third of motor vehicle collision fatalities in 2012, exceeding the number of deaths from assault.[4] In the United States, about one-third of those who die by suicide have been shown to be alcohol positive at the time of death.[5] Excessive use of alcohol causes secondary

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harm to others,[6] including substantial problems in families[7] and in the workplace,[8] and frequently involves aggression and violence.[9,10] Aggression is related to both overall consumption and frequency of intoxication.[11,12]

In Canada, burden related to alcohol in terms of costs that include health care, law enforcement and lost productivity has been estimated to be approximately $14.7 billion annually.[13] In most Canadian provinces, estimates of these burdens exceed revenues collected by governments.[14]

An effective prevention strategy requires a combination of population-level interventions and more focused interventions. The World Health Organization has identified three "best buys" for cost-effective alcohol policy interventions: tax increases, restricted access to retailed alcohol and bans on alcohol advertising.[15] Other population-level strategies include national/provincial/territorial alcohol strategies, alcohol pricing and type of alcohol control and retailing system.[16]

A population-level perspective is essential as the major burden of morbidity and mortality from alcohol is attributable not to the small proportion of the population that exhibit dependence on alcohol, but to the large portion of the population considered to be "moderate" drinkers.[17,18] Population-level interventions tend to avoid victim blaming and stigmatization of those who are alcohol dependent or regularly engage in high-risk drinking.[19] Other common interventions designed to promote population health include drinking and driving countermeasures, server interventions, and screening and brief interventions.

While there is substantial evidence supporting the effectiveness of population-level policies and interventions (e.g. studies by Babor et al.[20] and Anderson et al.[21]), more information is needed on the causal effects of policy on behaviour change.[18] The International Alcohol Control (IAC) Study was designed to address this gap. The IAC Study measures the impact of policy on behaviours such as purchasing and response to marketing to better understand the causal chain between policy and alcohol consumption.[18] The IAC Study also examines and interprets the impact of policies that are introduced as a package, as they tend to be.[18] The IAC study was modeled on the International Tobacco Control study, which was similarly designed to determine the effects of policy changes on changes in behaviour.[22]

The IAC Study draws on the World Health Organization's (2010) *Global Strategy to Reduce the Harmful Use of Alcohol*[23] and the international analysis of drinking patterns, harm from alcohol and effective interventions by Babor et al.[20] as well as other sources. The main rationale for the IAC Study was the substantial global burden of disease and injury from alcohol and the pressing need for effective policy to reduce the burden.[18]

The IAC Study uses several data sources. These include a longitudinal survey of individuals; a comprehensive literature review drawing on key policy, strategy, reporting and research documents; qualitative interviews with relevant stakeholders; and routinely collected and administrative data such as outlet location, alcohol price and treatment locations.[18] The IAC Study measures alcohol consumption using a within-location beverage-specific framework; this has been shown to provide estimates of consumption that are closer to alcohol sales data. Respondents are asked about mutually exclusive physical locations, types of beverage consumed for an estimate of alcohol content, number of drinks per location-session to estimate total alcohol consumed per drinking session and the frequency of location-sessions for total monthly consumption estimates.[24] As of December 2017, there were IAC Study initiatives in 13 countries, including this pilot study in the province of Ontario.[25]

Results from IAC Study initiatives for a number of countries have been published: Australia,[26] England and Scotland,[27] New Zealand[28] and the Republic of Korea.[29] Of these countries, Canada's social culture, political structures, gross domestic product (GDP) per capita and alcohol policies are similar to those of England, Australia and New Zealand, though per capita alcohol consumption is lower at 8.9 litres per year (in England this is 11.4 L; in Australia, 10.6 L; and in New Zealand, 10.7 L).[30] The research design of a longitudinal survey of drinkers, along with analysis of the policy context, permits the examination of changes over time within and between jurisdictions.

While many organizations in Canada monitor and report on alcohol use and problems,[1,31] there is no comprehensive source of information on drinking behaviour and the factors that influence it. Thus, the important information on levels of alcohol consumption in Canada and alcohol-related problems of youth and adult drinkers typically do not offer insight into how and where alcohol is consumed, how much is spent on alcohol in various environments or other topics salient from a policy perspective.

Several Canadian provinces have recently made, or are considering, major changes to alcohol policies that may significantly affect alcohol use and associated practices. These changes include the introduction of beer and wine sales in grocery stores in Ontario;[32] further privatization of alcohol retailing in several provinces;[33,34] changes to pricing policies;[35] and the increase in sanctions for hazardous alcohol-related behaviours (e.g. the provincial government of Ontario introducing immediate penalties for a blood alcohol concentration of 0.05 mg% when driving).[36,37] The ability to monitor the impact of these changes to help us understand the most appropriate ways to reduce alcohol-related harms is one of the key benefits of the IAC study.[21] The IAC Study has proven to be of substantial value in informing alcohol policy in several countries in recent years.[24]

In this paper, we describe a pilot assessment of the feasibility of implementing the survey component of the IAC Study in Ontario. This pilot assessment had three main purposes:

- To adapt the IAC Study survey instrument, which collects detailed information about drinking practices and contexts, to capture the heterogeneity of drinking in Canada,[38] while still providing data comparable to other IAC Study surveys in other countries;
- To administer the adapted survey in a pilot sample of participants in Ontario, Canada to test survey procedures; and
- To provide a preliminary assessment of what useful additional information could be obtained from using the IAC Study–based instrument

compared with already available information.

Methods

Survey design

The Canadian pilot of the IAC Study implemented a modified version of the New Zealand and Australian versions of the IAC Study. [22] The investigating team examined the original surveys and, after running a small-scale pre-test, determined that the full instrument would likely require well over 30 minutes to administer. A pilot questionnaire was designed, with input from the research firm conducting the surveys to ensure suitability for a computer-assisted telephone survey in Ontario. This questionnaire used a split-sample strategy of questioning with two subsets of questions. This split-sample strategy also took into account the need to conduct the pilot with finite resources. Adaptations included adjustments for Canadian drink size standards, volume of drinks and slang for drink containers.

The adapted questionnaires were assessed by the IAC Study principal investigators, Drs. Sally Casswell and Tasia Huckle, to ensure suitability as IAC Study instruments. The final adapted Canadian versions, available from the authors on request, were used in field testing.

Alcohol variables

Three derived variables representing drinking patterns were calculated according to the method reported by Chaiyasong et al.[39]

"High frequency drinking" refers to engaging in drinking sessions once a week or more frequently, at any location, over a six-month period. For the pilot study, a drinking session was defined as any occasion during which the respondent drank any amount of drink of at least 4% alcohol by volume.

"Typical occasion quantity" was defined as the weighted mean of standard drinks consumed per session across locations, taking into account location frequency. High quantity per session drinking was defined as drinking a mean of 8 or more standard drinks per occasion.

Definitions for standard drink sizes in terms of alcohol content vary across jurisdictions, with Australian standards containing less alcohol than Canadian standards. In comparisons between the results of the Chaiyasong et al. study[39] and this pilot study, numbers reflect the Australian standard drink size.

All other descriptions reflect Canadian standards (13.6 g of pure alcohol). Several variables related to risky drinking practices were also included. Binge-drinking is defined as 5 drinks or more per drinking session for men and 4 drinks or more per session for women. Pre-drinking refers to drinking alcohol before going to a location where drinking is also planned. Over-drinking refers to consuming more alcoholic drinks than planned.

Data collection

Survey participants had to be permanent residents of Ontario; living in private households (institutionalized populations were excluded, as is typical in telephone surveys,[40] because residents often do not have access to a telephone or appear on landline lists); aged 18–65 years; able to complete the survey in English; and have consumed at least one alcoholic beverage in the past six months. The plan was to survey an equal number of male and female respondents. The sample focused on current drinkers as most of the survey is concerned with capturing drinking behaviours.

Data were collected over a six-week period in the winter of 2017 through telephone surveys conducted by Focal Research. Due the limited resources of the pilot project, a sample of 500 participants was sought. Participants were drawn from two primary samples: a simple random sample of Ontario households with landline telephones, and a sample of Ontario residents with only cellphones. A small number were sampled from a research panel of Ontario residents maintained by Focal Research to achieve the desired number of young men.

A two-tiered sampling strategy was used. Households were first screened to identify any adult aged 18–65 years. Among these households, a brief survey was conducted to compile a roster of eligible adults, their age and sex. Each consenting adult was screened for alcohol consumption in the past six months, and one of these adults was randomly invited to participate in the survey and randomly allocated to either split sample.

About halfway through data collection, it became clear that the simple random sample initially planned might not provide enough younger or male participants for meaningful comparisons. A quota sampling procedure was then introduced to increase the number of men and participants aged under 45 years.

Of 5381 households invited to participate, 1827 (34%) were successfully contacted and agreed to participate. Of these, 1409 households were disqualified because they did not meet the inclusion criteria (i.e. no alcohol was consumed in the past six months) and/or their sex and age quota had been reached (which accounted for the largest number of disqualified households).

Due to low response rates in younger age groups, more respondents were drawn from older age categories. Upon completing an interview, if the respondent said that another eligible adult was in the household and they agreed to participate, that adult was randomly allocated to a split sample and also interviewed.

An average of 1.03, 1.25 and 1 participants per household were in the cellphone only, landline and research panel samples, respectively. A total of 500 participants from 418 households were included in this pilot study, with 87, 387 and 26 participants from the cellphone only, landline and research panel samples, respectively.

Data were cleaned and verified, with ranges examined to identify any responses outside of expected values and ensure that the study dataset included valid and meaningful responses. Data analysis and reporting of preliminary results were designed to address the three principle goals of the research. Results were weighted by age, sex and highest educational attainment, estimated based on the results of the 2016 census data for Ontario. All analyses were conducted using statistical package SPSS version 22 for Windows (IBM Corp., Armonk, NY, USA).

This project received research ethics approval from the Centre for Addiction and Mental Health (CAMH) REB certificate #114/2016.

Results

Consistent with the sampling approach, the participating sample was evenly split between men and women (Table 1). The largest proportion of respondents (30.8%) was aged between 45 and 54 years, followed by those 55 and above (28.6%). The smallest proportion was made up the youngest respondents aged 18 to 24 (8.4%), followed by those aged 25 to 34 (13.6%). These proportions differ from census data, particularly in the overrepresentation of adults aged 45 to 54 years (18.5% in the census).[41]

Most respondents were married (76.6%); born in Canada; not of Indigenous ethnicity (83.4%); and employed for wages (62.8%). Most respondents were living in a household with no children under the age of 18 (56.1%; data not shown). The mean (SD) number of household residents was 3.1 (1.4). Most of the sample reported completing either college (28.2%) or university (24.6%), while 13.8% reported some college or university and 5.6% reported a trade certificate. The proportion of the current sample who had completed some postsecondary training or education (71.2%) was high in comparison to the 2016 census for Ontario (65.2%).[42] Total family incomes were high, with nearly half of those responding (46.1%) reporting an annual family income of $100 000 or more, a higher median income than reported by Statistics Canada ($86 081).[43]

The IAC Study procedures result in higher consumption estimates, in terms of mean drinks per month, than those seen in a well-regarded survey of the adult population in Ontario, the 2016 CAMH Monitor survey (Table 2). The CAMH Monitor obtained its estimates using a typical quantity–frequency method.[44] Among female drinkers, IAC Study procedures resulted in an estimate of number of drinks consumed per month that was 3.12% higher than the CAMH Monitor survey estimate (statistically nonsignificant). Among male drinkers, IAC Study procedures resulted in a 10.13% higher estimate of number of drinks consumed per month ($t = 2.707$, $p < .001$). In the total population of drinkers, IAC Study procedures resulted in an 6.89% higher estimate of monthly number of drinks consumed, which is shown to significant in a two-tailed impendent samples t-test ($t = 3.175$, $p = .002$).

TABLE 1
Demographic characteristics of the combined sample ($N = 500$)

Characteristic	Number, *n*	Proportion, %
Sex		
Female	248	49.6
Male	252	50.4
Age (years)		
19–24	42	8.4
25–34	68	13.6
35–44	93	18.6
45–54	154	30.8
55–65	143	28.6
Relationship status		
Married/long-term relationship	383	76.6
Single	74	14.8
Separated/divorced/widowed	41	8.2
Refused to answer	—[s]	—[s]
Highest educational qualification		
High school or less	75	15.0
Trade certificate	28	5.6
Non-trade certificate	8	1.6
Some college or university	69	13.8
College diploma	141	28.2
Bachelor's degree	123	24.6
Graduate or professional degree	56	11.2
Household income (if others in household) per year, $		
<20 000	12	2.7
20 000–39 999	23	4.6
40 000–59 999	39	8.8
60 000–79 999	48	10.7
80 000–99 999	43	9.7
≥100 000	206	46.1
Refused	50	11.2
Unsure	26	58.0
Missing ($n = 53$)	—	—
Born in Canada		
No	62	12.4
Indigenous ethnicity		
No	417	83.4
Yes	21	4.2
Employment (multiple response allowed)		
Student	30	6.0
Employed for wages	314	62.8
Self-employed	81	16.2
Unemployed	15	3.0
Sick or on disability benefits	22	4.4
Retired	58	11.6
Parent / caregiver / doing unpaid work at home	28	5.6

[s] Counts of 5 or less were suppressed.

TABLE 2
Comparison of average number of drinks per month reported by Ontario drinkers, IAC Study sample 1 (n = 255) method and CAMH Monitor Survey

Consumption	Average drinks per month (n)	Valid respondents (n)	SD
Females			
IAC Study	15.2	124	20.2
CAMH Monitor	12.1	1179	19.7
Males			
IAC Study	36.8*	131	45.9
CAMH Monitor	26.6	1193	40.1
Total			
IAC Study	26.3*	255	37.3
CAMH Monitor	19.4	2372	32.4

Abbreviations: CAMH, Centre for Addiction and Mental Health; IAC, International Alcohol Control; SD, standard deviation.
* Significantly higher than value obtained by the CAMH Monitor, $p < .05$ (t-test).

The mean number of drinks consumed per drinking session varied substantially across drinking locations (Table 3). At 1.27 (0.51) and 1.70 (1.38), respectively, the fewest mean (SD) number of drinks per occasion were reported for drinking at work or restaurants. At 3.09 (2.23), about twice as many drinks per occasion were consumed when drinking at home. The average number of drinks per occasion was 6.12 (5.84) when drinking at a cottage/cabin or while camping and 4.24 (3.01) at public special events, indicative of binge-drinking.

Approximately 53.6% of the Ontario pilot study sample reported high frequency drinking, defined as engaging in a drinking session once a week or more frequently at all locations over a six-month period, while 6.5% of participants drank on average 8 or more drinks per drinking session (Table 4). The Ontario pilot study results are somewhat lower than those of England, Scotland and New Zealand for high frequency drinking, and much lower than all other countries for heavy typical occasion. Data from the WHO *Global Status Report on Alcohol and Health 2018* indicate that total per capita alcohol consumption for Canada is somewhat lower than for England, Scotland and New Zealand, consistent with the survey data we present here. [30]

When asked if they or anyone else had been injured as a result of their drinking, 91.2% said this had never happened and 7.5% said it had happened but not in the past six months (Table 5). When asked if a relative, friend, doctor or other health care worker had been concerned about their drinking or had suggested they cut down, 92.4% said that this had never happened to them, 5.3% said that this had happened but not in the past six months and 2.2% said that this had happened in the past six months. When asked if they had ever been involved with police as a result of their drinking, 98.1% said that this had never happened to them.

When asked about getting injured as a result of someone else's drinking, 86.4% said that this had never happened to them, 10.3% said that this had happened but not in the past six months and 3.3% said that this had happened in the past six months (Table 5). When asked if they had ever experienced other negative effects on their lives as a result of others' drinking, 63.3% said that this had never happened to them, 25.6% said that this had happened but not in the past six months and 11.2% said that this had happened in the past six months.

When asked if they supported restrictions on the number of alcohol outlets, the largest proportion of participants (44.2%) opposed or strongly opposed them such restrictions, while the next largest proportion (30.5%) neither supported nor opposed them (Table 6). About half of the respondents (51.6%) strongly opposed and about one-quarter (26.3%) opposed an increase in the price of alcohol. While the largest proportion of respondents neither supported nor opposed restrictions on alcohol advertising (35.0%), 31.0% supported and 5.9% strongly supported advertising restrictions. The largest proportion (41.4%) opposed and 20.6% strongly opposed earlier closing times for buying alcohol, while 24.6% neither supported nor opposed this. Of note, almost two-thirds of respondents (64.2%) strongly supported more police spot checks to detect drinking and driving.

A policy change at the time of the survey was the introduction of the sale of beer and wine in large grocery stores in Ontario; this began in 2015.[45] Among those who had purchased alcohol in the previous six months, there was little variation by age or sex between those who had and those who had not purchased alcohol at a large grocery store (Table 7). However, the rate of over-drinking was higher among those who had purchased alcohol

TABLE 3
Mean number of drinks consumed per drinking session in Ontario by location (Sample 1, n = 248)

Drinking location	Number of drinks				
	Mean (n)	Valid (n)	SD	Maximum	Minimum
Home	3.09	234	2.62	15.75	0.44
Someone else's home	3.10	196	2.64	15.12	0.63
Workplace	1.27	7	0.51	2.00	0.70
Cottage/cabin or camping	6.12	39	5.84	36.68	0.63
Unlicensed public spaces	4.00	26	2.95	10.40	1.00
Pubs/bars/hotels	2.72	143	2.32	15.02	0.70
Restaurants	1.70	165	1.38	8.00	0.00
Other public licensed spaces	2.29	52	2.39	15.75	0.69
Public special events	3.09	22	2.23	10.80	0.69
Private special events	4.24	73	3.01	16.00	0.70
Private clubs	3.30	23	3.65	15.75	0.70

Abbreviation: SD, standard deviation.

TABLE 4
Cross-jurisdictional comparison of prevalence of drinking behaviours ranked by per capita consumption per year in litres of pure ethanol (Sample 1, *n* = 243)

Country	Drinking behaviour		
	High frequency[a]	Heavier typical occasion[a]	Per capita consumption[b]
England	77.8	10.0	11.4[c]
Scotland	74.7	13.8	11.4[c]
New Zealand	75.3	10.2	10.7
Australia	71.0	12.2	10.6
Saint Kitts and Nevis	67.3	15.6	9.4
South Africa	49.1	53.6	9.3
Ontario (Canada)	**53.6**	**6.5**	**8.9[d]**
Viet Nam	59.3	13.1	8.3
Thailand	41.0	10.3	8.3
Mongolia	16.0	14.5	7.4

[a] Source: Chaiyasong et al.[39]
[b] Source: World Health Organization.[30]
[c] Total consumption is for the United Kingdom.
[d] Total consumption is for all of Canada.

TABLE 5
Harms and negative consequences experienced as a result of own or someone else's drinking in the past six months (Sample 2, *n* = 249)

Consequence	Number of respondents		
	n	%	95% confidence limits (%)
You or someone else injured as the result of your drinking?			
Never	227	91.2	87.16–94.22
Yes, but not in the last 6 months	19	7.5	4.82–11.42
Yes, during the last 6 months	—[s]	—[s]	—
Relative, friend or a doctor or other health worker concerned about your drinking or suggested you cut down?			
Never	230	92.4	88.58–95.18
Yes, but not in the last 6 months	13	5.3	2.96–8.52
Yes, during the last 6 months	6	2.2	1.01–4.90
Involvement with police due to own drinking			
No	243	98.1	95.64–99.23
Yes	5	1.9	0.77–4.36
Not stated	—[s]	—[s]	—
Injured as a result of someone else's drinking			
Never	215	86.4	81.67–90.18
Yes, but not in the last 6 months	26	10.3	7.10–14.69
Yes, during the last 6 months	8	3.3	1.53–5.97
Any other negative effects on your life as a result of someone else's drinking			
Never	157	63.3	56.93–68.87
Yes, but not in the last 6 months	64	25.6	20.58–31.39
Yes, during the last 6 months	28	11.2	7.77–15.61

[s] Counts of 5 or less were suppressed.

from a large grocery store than among those who had not (53% vs. 40%, respectively; $p = .039$), while there was no statistically significant difference in the prevalence of binge-drinking (62.13% vs. 58.75%, respectively; statistically nonsignificant).

Discussion

The purpose of this study was to pilot the IAC Study instrument in Canada in order to (1) adapt the IAC Study instrument to the Canadian context; (2) pilot the survey tool in a sample of participants in Ontario; and (3) provide a preliminary assessment of the information that can be gathered from the IAC Study–based instrument compared with the data collected by other IAC Study sites.

There were challenges and opportunities in adapting the original IAC Study instrument for use in Canada. A number of terms used in New Zealand for types of alcohol beverages and beverage sizes needed to be adapted. Also, typical drinking occasions differed between the two countries. For example, the Ontario sample showed far fewer heavier typical drinking occasions, as shown in Table 4. Before the instrument was ready for use in Ontario, the specific terminology related to beverages, sizes and drinking locations needed rewording, with care taken to avoid altering the essential meaning.

The decision to use a split-sample approach was a pragmatic one as it allowed all main survey dimensions to be piloted without imposing a time burden on respondents. The final average length for Sample 1 was 27.2 minutes and for Sample 2 was 30.4 minutes. These adjustments demonstrate that, with some reasonably small methodological modifications, the IAC Study instrument can be applied to the Ontario population.

The IAC Study method of collecting information on alcohol consumption based on information session location, type of drink and number of drinks per session results in higher estimates of consumption.[46] The IAC Study method of calculating consumption resulted in 35.6% higher estimates of average monthly consumption for the total sample compared to the standard quantity–frequency method used in the well-regarded CAMH Monitor survey of the Ontario adult population.[44]

TABLE 6
Attitudes related to possible alcohol policies (Sample 1, *n* = 247)

Possible alcohol policy	Number of respondents		
	n	%	Confidence limits (%)
Restrictions on the number of alcohol outlet			
Strongly oppose	22	8.3	5.5–12.3
Oppose	93	35.9	30.0–41.6
Neither support nor oppose	79	30.5	24.9–36.0
Support	51	19.5	15.1–24.7
Strongly support	14	5.5	3.1–8.6
Don't know/refused	—[s]	—[s]	—
An increase in the price of alcohol			
Strongly oppose	134	51.6	45.3–57.4
Oppose	69	26.3	21.4–32.0
Neither support nor oppose	33	12.7	9.0–17.1
Support	13	4.8	2.8–8.1
Strongly support	9	3.5	1.7–6.2
Don't know/refused	—[s]	—[s]	—
Restrictions on alcohol advertising and promotion			
Strongly oppose	17	6.6	4.0–10.0
Oppose	53	20.4	15.8–25.5
Neither support nor oppose	91	35.0	29.3–40.8
Support	81	31.0	25.7–36.8
Strongly support	15	5.9	3.40–9.07
Don't know/refused	—[s]	—[s]	—
Earlier closing times for buying alcohol			
Strongly oppose	54	20.6	16.1–25.9
Oppose	108	41.4	35.5–47.4
Neither support nor oppose	64	24.6	19.6–30.0
Support	22	8.5	5.5–12.3
Strongly support	12	4.7	2.5–7.7
Don't know/refused	—[s]	—[s]	—
More police spot checks to detect drinking and driving			
Strongly oppose	8	3.1	1.5–5.7
Oppose	12	4.5	2.5–7.7
Neither support nor oppose	20	7.8	4.9–11.4
Support	51	19.5	15.1–24.7
Strongly support	167	64.2	58.0–69.6
Don't know/refused	—[s]	—[s]	—

[s] Counts of 5 or less were suppressed.

It has long been recognized that survey-based measures of alcohol consumption substantially underestimate population alcohol consumption, as reflected by per capita consumption measures based on alcohol sales data.[47] Thus, while survey-based measures of alcohol use provide useful and valuable indicators of harmful drinking, their underestimation of population alcohol consumption lead to concerns about their utility for health planning and policy purposes. [47] Survey methods, like the IAC Study, that account for some of the "missing" alcohol may provide important additional value to efforts to understand and address harmful alcohol consumption.

The ability of the IAC Study methods to detect a higher level of consumption in Ontario demonstrates consistency between the pilot study and existing research on the IAC and supports the appropriateness of its use in Ontario.

Other results point to the importance of collecting the more comprehensive and nuanced data on alcohol use that is available with the IAC Study instrument. For example, heavy episodic or binge-drinking is widely recognized as a hazardous form of drinking, in part because on binge occasions individuals are more likely to be intoxicated and experience injuries, get into fights, drive while impaired and so on. Data on where binge-drinking occurs are sparse, and there is a common belief that binge-drinking occasions is common in bars.[48] However, we observed that the average number of drinks per drinking occasion was relatively low in bars compared with other locations. This may point to the success of efforts in the past few years to control heavy or excessive drinking in bars, taverns and pubs.[49]

Of particular interest, we found that the average or typical drinking occasion when staying at a cottage/cabin or camping and at public special events is equivalent to binge-drinking. This may be influenced by the relative isolation and control over such events, which might lower the chances for drinking at several locations in the same day, for example, pre-drinking before going to a bar. Identifying locations where heavy or binge-drinking are most common may help inform more effective prevention efforts.

Compared to other jurisdictions that have used the IAC Study design, high frequency drinking and high quantities in typical drinking occasions are relatively low in this pilot study. According to the WHO *Global Status Report on Alcohol and Health 2018,* Canada does have lower drinking rates than many of the comparators used.[30]

Despite employing several sampling strategies to try to increase the number of younger adult respondents, this pilot study had a disproportionately large number of adults aged over 45. This likely

TABLE 7
Comparison of risky drinking behaviours between those who had and had not bought alcohol at a grocery store in the past six months (Samples 1 + 2)

Parameter	Number of respondents				χ^2 test	*p*
	Did not buy at a grocery store		Bought at a grocery store			
	Count	%	Count	%		
Sex (*n* = 398)					0.592	.442
Female	193	48.6	40	53.2		
Male	205	51.5	35	46.8		
Age category (*n* = 398)					3.214	.523
18–24 years	49	12.2	7	9.9		
25–34 years	57	14.4	15	19.6		
35–44 years	55	13.8	13	16.9		
45–54 years	73	18.4	10	12.9		
55+ years	164	41.2	31	40.8		
Pre-drinking (*n* = 397)					5.364	.021
No	286	72.0	44	58.8		
Yes	111	28.0	31	41.2		
Over-drinking (*n* = 395)					4.242	.039
No	235	59.5	35	46.5		
Yes	160	40.5	40	53.5		
Planned drunk (*n* = 398)					0.364	.546
No	296	74.3	54	71.3		
Yes	102	25.7	22	28.8		
Binge-drinking (5+ drinks per occasion) (*n* = 399)					0.325	.569
No	151	37.9	31	41.3		
Yes	248	62.1	44	58.8		

resulted in underestimating heavy drinking as binge-drinking tends to be more common in younger age groups in Ontario.[50] Despite this possible bias, the relative drinking patterns of Ontarians this pilot study determined were proportional to the findings of other current sources of information on drinking behaviour patterns.[30] That the study data are in line with comparisons between Canada and other countries[30] also indicates the appropriateness of the IAC Study for use in Canada.

Only about 8% of respondents said they had personally experienced harm or other problems linked with their own drinking (Table 5). However, nearly 14% reported being injured as a result of others' drinking, and about 37% reported experiencing negative effects as a result of someone else's drinking. The latter is substantially higher than that reported in surveys of Ontario in 2006[6] although the 2006 survey included non-drinkers, who may be less likely to have experienced harm from others.[51]

Implementation of the IAC Study in Canada would expand the collection of important data on Canadians' attitudes towards alcohol policy. The findings on attitudes on five alcohol policies (Table 6) show some support for effective policies but rejection of others that are also known to be very effective, such as alcohol pricing.[2,52,53] The proportion ranged from 84% supporting police spot checks to detect drinking and driving, to only 8% supporting an increase in the price of alcohol. However, it is noteworthy that 37% supported restrictions on alcohol advertising and promotion. These findings are generally in line with previous research focusing on Ontario adults,[54] and at least partially support a claim by Room et al.[2] that popular policies are largely ineffective, and effective policies are unpopular.

The pilot study was also able to capture information on a relatively recent policy change in Ontario, the sale of beer of and wine in grocery stores. Though grocery store purchasing showed no difference in sex and age, there was a significant difference in rate of over-drinking with grocery store purchasers drinking more than they had planned in a drinking session more often. Though the differences in pre-drinking, planned intoxication and binge-drinking were not significant, they were fairly large and would likely show significance in a sample with greater statistical power.

More frequent risky drinking practices among grocery store purchasers has important implications for policy decisions when considered through the lens of the total consumption model of alcohol-related harm. This model holds that an increase in the accessibility of alcohol is associated with an increase in the consumption, which in turn, is strongly predictive of the extent of alcohol-related harms.[55] The association of over-drinking with grocery store purchasing in particular suggests that the introduction of alcohol purchasing in grocery stores presents a risk to population health. It should be noted that the direction of this relationship is not discernible given the current cross-sectional design. In order to determine whether availability increases the risk of harmful drinking practices or whether those who engage in riskier drinking practices are likely to buy alcohol at any location (including grocery stores) more frequently, longitudinal analysis of drinking patterns is necessary. Implementation of the longitudinal component of the IAC Study would make such a determination possible.

Limitations

An important feature of the IAC Study is its longitudinal design, which allows the tracking of changing drinking behaviours across policy changes, but longitudinal data collection was outside the scope of the current pilot project. The results of this pilot suggest that implementing a longitudinal design would be a necessary next step in implementing the IAC Study in Canada. However, as is the trend in much survey research, low response rates continue to be a challenge. Future research

should consider methods for increasing participation rates, such as provision of incentives while reducing the potential for bias in participation.

Another important limitation of this current study was the limited representativeness of the sample. Quota sampling and inclusion of a cellphone sampling frame were implemented in order to bring the age distribution closer to the age profile of Ontario adults. However, the sample was not reflective of the age distribution of Ontario, with adults over the age of 45 overrepresented. Weighting procedures were used to help reduce the effect of this bias, but the limitations of the sample should still be kept in mind when interpreting the study results.

A small degree of clustering was present in our sample, with 500 participants drawn from 418 households. Our analyses did not account for the clustered nature of the sample, and variance may be underestimated due to this. This relatively small sample also means that the current analyses are likely to be underpowered.

The survey design also relied on self-reporting of drinking and purchasing behaviours, the experience of harm and attitudes on policy. As such, findings in this study may reflect recall or social desirability bias on part of survey respondents.

Conclusion

The results of this pilot study suggest that the IAC Study can be feasibly applied in the Canadian context. The IAC Study represents an important opportunity to improve the quality of information on drinking behaviours in Ontario and other Canadian jurisdictions at a time when recent, ongoing and suggested changes in alcohol policy may increase drinking and drinking-related harms. Improved methods for identifying harmful drinking patterns, attitudes towards alcohol policy and negative consequences of drinking alcohol plus the ability to compare these findings with those in other countries will likely improve prevention of these harms.

Despite the potential value of the IAC Study in Canada, the pilot also identified potential problems in the length of survey administration, difficulties in obtaining an appropriate sample and the limited insight of a cross-sectional pilot for a longitudinal study.

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Conflict of interest

RG is the Editor-in-Chief of the HPCDP Journal, but recused himself from taking any editorial decisions on this manuscript.

Authors' contributions and statement

RG, NG and RM conceived the study. NG, RM, MvM and GS managed data collection. RG and HO provided study guidance and support. MvM analysed the data. NG, RM, MvM and HO interpreted the results. NG, MvM and HO wrote the manuscript. All authors reviewed and approved the final manuscript.

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Original quantitative research

Psychotic disorder and cannabis use: Canadian hospitalization trends, 2006–2015

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Abstract

Introduction: Given the recent and impending changes to the legal status of nonmedical cannabis use in Canada, understanding the effects of cannabis use on the health care system is important for evaluating the impact of policy change. The aim of this study was to examine pre-legalization trends in hospitalizations for mental and behavioural disorders due to the use of cannabis, according to demographic factors and clinical conditions.

Methods: We assessed the total number of inpatient hospitalizations for psychiatric conditions with a primary diagnosis of a mental or behavioural disorder due to cannabis use (ICD-10-CA code F12) from the Hospital Mental Health Database for ten years spanning 2006 to 2015, inclusive. We included hospitalizations from all provinces and territories except Quebec. Rates (per 100 000 persons) and relative proportions of hospitalizations by clinical condition, age group, sex and year are reported.

Results: Between 2006 and 2015, the rate of cannabis-related hospitalizations in Canada doubled. Of special note, however, is that hospitalizations during this time period for those with the clinical condition code "mental and behavioural disorders due to use of cannabinoids, psychotic disorder" (F12.5) tripled, accounting for almost half (48%) of all cannabis-related hospitalizations in 2015.

Conclusion: Further research is required to investigate the reasons for the increase in hospitalizations for cannabis-related psychotic disorder. The introduction of high-potency cannabinoid products and synthetic cannabinoids into the illicit market are considered as possible factors.

Keywords: *cannabis, psychotic disorders, hospitalization, Canada*

Highlights

- Between 2006 and 2015, the rate of hospitalizations for cannabis-related mental or behavioural disorders in Canada rose from 2.11 to 5.18 per 100 000.
- Males consistently accounted for over two-thirds of all hospitalizations for cannabis-related mental or behavioural disorders.
- Young people aged 15 to 24 years represented the greatest proportion of hospitalizations (between 49% and 58%) of any age group.
- Over the entire study period, psychotic disorder was the most common clinical condition among hospitalizations for cannabis-related mental or behavioural disorders, and accounted for 48.0% of cannabis-related hospitalizations in 2015.
- Between 2006 and 2015, the rate of hospitalizations due to cannabis-related psychotic disorder tripled, from 0.80 to 2.49 per 100 000.

Introduction

Cannabis is a psychoactive substance widely used in Canada, with 14.8% of Canadians aged 15 years and older reporting past-year use in 2017,[1] which is comparable to the 2014 estimate of 13.2% for past-year use in the United States among Americans aged 12 years and older.[2] Past-year prevalence of use in Canada was higher among males (18.7%) than females (11.1%) and also among young people aged 15 to 24 (26.9%) compared to adults aged 25 and older (12.7%).[1]

Although there is evidence for moderate therapeutic effectiveness of cannabis in the treatment of some health conditions (e.g. chronic pain, chemotherapy-induced nausea and vomiting, multiple sclerosis spasticity symptoms),[3-7] there is little evidence to suggest that cannabis can be beneficial for mental disorders and symptoms.[8] Moreover, cannabis use, particularly frequent use over periods of months or years, has been associated with increased risk for health harms, including psychosis,[9-13] negative respiratory symptoms,[12,14,15] motor vehicle collisions[9,12,16-18] and adverse effects on adolescent brain development.[12,19,20]

A recent study of the costs associated with substance use in Canada found that in 2014 over $208 million was spent in cannabis-related health care costs, including over $38 million for inpatient hospitalizations.[21] Moreover, cannabis-related health

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care costs have been increasing in Canada. The costs of all cannabis-attributable inpatient hospitalizations increased by 22% between 2007 and 2014,[22] with the cost of inpatient hospitalizations for mental and behavioural disorders due to cannabis use increasing by 52% between 2006 and 2011.[23] As of now, there is limited research exploring the specific contribution of different mental and behavioural disorders to these observed increases in cannabis-attributable hospitalizations. This study evaluated trends in hospitalization rates between 2006 and 2015 for mental and behavioural disorders attributable to cannabis by age and sex and examined the number and proportions of these hospitalizations according to the type of clinical condition.

Methods

Data sources

Data for this analysis were acquired from the Canadian Institute for Health Information (CIHI). Specifically, data on inpatient separations (herein referred to as hospitalizations) for those with a primary diagnosis of mental and behavioural disorders due to use of cannabinoids (herein referred to as cannabis) were extracted from the Hospital Mental Health Database (HMHDB) for the ten fiscal years spanning April 2006 to March 2016 (herein referred to as 2006 to 2015). The HMHDB is a comprehensive pan-Canadian administrative database capturing demographic and clinical information on patient hospitalizations for psychiatric conditions from both general acute care and specialized psychiatric hospitals. CIHI compiles data for the HMHDB from four sources: the Discharge Abstract Database (DAD), the Hospital Morbidity Database (HMDB), the Ontario Mental Health Reporting System (OMHRS) and the Hospital Mental Health Survey (HMHS).[24]

Measures

Hospitalizations

We defined a hospitalization as a departure from an inpatient hospital, due to discharge or death, where the patient had a primary diagnosis of a mental or behavioural disorder due to use of cannabis. These specific diagnoses were identified using the International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada (ICD-10-CA), and diagnoses are determined from a patient's medical record. Given the nature of these data, it was possible for an individual to have more than one hospital stay recorded in a given year. We included hospitalizations from all provinces and territories except Quebec. At the time of this study, data from Quebec were not available. Hospitalizations recorded in OMHRS were coded using the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR), rather than the ICD-10-CA coding system, and therefore were excluded from this analysis. In any given year, a large proportion (57.3%–74.0%) of cannabis-related hospitalizations in Ontario were excluded due to being recorded in the OMHRS and coded with the DSM-IV-TR. The remainder of hospitalizations were recorded in the DAD, HMBD or HMHS and used ICD-10-CA codes. On average, 63% of Ontario hospitalizations were excluded, meaning that a total of 1252 hospitalizations were included and 2088 hospitalizations were excluded for Ontario between 2006 and 2015.

Clinical conditions

According to ICD-10-CA, there are 10 clinical condition codes (F12.0–F12.9) used to describe the type of mental and behavioural disorder due to use of cannabis that constitutes a patient's primary reason for hospitalization. These conditions include: acute intoxication (F12.0), harmful use (F12.1), dependence syndrome (F12.2), withdrawal state (F12.3), withdrawal state with delirium (F12.4), psychotic disorder (F12.5), amnesic syndrome (F12.6), residual and late-onset psychotic disorder (F12.7), other mental and behavioural disorders (F12.8), and unspecified mental and behavioural disorder (F12.9). Full descriptions of these conditions are available from the World Health Organization.[25] It is important to note that none of these codes includes any information about type (plant based, extract or synthetic) or quantity of cannabis used, the route of administration (inhaled or ingested) or the reason for use (medical or nonmedical).

Age group

Counts of cannabis-related hospitalizations were categorized according to the age groups 0 to 14 years, 15 to 24 years, 25 to 44 years, 45 to 65 years and 65+ years.

Sex

Counts of cannabis-related hospitalizations were grouped by sex (male and female). Hospitalizations for which the patient's sex was not recorded as male or female were excluded.

Analytic strategy

To examine trends in cannabis-related hospitalizations in Canada over the ten fiscal years from 2006 to 2015, we analyzed the count, proportion and sex- and age-specific rates of cannabis-related hospitalizations by year and clinical condition. Where applicable, we expressed relative proportions by clinical condition in relation to the total volume of hospitalizations for mental and behavioural disorders due to use of cannabis. We calculated the overall crude rate for the Canadian population and sex- and age-specific rates using annual population estimates derived by Statistics Canada using the mid-calendar population estimate.[26]

In accordance with CIHI's privacy policy, at the time they provided the aggregate data requested for this analysis, some small cells were suppressed for confidentiality. This included cells with single digits (i.e. 1–9 were indicated by "§") as well as cells with multiple digits (i.e. 10–19 were indicated by "1§"). For the purposes of this analysis, we replaced any suppressed digits with "1" in order to estimate hospitalizations for these cells (i.e. a cell indicated by "§" was replaced with "1", and a cell indicated by "1§" was replaced with "11").

Results

Between 2006 and 2015, the number and crude rate of hospitalizations associated with mental or behavioural disorders due to cannabis use in Canada rose from 525 (2.11 per 100 000) in 2006 to 1430 (5.18 per 100 000) in 2015 (Table 1; Figure 1).

Across all years examined, males consistently accounted for at least 70% of all cannabis-related hospitalizations and young people aged 15 to 24 years represented the greatest proportion of hospitalizations (between 49% and 58%) of any age group (Table 1).

Examination of sex- and age-specific rates for cannabis-related hospitalizations showed a 19-fold increase in hospitalization rates between 2006 and 2015 among those aged 15 to 24 years (Table 2). We also observed large increases in hospitalization rates among individuals aged 25 to 44 and individuals aged 45 to 64. Increases of

TABLE 1
Number and proportion (%) of hospitalizations for cannabis-related mental or behavioural disorders by demographic characteristics, Canada (excluding Quebec), 2006–2015

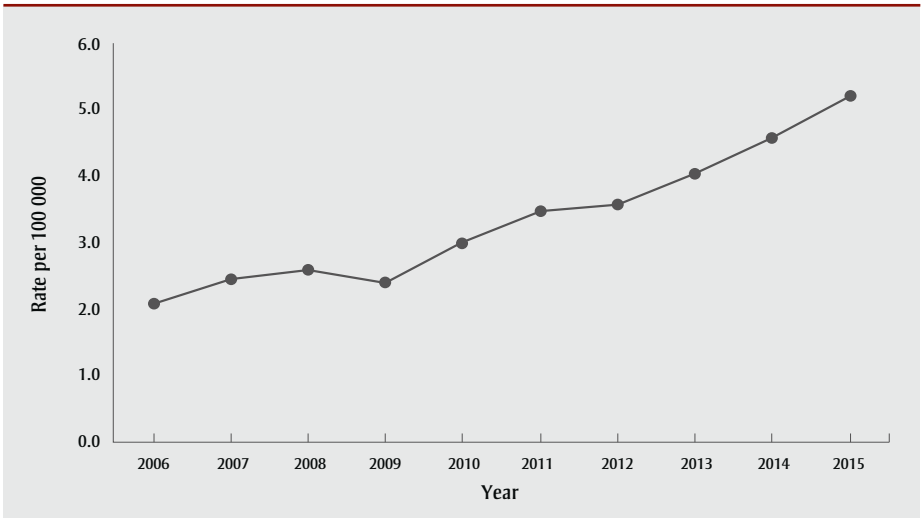
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Overall	525	615	661	618	779	911	952	1085	1243	1430
Sex										
Male	369 (70.3)	455 (74.0)	469 (71.0)	464 (75.1)	583 (74.8)	708 (77.7)	726 (76.3)	810 (74.7)	893 (71.8)	1026 (71.7)
Female	156 (29.7)	160 (26.0)	192 (29.0)	154 (24.9)	196 (25.2)	203 (22.3)	226 (23.7)	275 (25.3)	350 (28.2)	404 (28.3)
Age										
0–14	21[a] (4.0)	20 (3.3)	30 (4.5)	19 (3.1)	21 (2.7)	28 (3.1)	31[a] (3.3)	22 (2.0)	30 (2.4)	41 (2.9)
15–24	272 (51.8)	302 (49.1)	353 (53.4)	341 (55.2)	428 (54.9)	486 (53.3)	503 (52.8)	627 (57.8)	691 (55.6)	746 (52.2)
25–44	178 (33.9)	229 (37.2)	211[a] (31.9)	215 (34.8)	251[a] (32.2)	304 (33.4)	317 (33.3)	351 (32.4)	408 (32.8)	494 (34.5)
45–64	54 (10.3)	61[a] (9.9)	56 (8.5)	43 (7.0)	68 (8.7)	86 (9.4)	96 (10.1)	78 (7.2)	106 (8.5)	136 (9.5)
65+	1[a] (0.2)	1[a] (0.2)	1[a] (0.2)	0 (0.0)	1[a] (0.1)	7 (0.8)	1[a] (0.1)	7 (0.6)	8 (0.6)	13 (0.9)

Data source: Canadian Institute for Health Information.[24]
Note: Hospitalizations were extracted from the Hospital Mental Health Database (HMHDB) for the ten fiscal years spanning April 2006 to March 2016 (herein referred to as 2006 to 2015).
[a] Estimation; small cells were suppressed to ensure confidentiality.

2.5-fold from 2006 to 2015 were reported for both males and females.

In an attempt to understand which clinical conditions might be associated with this increase, we assessed the distribution of clinical conditions for each year. In 2006, the two most common clinical conditions for cannabis-related hospitalizations—psychotic disorder and harmful use—accounted for similar proportions of hospitalizations, at 37.9% and 33.9%, respectively. However, by the end of the study period, the proportion of hospitalizations due to cannabis-related psychotic disorder was nearly double that of hospitalizations due to harmful use of cannabis, at 48.0% and 26.0%, respectively. Throughout the course of the study, cannabis-related psychotic disorder was the most common clinical condition seen in cannabis-related hospitalizations (Figure 2). Indeed, between 2006 and 2015, the rate of hospitalizations due to cannabis-related psychotic disorder tripled, from 0.80 to 2.49 per 100 000 (data not shown).

FIGURE 1
Rate of hospitalizations for cannabis-related mental or behavioural disorder (per 100 000) in Canada (excluding Quebec), 2006–2015



Data source: Canadian Institute of Health Information.[24]
Note: Hospitalizations were extracted from the Hospital Mental Health Database (HMHDB) for the ten fiscal years spanning April 2006 to March 2016 (herein referred to as 2006 to 2015).

Discussion

The overall rate of cannabis-related hospitalizations increased between 2006 and 2015, with the largest increase occurring in those hospitalizations with the clinical condition code "mental and behavioural disorders due to use of cannabinoids, psychotic disorder." These results could be due to increased prevalence of cannabis use. However, as there is little evidence for increased prevalence of cannabis use across our period of analysis, particularly among youth and young adults, we suggest that a central explanation for our results is the increasing potency of cannabis and the introduction of synthetic cannabinoids into the illicit drug market. Further, changes in the way that hospitalization data is collected and coded, as well as changes in attitudes toward reporting cannabis use, may also contribute to the observed increases in psychiatric hospitalizations.

The link between cannabis use and psychosis and schizophrenia

The link between cannabis use and the risk for developing schizophrenia is an important consideration for understanding why the largest proportions of cannabis-related hospitalizations are due to psychotic disorders. A key symptom of schizophrenia is psychosis, and a first episode of psychosis can be an initial diagnostic feature of schizophrenia, especially among those with a family history of

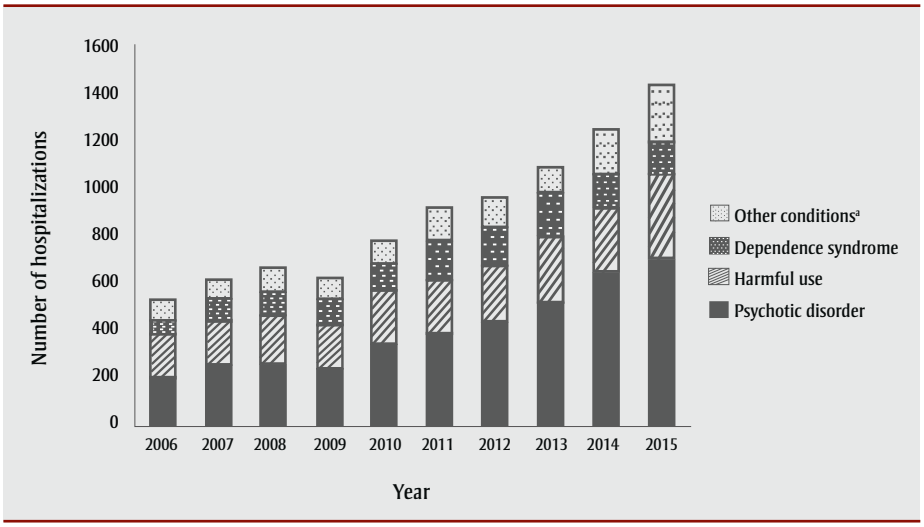
TABLE 2
Rates of hospitalizations for cannabis-related mental or behavioural disorders (per 100 000) by demographic characteristics, Canada (excluding Quebec), 2006–2015

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Overall	2.11	2.44	2.59	2.40	2.99	3.46	3.57	4.02	4.55	5.18
Sex										
Male	2.98	3.64	3.71	3.63	4.51	5.43	5.49	6.05	6.59	7.50
Female	1.24	1.26	1.49	1.18	1.49	1.53	1.68	2.02	2.54	2.90
Age										
0–14	0.48[a]	0.46	0.68	0.43	0.48	0.64	0.70[a]	0.50	0.67	0.92
15–24	1.09	8.61	10.02	9.63	12.02	13.59	13.97	17.37	19.14	20.82
25–44	0.71	3.18	2.93[a]	2.99	3.49[a]	4.21	4.35	4.76	5.47	6.57
45–64	0.22	0.90[a]	0.80	0.60	0.93	1.15	1.28	1.03	1.39	1.77
65+	0.00[a]	0.03[a]	0.03[a]	0.00	0.03[a]	0.19	0.03[a]	0.17	0.19	0.30

Data source: Canadian Institute of Health Information.[24]
Note: Hospitalizations were extracted from the Hospital Mental Health Database (HMHDB) for the ten fiscal years spanning April 2006 to March 2016 (herein referred to as 2006 to 2015).
[a] Estimation; small cells were suppressed to ensure confidentiality.

mental disorders. Although cannabis use is significantly higher among individuals with schizophrenia,[27,28] there is substantial evidence that cannabis use, especially frequent use over longer periods of time, increases the risk of developing both psychosis and schizophrenia.[29-33] The risk of psychosis also increases with the frequency of cannabis use in a dose-dependent manner[30,31,34-37] and with increasing percentage of delta-9 tetrahydrocannabinol (THC) in the product consumed.[34-36] Early initiation of cannabis use, especially during adolescence, also elevates the risk for developing psychotic disorders, including schizophrenia.[38-41] Molecular genetic research demonstrates that another key factor influencing the degree of risk conferred by cannabis use for developing schizophrenia or psychosis is having a family history of these disorders.[37,42-46] Although it has been reported that some genetic risk factors underlie both the risk for developing schizophrenia and for initiating cannabis use,[47,48] cannabis use on its own is still an independent risk factor for psychosis and related mental disorders such as schizophrenia.

FIGURE 2
Number of hospitalizations for cannabis-related mental or behavioural disorders in Canada (excluding Quebec) by clinical condition, 2006–2015



Data source: Canadian Institute of Health Information.[24]
Note: Hospitalizations were extracted from the Hospital Mental Health Database (HMHDB) for the ten fiscal years spanning April 2006 to March 2016 (herein referred to as 2006 to 2015).
[a] Other conditions include acute intoxication, withdrawal state, withdrawal state with delirium, amnesic syndrome, residual/late-onset psychotic disorder, other mental and behavioural disorders and unspecified mental and behavioural disorder.

Increasing THC content in cannabis products available in the illicit market

Data from Statistics Canada show a relatively stable age of initiation among youth between 2004 and 2015,[49-51] and that the prevalence of cannabis use actually decreased among those under the age of 25.[52] During this same period, however, there is evidence of increased availability of high potency cannabis extracts[53] and the introduction of potent synthetic cannabinoids[53-56] into the global illicit market.

Globally, the average proportion of THC, the main psychoactive component responsible for the "high" feeling associated with cannabis consumption, in herbal cannabis has risen over the last 50 to 60 years.[53,57] While in the 1960s the proportion of THC in herbal cannabis averaged around 3%, in the early 21st century, countries have seen average proportions of THC in the range of 12% to 20%.[53] In addition to the increase in proportion of THC in herbal cannabis, new high-THC products referred to as "extracts" (e.g. "shatter" or "butane honey oil") have been found with THC concentrations of 80%[53] to 99%.[58]

Given that the use of higher potency cannabis products is associated with an increased risk of adverse health outcomes,[25,36,53] it is possible that the increasing availability of high potency cannabis products, including herbal cannabis with higher THC potency as well as cannabis extracts, may be contributing to the increasing rate of cannabis-related hospitalizations

in Canada, particularly those associated with psychotic disorder.

It will be prudent to evaluate these trends from 2016 onward to the era of legalized nonmedical cannabis, and to continue to monitor them, since cannabis extracts became legal in Canada in October 2019. In addition, investments in public education and harm reduction strategies are needed to prevent hospitalizations due to cannabis use. For example, this could include increasing the awareness and implementation of the lower-risk cannabis use guidelines, which mention choosing products with lower THC content, among other recommendations, to reduce the risk of adverse health effects from cannabis.[59] The data presented here also highlight the need for comprehensive and integrated mental health and addiction services, especially for youth and young adults (i.e. aged 15–24) in order to better address the overlap between cannabis use and mental and behavioural outcomes.

Synthetic cannabinoids

Synthetic cannabinoids are a large and diverse family of compounds that, like THC, bind to cannabinoid receptors in the body, but are typically more potent and toxic.[60] Documented adverse health effects of synthetic cannabinoids include cardiovascular problems (e.g. hypertension, chest pain, tachycardia) and psychiatric issues (e.g. psychosis, anxiety, withdrawal), among others.[60] The first identification of a synthetic cannabinoid in the illicit drug supply can be traced to 2008.[55] Though there is limited Canadian epidemiological data on the use of synthetic cannabinoids, we do know that they have been used in Canada since at least 2009.[54] The 2017 Ontario Student Drug Use and Health Survey indicated that 1.5% of students in Grades 7 to 12, encompassing the ages of 12 through 18, reported using synthetic cannabis in the past year, and that this estimate had remained stable since the survey first asked about synthetic cannabinoid use in 2013.[56] Between April 2018 and April 2019, synthetic cannabinoids were found in 0.2% of samples analyzed by Health Canada's Drug Analysis Service.[61] Therefore, in addition to the availability and use of higher potency cannabis products, it is also possible that the rise in cannabis-related hospitalizations may be linked to the appearance of synthetic cannabinoids in the illicit drug marketplace.

Strengths and limitations

By furthering our understanding of the clinical conditions responsible for the observed increase in cannabis-related hospitalizations, we will be in a better position to provide prevention, treatment and harm reduction strategies for those who use cannabis. Given the period of study, this analysis further provides a snapshot of hospitalization trends before legalization of nonmedical cannabis in Canada, and can be a useful benchmark to compare with post-legalization follow-up analyses.

The dataset that we analyzed only included the total number of hospitalizations and not the total number of people who were hospitalized. Therefore, we are unable to comment on the proportions of hospitalizations that may be due to a person being hospitalized multiple times throughout a fiscal year, and which conditions are associated with multiple hospitalizations. This should be an important consideration for future studies, given that 12.1% of patients hospitalized for mental illness had at least three hospital stays in 2017/18.[62]

The dataset we used for this study was also limited as to the scope of demographic factors analyzed that could be associated with cannabis-related hospitalizations for psychiatric conditions. In addition to age and sex, important factors to consider for future studies include socioeconomic status (income and education), geography (urban vs. rural), ethnicity and the use of other substances.

The ICD-10-CA coding system used by the databases we accessed contains a great deal of detail, but there are limitations. The classification codes for mental and behavioural disorders due to use of cannabinoids do not distinguish between those admitted to hospital for disorders associated with herbal cannabis versus synthetic cannabinoids, or whether the individual admitted was using a cannabis product for medical or nonmedical purposes. Therefore, the results cannot be linked with the prevalence of use of different types of cannabis products. In addition, we cannot account for differences in clinical practice settings that may influence the ICD-10 code applied to a particular diagnosis. For example, the perceptions of health care practitioners or their awareness of cannabis as a contributor to some psychological symptoms may have changed over time, perhaps due to increased public and political dialogue concerning cannabis legalization. The changing political landscape of cannabis throughout our period of study may also have influenced the likelihood that patients would disclose their cannabis use.

The results presented here are likely to be an underestimate of the true number of cannabis-related hospitalizations for several reasons. These data do not include inpatient hospitalizations for which a cannabis-related disorder was a secondary diagnosis. They also do not include hospitalizations for which a primary diagnosis code of "mental and behavioural disorders due to multiple drug use and use of other psychoactive substances" was given, of which some cases may be attributable to cannabis use. Further, Quebec and Ontario were not comprehensively included in the study. When investigating the clinical conditions associated with each hospital stay, only hospitalizations coded with the ICD-10-CA coding system were used, thus omitting a large proportion of cannabis-related hospitalizations in Ontario. As noted in the Methods section, approximately 63% of hospitalizations in Ontario were therefore excluded from this study's analysis. Data from Quebec, a province that accounts for close to a quarter of the Canadian population, were not available for this analysis. Finally, we applied conservative estimation procedures for dealing with suppressed data cells, since these were assumed to have a value of 1, despite the actual value ranging between 0 and 9 due to secondary data suppression.

Conclusion

The increasing rate of hospitalizations due to cannabis-related psychotic disorder in Canada between 2006 and 2015 is a trend that warrants further investigation, in light of both what is known regarding the association between frequent cannabis use and psychosis and the recent legalization of nonmedical cannabis use in Canada. Further research is required to clarify the cause of these increased harms, particularly among those with the highest rate of cannabis-related hospitalizations (younger individuals and males), in order to better target public education efforts around lower-risk use and prevention of cannabis-related harms. Ongoing monitoring of cannabis use and related harms, including high potency cannabis products such as cannabis extracts and synthetic

cannabinoids, will also be essential to understanding the impact of legislative change on these trends in the future.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

All four authors, BMH, SCW, SK and MMY, contributed to each stage of developing the manuscript. This includes the research design, acquisition of data, analysis of data, drafting and revising of the paper, and approval of 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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Original quantitative research

Surveillance from the high ground: sentinel surveillance of injuries and poisonings associated with cannabis

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Abstract

Introduction: In October 2018, Canada legalized the nonmedical use of cannabis for adults. The aim of our study was to present a more recent temporal pattern of cannabis-related injuries and poisonings found in the electronic Canadian Hospitals Injury Reporting and Prevention Program (eCHIRPP) database and provide a descriptive summary of the injury characteristics of cannabis-related cases captured in a nine-year period.

Methods: We conducted a search for cannabis-related cases in the eCHIRPP database reported between April 2011 and August 2019. The study population consisted of patients between the ages of 0 and 79 years presenting to the 19 selected emergency departments across Canada participating in the eCHIRPP program. We calculated descriptive estimates examining the intentionality, external cause, type and severity of cannabis-related cases to better understand the contextual factors of such cases. We also conducted time trend analyses using Joinpoint software establishing the directionality of cannabis-related cases over the years among both children and adults.

Results: Between 1 April, 2011, and 9 August, 2019, there were 2823 cannabis-related cases reported in eCHIRPP, representing 252.3 cases/100 000 eCHIRPP cases. Of the 2823 cannabis-related cases, a majority involved cannabis use in combination with one or more substances (63.1%; 1780 cases). There were 885 (31.3%) cases that involved only cannabis, and 158 cases (5.6%) that related to cannabis edibles. The leading external cause of injury among children and adults was poisoning. A large proportion of cannabis-related cases were unintentional in nature, and time trend analyses revealed that cannabis-related cases have recently been increasing among both children and adults. Overall, 15.1% of cases involved serious injuries requiring admission to hospital.

Conclusion: Cannabis-related cases in the eCHIRPP database are relatively rare, a finding that may point to the fact that mental and behavioural disorders resulting from cannabis exposure are not generally captured in this surveillance system and the limited number of sites found across Canada. With Canada's recent amendments to cannabis regulations, ongoing surveillance of the health impacts of cannabis will be imperative to help advance evidence to protect the health of Canadians.

Keywords: *cannabis, eCHIRPP, legalization, edibles, injuries, poisonings, Canada*

Highlights

- Between 1 April, 2011, and 9 August, 2019, there were 2823 cannabis-related cases reported in the electronic Canadian Hospitals Injury Reporting and Prevention Program (eCHIRPP), representing 252.3 cases/100 000 eCHIRPP cases.
- Males have consistently represented a higher proportion of cases across all age groups, with the exception of the group aged 10 to 14 years, in which females represented a slightly larger proportion.
- Of the 2823 cases, 158 cases (5.6%) involved cannabis edibles.
- Significant increases in annual percent change (APC) in cannabis-related cases were identified across every group in recent years: among adults, a 27.9% APC was noted between 2013 and 2018; among children, a 35.6% APC was noted between 2016 and 2018; and overall, a 30.1% APC was noted between 2015 and 2018.
- The leading external cause of injury across all groups was poisoning.

Introduction

In October 2018, Canada became the second country in the world to legalize the nonmedical use of cannabis for adults, nearly two decades following its 2001 *Marihuana Medical Access Regulations*. At the national level, cannabis use has become increasingly prevalent in recent decades. For example, between 2004 and 2017, past-year use of cannabis among the Canadian household population aged 15 years or over increased from 9.4% to 14.8%.[1] Recent post-legalization national figures also show an increase in cannabis use for the same population: a comparison of first quarter estimates from 2018 and 2019 reveal a 29% increase in past-three-month use (from 14% to 18%).[1] In this short time period, a significant increase in cannabis use was noted among males between the ages of 18 and 64 years,[1] and the number of new users

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nearly doubled among both sexes (from 327 000–646 000).[2]

Conversely, among youth, a decrease in cannabis use has been observed in the past decade. Between 2008/09 and 2014/15, past-year cannabis use decreased from 27.3% to 16.5% among youth in Grades 7 through 12.[3] More recent findings from 2016/17 and 2018/19, however, show that past-year cannabis consumption among this group has remained unchanged from 2014/15, at 18.1%.[4,5] Significant changes in the risk perception of this substance were also noted within this time period, suggesting a decreasing trend in the viewing of cannabis as a harmful substance: whereas in 2014/15, 7% of respondents reported that regular cannabis use posed "no risk," in 2016/17, this percentage was up to 9%.[4,6] Further, when asked if people were at "great risk" of harming themselves when using cannabis on a regular basis, a statistically significant decrease was noted (58%–54%).[4] Such perception changes among this population are of concern, considering the findings of a recent pan-Canadian study by the Canadian Institute for Health Information (CIHI) showing that, of the 23 580 hospitalizations for harm caused by substance use among youth aged 10 to 24 years in 2017 to 2018, those related to cannabis were more common (38.5%) than those caused by any other substance, including alcohol, opioids and cocaine.[7] Moreover, this report noted that 81% of the cannabis-related hospitalizations involved a concurrent mental health condition.

The degree to which cannabis can affect the health of populations has also been examined in epidemiological studies. An area of research that has gained much attention is the ways in which cannabis consumption affects the operation of motor vehicles. Simulated driving experiments, for instance, following acute cannabis consumption have found that cognitive functions required to safely operate vehicles may become affected, resulting in greater risk of vehicle collisions.[8,9] These effects have also been found among regular cannabis users participating in such driving-simulation studies.[9] Observational studies have also found significant associations between acute cannabis intoxication and motor vehicle collisions,[10] including those resulting in fatalities.[11,12] As might be expected, preventing "drugged driving" has become a priority for governments and law enforcement in Canada.[13] At the federal level, for instance, the government of Canada launched the *Don't Drive High* campaign in 2017, a widespread public safety initiative reaching Canadians through media platforms including television, cinema and popular social media applications.[14]

Medical studies highlighting clinical presentations of acute ingestions of cannabis among children and adults have also been undertaken in an effort to better inform medical practitioners. These studies have documented pediatric patients presenting with decreased levels of consciousness, confusion, anxiety, ataxia and respiratory distress as a result of cannabis exposure.[15-17] Among adults, a Colorado-based study examining emergency department (ED) visits found that gastrointestinal ailments, intoxication and psychiatric symptoms were the most common medical conditions associated with inhaled cannabis–related visits.[18]

With Canada's recent amendments to cannabis regulations and the noted changes in trends in prevalence and the perceptions of this substance, the need for the ongoing surveillance of the health impacts of cannabis is evident. Expanding on Rao's 2018 study,[19] the aim of our study was to present a more recent temporal pattern of cannabis-related injuries and poisonings found in the electronic Canadian Hospitals Injury Reporting and Prevention Program (eCHIRPP) database and provide a descriptive summary of the injury characteristics of cannabis-related cases captured since 1 April, 2011. Specifically, this study (1) analyzed three additional years of cannabis-related data using a similar methodology in eCHIRPP; (2) examined the factors involved in cases where edible cannabis products were consumed; and (3) established a baseline for future cannabis-related studies using the eCHIRPP database.

Methods

Data source

The eCHIRPP is a sentinel surveillance system that gathers injury and poisoning data from 19 selected EDs across Canada, 11 of which are primarily pediatric hospitals; the remaining hospitals serve both the child and adult populations. As a result, the eCHIRPP database contains a larger proportion of injuries and poisonings involving children. The program was designed to help researchers better understand the ways in which injuries and poisonings occur by obtaining a narrative description from patients, caregivers and/or onsite eCHIRPP personnel. In these narratives, questions addressing how, where and why the injuries occurred are generally answered. Additional information is also entered in reports by health care providers and eCHIRPP coders, who provide clinical and contextual data that include the presence of substance use, the region(s) of the body affected by the injuries, the location (e.g. home, public space) in which the injuries occurred, and the nature and external causes of the injuries. The capture of contextual factors by the eCHIRPP sentinel surveillance system makes it an important resource in the realm of injury prevention. Indeed, for nearly 30 years, data from the CHIRPP program have contributed to injury research by informing timely epidemiological reports and studies conducted in academic and organizational settings on a range of topics including fractures,[20,21] injuries as a result of products or equipment[22,23] and sports-related injuries.[24,25]

Data extraction

On 9 August, 2019, we conducted an extraction of all eCHIRPP records that had been entered into the system since 1 April, 2011 (total = 1 118 930), thus covering a nine-year time period.

Age groups

We conducted descriptive analyses by examining injuries and poisonings across three groups: children (aged 17 years or younger), adults (18 years and over) and all individuals combined. To present greater granularity of the data, we also conducted further analyses examining smaller age group ranges, though such groups were not the principal focus of this study.

Case identification

To identify all cannabis-related cases, we examined three variables in the eCHIRPP records: substance use, substance ID and the narrative description of the injury. The substance use code was the primary variable used to identify cannabis-related cases. We screened all records in which the substance use field indicated "yes" or

was left blank by searching key words pertaining to cannabis in the narrative description and substance ID fields. Subsequently, accounting for human coding error, we conducted a similar process for records in which the substance use field indicated "no."

Injury characteristics

In parallel with Rao's 2018 study,[19] we grouped injury characteristics into four broad categories examining the intentionality, external cause, type and severity of all cannabis-related cases. Table 1 shows the eCHIRPP codes used in the analyses, along with their descriptions.

Statistical analyses

Estimates of identified cannabis-related cases relative to all cases found in the database are presented as proportions relative to 100 000 eCHIRPP records. The proportions of the injury characteristics we examined are relative to all cannabis-related cases. We performed time trend analyses across three groups—children, adults and all ages—covering an eight-year period using Joinpoint (Version 4.6.0.0),[26] This software detects inflection points, calculates whether annual percent changes (APC) of segments are significantly different from zero (alpha = 0.05), and provides 95% confidence intervals. In our study, time trend analyses were based on the proportion of cannabis-related cases relative to all cases found in eCHIRPP according to the given groups.

TABLE 1
Cannabis-related injury characteristics and codes, eCHIRPP, 2011 to 2019

Injury characteristic	Description	eCHIRPP codes	Rationale for inclusion in analysis
Intent of the injury or poisoning	Unintentional injury	10IN, 16IN	To examine the intentional nature of the injury or poisoning event. Key word search terms were also used for classification.
	Physical assault and/or aggression	15IN	
	Self-harm	11IN	
	Involvement of emergency response personnel (ERP)	19IN	
	Sexual assault	12IN	
	Maltreatment	13IN, 14IN	
External cause	Poisoning	210EC, 301EC	To examine the mechanism of the injury or poisoning. Key word search terms were also used for classification.
	Fall	201EC, 2011EC	
	Assault	400EC, 4001EC	
	Transport	100EC, 101EC, 102EC	
	External agent	202EC, 203EC, 205EC, 209EC, 302EC, 305EC, 309EC	
Nature of injury	Intoxication	50NI	To examine the type of injuries sustained. Key word search terms were also used for classification.
	External wound	10NI, 11NI	
	Internal wound	24NI, 25NI, 26NI, 27NI, 52NI, 53NI, 60NI, 77NI	
	Brain injury	41NI, 42NI, 43NI	
	Fracture, sprain, or strain (or key terms)	12NI, 13NI, 14NI, 15NI, 16NI, 17NI, 75NI	
Severity	Severe	700T, 800T, 900T	The severity of the injuries or poisonings was dichotomized based on treatment outcomes. Patients admitted in hospitals or pronounced dead in emergency departments were deemed as severe, whereas patients requiring treatment or observational care in the emergency departments were deemed as not severe.
	Not severe	100T, 200T, 300T, 400T, 500T, 600T	

Abbreviation: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.

Results

Between 1 April, 2011, and 9 August, 2019, there were 2823 cannabis-related cases reported in eCHIRPP, representing 252.3 cases/100 000 eCHIRPP cases. Of the 2823 cannabis-related cases, a majority involved cannabis use in combination with one or more substances (63.1%; 1780 cases). There were 885 (31.3%) cases that involved only cannabis, and 158 cases (5.6%) that related to cannabis edibles. Excluding cases involving cannabis edibles, males represented the largest proportion (compared to females) at 60.9% (n = 1623). Conversely, among those involving edibles, females represented the largest proportion at 53.2% (n = 84), as shown in Table 2.

Table 2 also summarizes the results for both sexes across eight different age groups. Males consistently accounted for a higher proportion of all cannabis-related cases across the majority of age groups, with the exception of the group aged 10 to 14 years, in which females represented a slightly larger proportion compared to males (50.3% vs. 49.7%). When comparing children (aged 17 years and younger) and adults, the former accounted for the largest proportion of all cannabis-related cases at 67.8%, representing 1914 cases or 210.4 cases/100 000 eCHIRPP cases. Adults accounted for 907 cannabis-related cases, or 32.2%; however, in relation to all eCHIRPP records, the proportion was higher among this group compared to children, at 434.6 cases/100 000 eCHIRPP cases.

With respect to temporal patterns, we conducted time trend analyses examining the three groups—children, adults and overall cases. Of note, these analyses only included cases related to cannabis and cannabis edibles up to the end of the 2018 calendar year and not 2019, accommodating the varying entry time for eCHIRPP records. As shown in Figure 1, significant increases in annual percent change (APC) in all cannabis-related cases were detected

TABLE 2
Number of cannabis-related cases by age group and sex, eCHIRPP, 2011 to 2019

Category	Total (column%)	Males (%)	Females (%)
Edibles	158 (5.6%)	74 (46.9)	84 (53.2)
Cannabis alone	884 (31.3%)	549 (62.1)	335 (37.9)
Polysubstance use	1780 (63.1%)	1074 (60.3)	706 (39.7)
All cases[a]	2822	1697 (60.1)	1125 (39.9)
Age groups[b]			
Children (17 years or younger)	**1914 (67.8%)**	**1001 (52.3)**	**913 (47.7)**
Adults (18 years or older)	**907 (32.2%)**	**696 (76.7)**	**211 (23.3)**
Under 10 yrs	97	50 (51.6)	47 (48.4)
10 to 14 yrs	477	237 (49.7)	240 (50.3)
15 to 19 yrs	1457	800 (54.9)	657 (45.1)
20 to 29 yrs	383	307 (80.2)	76 (19.8)
30 to 39 yrs	205	156 (76.1)	49 (23.9)
40 to 49 yrs	99	70 (70.7)	29 (29.3)
50 to 64 yrs	91	68 (74.7)	23 (25.3)
65 yrs and older	12	9 (75.0)	3 (25.0)

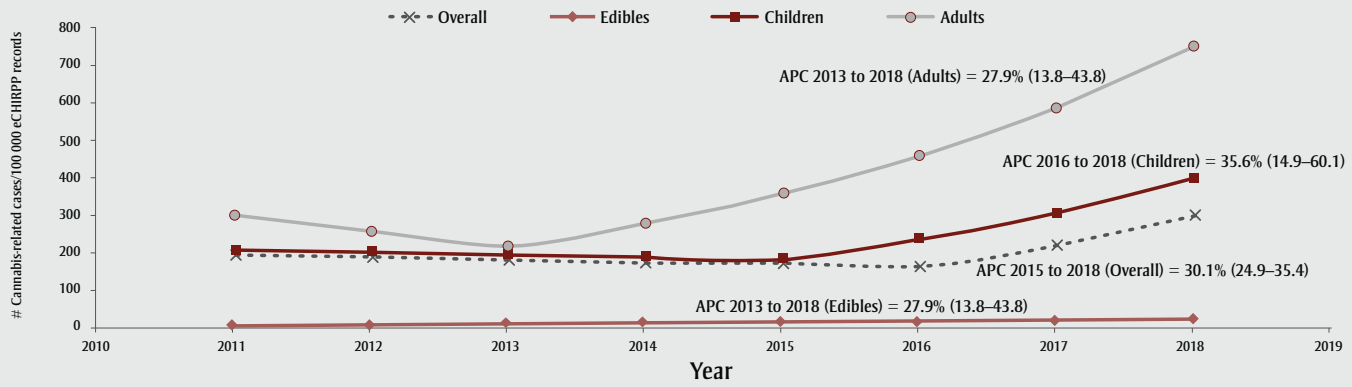
Abbreviation: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.
[a] One case removed from category "all cases" due to missing sex.
[b] Two cases removed from this table due to missing ages.

in the Joinpoint software across every group in recent years: among adults, a 27.9% APC was noted between 2013 and 2018; among children, a 35.6% APC was noted between 2016 and 2018; and overall, there was a 30.1% APC between 2015 and 2018. We also noted a significant increase in APC (26.0%, CI: 6.0%–49.8%) between 2011 and 2018 when examining overall cases related to cannabis edibles, though caution should be taken when interpreting this result, given the low number of these cases (Figure 1).

When examining the intentionality of the cannabis-related cases, we identified similar patterns among children and adults. As shown in Figure 2, the majority of all cannabis-related cases were unintentional in nature (e.g. poisonings, falls and motor vehicle collisions) among both groups (children 66.3%, adults 58.2%), followed by those caused by self-harm (e.g. suicidal ideations and attempts; children 15.7%, adults 19.8%) and physical assault/aggression (e.g. physical altercations or striking of inanimate objects; children 9.7%, adults 16.9%). Of the 481 self-harm cases, 62.4% involved children (n = 300), with a median age of 16 years, and the remaining 37.6% (n = 181) involved adults, with a median age of 30 years. As for the degree of severity among self-harm cannabis-related cases, 29.3% of children and 18.3% of adults were admitted to hospitals (data not shown). Representing the smallest proportions in this category were cases involving Emergency Response Personnel (ERP) and those related to sexual assault and other maltreatment. Cases involving ERP (children 7.4%; adults 4.0%) included situations in which patients were unresponsive or disorderly in public. Sexual assault–related cases (children 0.7%; adults 0.2%) included situations in which patients were touched or forced into intercourse. Of note, all sexual assault–related cases involved the presence of other substances in addition to cannabis, including alcohol, ecstasy and cocaine. Lastly, maltreatment cases (children 0.3%; adults 1.0%) included circumstances related to intimate partner violence as well as abuse by family members.

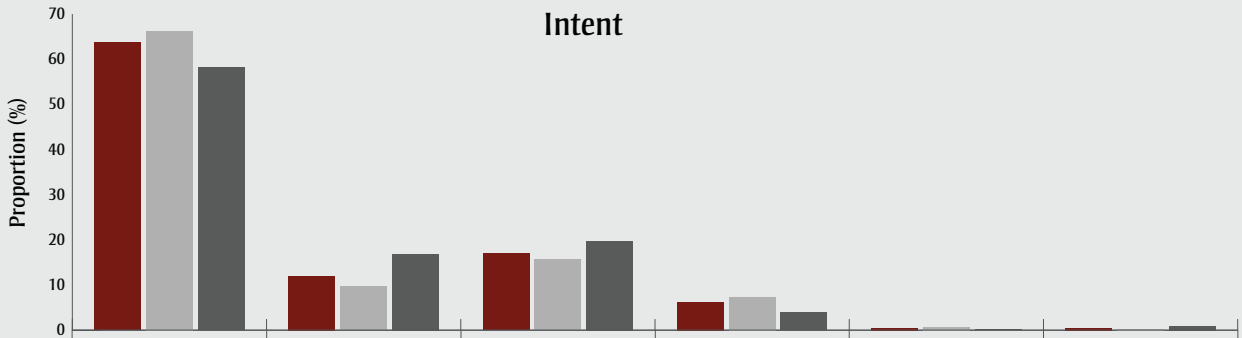
The leading external cause across all three groups was poisoning, as shown in Figure 3. Cases captured in this category included those with adverse reactions to cannabis use, but also included incidents in which cannabis was involved in

FIGURE 1
Time trend of cannabis-related cases presenting to emergency departments, children, adults and overall cases, eCHIRPP, 2011 to 2018[a]



Abbreviations: APC, annual percent change; eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.
[a] Records for 2019 were suppressed due to varying entry times in eCHIRPP.

FIGURE 2
Distribution of intent categories among cannabis-related injury cases in the eCHIRPP, 2011 to 2019[a]



	Unintentional	Physical assault/aggression	Self-harm	ERP involvment	Sexual assault	Maltreatment
All ages	63.66	11.97	17.04	6.31	0.53	0.50
Children	66.30	9.67	15.67	7.42	0.68	0.26
Adults	58.15	16.85	19.82	3.96	0.22	0.99

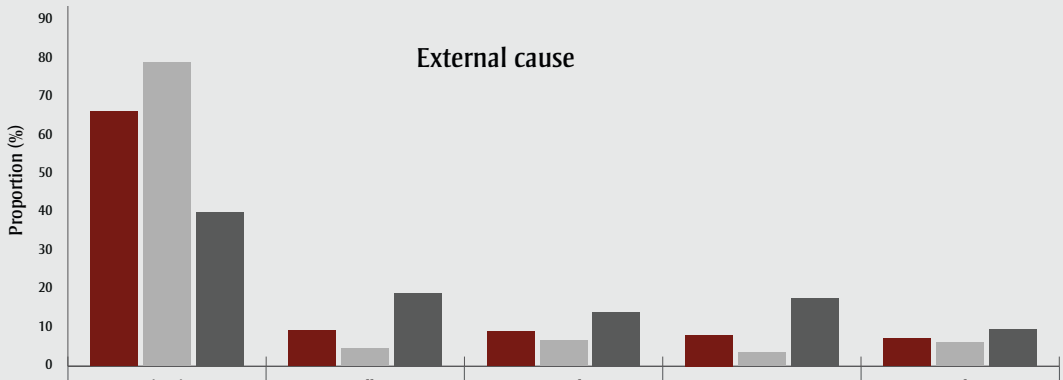
Abbreviations: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program; ERP, emergency response personnel.
[a] Records entered on or before 9 August, 2019.

conjunction with other substances including alcohol, cocaine and methamphetamine. Whereas falls and transport-related injuries represented the second and third most frequent external causes among adults, at 18.9% and 17.6%, respectively, assaults and external agent–related injuries were the second and third most frequent external causes among children, at 6.6% and 6.2%, respectively. The external agent category captured both intentional and unintentional cases in which external agents were factors contributing to the injuries—these agents included objects such as windows, knives and items of furniture.

With respect to the nature of the injuries or poisonings reported, Figure 4 shows that an overwhelmingly large proportion of cases (84.6%) involved intoxication among children. In this category, the median age was 16 years, and cases included children suffering adverse effects of cannabis alone or in conjunction with other substances. The second most common type of injury among children was external wounds, representing 7.7% of cases. Here, cases included falls, altercations and motor vehicle collisions. Among adults, we identified a similar pattern, in which intoxication (42.5%) was most common (median age of 29 years). As shown in Figure 4, the external wounds (20.7%) and fracture, sprain or strain (20.2%) categories were the second and third most frequent types of injuries sustained.

With respect to the severity of all cannabis-related cases, 15.1% of cases involved serious injuries requiring admission to hospital. Of these cases, 238 (56%) involved children, with an overall median age of 16 years, and a higher proportion of males (52.2%; data not shown). In this category of serious injuries involving children, suicide attempts, motor vehicle collisions and polysubstance use were

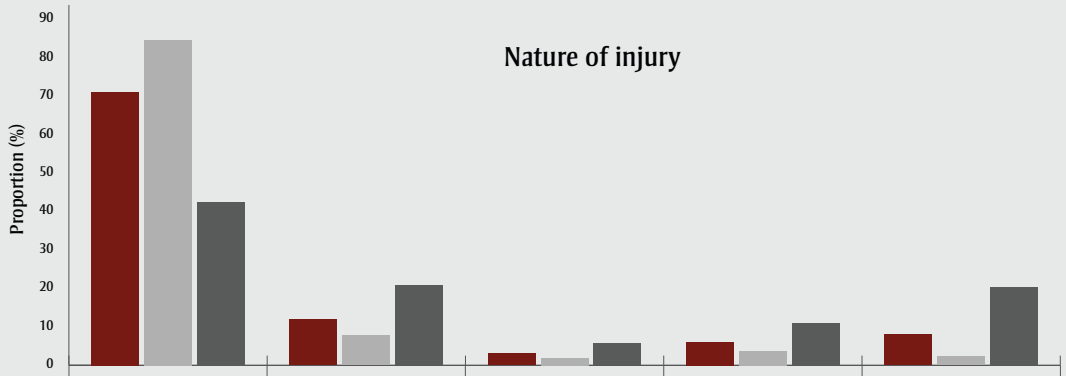
FIGURE 3
Distribution of external cause among cannabis-related injury cases in the eCHIRPP, 2011 to 2019[a]



	Poisoning	Falls	Assault	Transport	External agent
All ages	66.29	9.29	9.00	8.15	7.27
Children	79.03	4.64	6.61	3.55	6.17
Adults	40.07	18.86	13.92	17.62	9.54

Abbreviation: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.
[a] Records entered on or before 9 August, 2019.

FIGURE 4
Distribution of nature of injury among cannabis-related cases in the eCHIRPP, 2011 to 2019[a]



	Intoxication	External wound	Internal wound	Brain injury	Fracture, sprain or strain
All ages	71.06	11.87	3.05	6.02	8.01
Children	84.59	7.68	1.83	3.66	2.25
Adults	42.51	20.70	5.62	11.01	20.15

Abbreviation: eCHIRPP, electronic Canadian Hospitals Injury Reporting and Prevention Program.
[a] Records entered on or before 9 August, 2019.

contributing factors. Among adults, there were 187 cases requiring admission to hospital, of which 81.8% involved males (data not shown). Factors contributing to these cases among adults were similar to those involving children, and included assaults, suicide attempts and motor vehicle collisions. Notably, only one death was identified in this study; polysubstance use and a motor vehicle collision were the factors involved.

Lastly, because edible cannabis products were legalized in Canada in October 2019, this study examined cases in which such products were involved. Of the 158 cases identified, a significantly large proportion involved children (87.3%), among whom females represented a slightly higher proportion than males, at 56.5%. Here, symptoms included dizziness, drowsiness and emesis. Among children under the age of 10 years, there were 35 cases, all of which were unintentional in nature and two of which were admitted to hospital. Based on these narratives, these edible products were either mistakenly left within the reach of children or unintentionally given to them. Among the 20 cases in adults, 14 cases involved males (70%). Among this group, symptoms included anxiety, disorientation and emesis.

Discussion

This study demonstrated that cannabis-related injury and poisoning cases are relatively rare in the eCHIRPP database. A possible explanation for this finding may be supplied by the CIHI study mentioned earlier,[7] which found that the majority of cannabis-related hospitalizations can be attributed to concurrent mental health conditions—conditions that may not be captured in the eCHIRPP database.

Our study's findings, however, are consistent with other studies examining US data from poison centres and EDs, which show that males generally represent the largest proportion of cannabis-related cases presenting there.[27,28] In Canada, the higher proportion of cannabis-related cases involving males may be in part a reflection of patterns of cannabis use; both past and recent national statistics have shown that the prevalence of cannabis use among Canadians aged 15 years or older is statistically higher among males.[1,29] Further, recent national figures for Canadians aged 15 years and older have shown that daily or almost daily use of cannabis was significantly higher among males compared to females, at 7.6% versus 4.5%, respectively.[2]

Time trend analyses showed increases in APC regarding the proportion of cannabis-related cases in eCHIRPP among both children and adults in some years during the study period. While the recent increase in the prevalence of cannabis use among the adult population may help explain such a pattern, the noted decreasing prevalence of cannabis use among youth suggests otherwise. However, despite these trends, cannabis use among the younger population still remains higher in proportion compared to adults,[1] which points to their higher degree of exposure. It is possible that the large amount of media coverage and discussion surrounding cannabis in the years leading up to the 2018 legalization may have resulted in individuals being less reluctant to disclose cannabis use when presenting to EDs, thereby apparently increasing the overall number of cannabis-related cases.

A large majority of cases among children and adults presenting to the ED were unintentional in nature; patients were simply experiencing the adverse effects of cannabis. Of concern are the ways in which such unintentional cannabis-related exposures can affect younger children. Indeed, a systematic review examining the health effects of unintentional cannabis exposure concluded that when children present to EDs with lethargy and ataxia, clinicians should suspect cannabis toxicity.[30] The 35 cases in our study that involved the unintentional ingestion of cannabis products among those under 10 years of age also reinforce the need for safer practices in individual households, mainly the safer storage of such products. Child-resistant, plain packaging and THC limits are examples of other measures that have been considered to prevent such events.[31] And though much warranted attention is focussed on edibles, there are

other hidden hazards that parents and caregivers need to be mindful of when children are present, including cannabis resin and joints.[30]

From a public health perspective, transportation-related incidents captured in this study not only speak to the adverse outcomes that may arise at the individual level, but also to those that may affect the public. This aspect of cannabis use will likely continue to be a priority among law enforcement and nongovernmental organizations such as Mothers Against Drunk Driving Canada (MADD),[32] given the recent changes to cannabis regulations.

Lastly, with respect to the severity of cannabis-related cases, this study identified 425 cases of serious injuries requiring admission to hospital. Of these, 56% involved children. While this larger proportion of children is likely reflective of the fact that eCHIRPP is more likely to capture the pediatric population than adults, it nevertheless signals an ongoing need to keep cannabis products out of the reach of children. The implementation of a minimum legal age requirement enforced by the provinces and territories is in line with this need, though to determine the effectiveness of this regulation, as well as the others introduced as a result of the October 2018 legalization, ongoing surveillance efforts examining cannabis-related injuries and poisonings will be required.

Strengths and limitations

The principal strength of our study is the use of eCHIRPP data, since the program can capture contextual information about injuries or poisonings presenting in EDs. This information is then transformed into a standardized form of coding, which allows for analysis. However, there are some limitations. While eCHIRPP sites are found in various regions across Canada, injury estimates arising from this program are not representative of the national population. A slight exception is injuries among youth, which may in fact be reflective of those occurring at the national level. For example, when comparing injury findings of the World Health Organization's Health Behaviour in School-Aged Children Survey (WHO-HBSC) to those in eCHIRPP, Pickett et al.[33] found that the program may be representative of the general injury patterns among youth in Canada. However, such a finding does not apply to injuries and poisonings among older teenagers, adults, First Nations and Inuit peoples and those who live in rural and remote areas.[34] Additionally, at both ends of the severity spectrum, eCHIRPP does not capture fatal injuries or poisonings that occur outside of EDs, nor injuries or poisonings that are mild in nature and for which treatments are carried out in other medical settings, including medical clinics.

Of particular relevance to our study, strong sensitivity and specificity of the variables used for identifying cannabis-related cases in eCHIRPP have been demonstrated in Rao's 2018 study,[19] reflecting good capture. However, patients' reluctance to disclose the use of cannabis may have resulted in the underreporting of cannabis-related cases in eCHIRPP, especially in the years prior to the legalization of the recreational use of cannabis. Underreporting may also occur among those who use cannabis on a more regular basis and perhaps fail to recognize this substance as being one of the factors contributing to the injuries. Furthermore, because of the limitations of eCHIRPP data, we were not able to distinguish whether cannabis was used for medical or recreational purposes, nor were we able to ascertain the amount of the substance taken at the time of injury or poisoning. In the future, obtaining such information may lead to better identification of at-risk populations and a better understanding of the dose-response relationship of such injuries.

Conclusion

The aim of our study was to present a more recent temporal pattern of all cannabis-related injuries and poisonings found in the eCHIRPP database and provide a descriptive summary of the injury characteristics of such cases captured in the nine-year time period from 1 April, 2011, to 9 August, 2019. In so doing, we identified APC increases in cannabis-related cases among both children and adults in recent years. Males consistently represented a higher proportion of cannabis-related cases, which signals potential educational opportunities. While there was an increase in edible cannabis–related cases throughout this study period, they represented only a small proportion of all the cannabis-related cases. Such a finding suggests the need for parents and caregivers to implement safer storage practices. Though not representative of the national population, our findings indicate that cannabis-related injuries have increased in recent years in the eCHIRPP database among both children and adults. Continuing to monitor such injuries and poisonings through surveillance measures will be imperative, considering the recent changes to cannabis regulations in Canada.

Acknowledgements

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Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

ASC, SRM, WT and FB were involved in the design and conceptualization of the project. ASC conducted the data analyses and drafted the manuscript. All authors contributed to the interpretation of the results and revisions of the paper.

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

Setting the baseline: a description of cannabis poisonings at a Canadian pediatric hospital prior to the legalization of recreational cannabis

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This article has been peer reviewed.

Abstract

Introduction: This study describes the events and circumstances preceding children aged 16 years or younger being treated for cannabis poisoning in the emergency department (ED) of a Canadian pediatric hospital.

Methods: We extracted cannabis poisonings treated in the ED at British Columbia Children's Hospital (BCCH) between 1 January, 2016, and 31 December, 2018, from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) database. The poisonings were distinguished by the inadvertent or intentional ingestion of cannabis. We reviewed the hospital's electronic health information system and the patients' health records to obtain additional information on the context, including spatial and temporal characteristics.

Results: Of the 911 poisonings treated at BCCH, 114 were related to intentional cannabis use (12.5%). Fewer than 10 poisonings resulted from inadvertent ingestion by children, and the median age for these was 3 years. All inadvertent ingestions occurred at home and involved cannabis belonging to the patient's family. The vast majority of poisonings resulted from the intentional use of cannabis only (28.9%) or cannabis use with other psychoactive substances (co-ingestions; 71.1%). The median patient age was 15 years. Most patients reported consuming cannabis through inhalation and with peers. Cannabis and co-ingestion poisonings were more often reported on weekdays than weekends. The consumption of cannabis leading to poisoning more often occurred in private residences. Patients with cannabis poisoning more often sought medical treatment themselves or were helped by their family.

Conclusion: The characteristics of cannabis poisonings among children are described for the three-year period prior to recreational cannabis legalization in Canada in order to set a baseline for future comparisons. Implications for improving injury prevention initiatives and policies are discussed.

Keywords: *cannabis, marijuana, substance use, poisoning, child, youth, injury prevention*

Highlights

- Few pediatric poisonings involved the inadvertent ingestion of cannabis; in these cases, patients consumed cannabis found in their home.
- The vast majority of pediatric cannabis poisonings resulted from intentional use. Of these, more poisonings resulted from cannabis co-ingestions with alcohol as compared to cannabis use only.
- Cannabis was most often intentionally consumed in the company of peers and in private residences.
- Cannabis-only and cannabis co-ingestion poisonings were more often reported on weekdays than on weekends.
- A higher proportion of patients with cannabis poisoning sought medical treatment themselves or were helped by family members, rather than being helped by a bystander.

Introduction

Cannabis is one of the most commonly reported illicit psychoactive substances consumed by Canadian children, aside from alcohol.[1,2] Despite laws and regulations restricting cannabis access to adults over 18 years of age, an estimated one-fifth of students in Grades 7 to 12 across Canada reported past cannabis use in a 2015 survey.[3] The average age of first cannabis use was reported to be around 14 years and most students reported high confidence in their ability to access cannabis.[3,4]

Cannabis can elicit feelings of euphoria when consumed in moderation,[5] but to an inexperienced user, the effects can produce negative outcomes. Children are especially vulnerable to cannabis poisoning due to their metabolism and lower body weight.[6,7] Other contributing factors

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to cannabis poisoning include inexperience with using psychoactive substances;[8] substances obtained from unlicensed sources;[9] co-ingestion with stimulants, opioids, or psychedelics;[10,11] and lack of insight into harm reduction behaviours.[12] Common signs of cannabis poisoning include vomiting, dizziness, slurred speech and a decreased level of consciousness.[13-15] Oftentimes, these symptoms can be resolved in the emergency department (ED) and pose little or no long-term harm.[13]

According to the Canadian Institute for Health Information, approximately 40% of the 23 580 Canadians aged 10 to 24 years who were hospitalized in 2017-2018 for harms caused by substance use have been admitted due to cannabis use. This is equivalent to 25 youth hospitalized each day due to cannabis use.[16] Individuals poisoned by cannabis can be categorized into two groups: inadvertent ingestions and intentional use. Inadvertent ingestions often involve younger children unintentionally exposed to cannabis in the home.[17-19] In comparison, those with intentional cannabis use leading to poisoning tend to be older than their inadvertent counterparts, and are often male.[20] Research into the health impacts of cannabis poisonings continues to be conducted primarily on adult populations. Comparatively less is known about harms to children from exposure to cannabis, and when studied, it is often in the context of inadvertent ingestion.[21-23] Cannabis-related harms in children and youth who intentionally consume cannabis are substantially harder to capture due to the illegal nature of underage use.[24] Therefore, there is limited research into intentional cannabis use leading to poisoning among children, and it is currently unclear how, where, when and with which substance children who intentionally use cannabis are most likely to experience poisonings.

With the October 2018 legalization of recreational cannabis use in Canada impending,[24] the purpose of this study was to examine the circumstances of cannabis poisonings in children aged 16 years or younger resulting in treatment in the ED, in order to establish the baseline dataset for future comparisons. This data included spatial and temporal characteristics of cannabis use leading to poisoning, and the persons responsible for helping poisoned patients seek medical care. The sample consisted of children that were treated in the ED of a pediatric hospital in British Columbia (BC) between 1 January, 2016, and 31 December, 2018. Ethics approval was obtained from the University of British Columbia (UBC), Children's & Women's Health Centre of British Columbia (CW), Research Ethics Board; certificate number H18-03680.

Methods

Data collection and extraction

We accessed data regarding cannabis poisoning–related ED visits at British Columbia Children's Hospital (BCCH) using the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) database. CHIRPP is an ED surveillance system that collects information on all injuries, including poisoning, by means of forms administered by the ED registration clerk to the patient or caregiver. If a patient or caregiver is unable to complete the CHIRPP form, the CHIRPP coordinator uses the information from the hospital's electronic health information system and the patient's health record to complete the form. Subsequently, the coordinator reviews all ED visits daily or near daily to ensure all injuries have been captured comprehensively and accurately.

Once the data were entered into the CHIRPP database, we selected poisoning cases fulfilling the following requirements: patients aged 16 years or younger; injuries with codes "50NI: poisoning or toxic effect" and "900BP: body part not required"; ED visits occurring at BCCH between 1 January, 2016, and 31 December, 2018; and injury event descriptions in which a string search found one or more of the following words: "cannabis," "hash," "CBD," "marijuana," "weed," "THC," "bong," or "edible." To ensure that all cannabis poisonings were captured, we conducted a final review of the injury event descriptions attached to poisonings for those not already captured. Age, sex, description of the poisoning event, time and place of poisoning, substances consumed and patient disposition were collected from the CHIRPP database. The following variables were obtained from the patients' health records and the hospital's electronic health information system: whether the poisoning was due to inadvertent ingestion or intentional use; the location where the substance or substances were consumed; whether the substance or substances were consumed in the presence of another person (peer substance use); whether alcohol, illicit drugs (including fentanyl and its derivatives, heroin, cocaine, methamphetamine, MDMA, psilocybin, LSD/acid) or medication (including prescription or over-the-counter drugs used for other than their intended medicinal purposes) were consumed with cannabis; the primary individual who sought medical care for the patient (treatment-seeking individual); and the mode of arrival at the hospital. The method of cannabis use was characterized as "inhaled" or "orally ingested."

Interrater reliability

We calculated interrater agreement as described by the Cohen kappa statistic for peer substance use and treatment-seeking individual, as this information was not explicit for every poisoning. For peer substance use, two coders were assigned to code "yes" for those who had consumed cannabis with one or more individuals prior to their poisoning, or "no" for those who consumed the substance while alone. For treatment-seeking individual, the coders were instructed to code for "bystander," "patient" or "family or friend." A bystander is defined as an individual who did not participate in the substance use with the patient, and was not a friend or family member of the patient. Family is defined as all individuals within the patient's nuclear and extended family. One-quarter of the poisoning cases containing the coded variables were randomly selected for comparison. The interrater reliability for peer substance use was $\kappa = 0.796$ (SE = .090, $p < .001$) and treatment-seeking individual was $\kappa = 0.755$ (SE = .088, $p < .001$).

Data analyses

Data analyses were conducted using IBM SPSS Statistics Version 25.0 (IBM Corp, Armonk, NY, USA) and RStudio Version 1.2.1335 (R Development Core Team, Vienna, Austria). We analyzed data separately for cases of inadvertent ingestion and intentional use. Poisonings resulting from inadvertent ingestion of cannabis were aggregated due to low counts. Those resulting from intentional use were analyzed separately for cannabis-only cases and cannabis co-ingestion cases. Cannabis co-ingestions included patients who consumed cannabis with alcohol, illicit drugs and/or medication. We calculated descriptive statistics and χ^2 tests using SPSS and

conducted the post-hoc analyses with false discovery rate corrections in RStudio using the R Companion package (Mangiafico S, R Companion, version 2.3.21);[25] results were interpreted to be significant if $p < .05$.

Results

Between 1 January, 2016, and 31 December, 2018, there were 114 ED visits due to poisoning by intentional cannabis use, representing 12.5% of all 911 poisoning-related ED visits at BCCH.

Fewer than 10 patients captured reported inadvertent cannabis ingestion.

Inadvertent cannabis ingestion leading to poisoning

Although few patients were treated for poisoning resulting from the inadvertent ingestion of cannabis, they shared common circumstances and events that led up to their presentation at the BCCH ED. This sample consisted predominantly of male patients ranging from 1 to 11 years of age. The median age was 3 years (interquartile range [IQR] = 1–7.5 years). Most inadvertent ingestions occurred on a weekend (i.e. Saturday or Sunday) while the patient was at home. Products inadvertently ingested by the patient included edibles, topicals and undiscarded cannabis cigarettes. All products mentioned belonged to the parents or siblings of the patient. Patients were brought to BCCH either by their parents or with Emergency Health Services (EHS). Most poisoning symptoms were resolved in the ED and the patients subsequently discharged.

Demographics of intentional cannabis use leading to poisoning

Of the 114 patients with reported intentional use, 28.9% had consumed cannabis only and 71.1% reported co-ingesting cannabis with alcohol, illicit drugs and/or medication (Table 1). The median age of patients was 15 years (IQR: 14–15 years for cannabis-only, 14–16 years for co-ingestions), with ages ranging from 12 to 16 years. Patients' sex did not vary significantly between the two groups ($p = .293$), with cannabis-only use fairly even between males and females, and co-ingestions slightly higher among males than females. The majority of poisonings were described as unintentional as compared to purposeful self-harm, and most patients were discharged directly from the ED.

Temporal distribution of intentional cannabis use leading to poisoning

Over short time periods, poisoning-related ED visits aggregated at certain times in the day ($p = .003$) and days of the week ($p = .014$) (Table 2). Post-hoc analyses indicated that cannabis and co-ingestion poisonings were equally common in the evening and in the morning ($p = .535$), but more cannabis poisonings were reported in the afternoon than the morning ($p = .013$), while more co-ingestion poisonings were reported in the evening than the afternoon ($p = .013$) (data not shown). Both cannabis-only and co-ingestion poisonings were more prevalent on weekdays than weekends (90.9% and 69.1%, respectively).

Characteristics of intentional cannabis ingestion leading to poisoning

Common characteristics of intentional cannabis use leading to poisoning are presented in Table 3. Most cannabis-only and co-ingestion patients reported using inhalation methods achieved either through a blunt, bong, joint, pipe or vaporizer to consume cannabis. Fewer than 15 patients reported using edibles, which included the ingestion of brownies, cookies, chocolate or gummies, and fewer than ten patients reported using multiple consumption methods. Alcohol was the predominant substance used (59.3%) among those who reported co-ingesting other substances along with cannabis, followed by alcohol with illicit drugs (12.3%), and illicit drugs (11.1%) (data not shown). Fewer than five patients reported consuming cannabis with medication, or cannabis with illicit drugs and medication. Regardless of how cannabis was consumed, over half of cannabis-only and co-ingestion poisoning patients reported consuming the substances in the company of peers (54.5% and 60.5%, respectively).

Although one-third of cannabis-only use and one-quarter of co-ingestions occurred in residential spaces such as the patient's home, over one-third of cannabis-only poisoning patients and over half of the patients with co-ingestion poisonings did not provide information on where they consumed the substances. Similar to the location of cannabis consumption, cannabis poisoning events often occurred in residential spaces (39.4% for cannabis-only, 38.3% for co-ingestions), and in public spaces among co-ingestion patients (38.3%), while five cannabis patients reported being poisoned in public spaces.

Almost half of all cannabis-only poisonings were reported by the patient's family or friends (45.4%), while co-ingestion poisonings were most often reported by bystanders (39.5%) and family or friends (34.5%). EHS, including ground and air ambulance, was the most common mode of transport to the ED across all poisonings (69.7% for cannabis-only, 88.9% for co-ingestions).

Discussion

This study describes the events and circumstances preceding treatment for cannabis poisoning of children aged 16 years or younger in the ED of a Canadian pediatric hospital. Further, it establishes the baseline data on pediatric cannabis poisoning seen in the ED from both inadvertent cannabis ingestion and intentional cannabis use, prior to the legalization of recreational cannabis use in Canada. Despite the small sample, the inclusion of those poisoned by inadvertently ingesting cannabis is crucial in capturing the complete range of cannabis poisonings treated at the ED. Consistent with past research, this study found that all cannabis products inadvertently ingested by children, including edibles and inhalation materials, belonged to the patient's family and occurred predominantly on the weekends at the patient's home.[17,18] It is well known that edibles are a particularly dangerous form of cannabis for children, due to their enticing appearance as candy and treats;[23] however, this study highlights the importance of proper storage of all cannabis products securely out of the reach of young children. The continued surveillance of inadvertent cannabis ingestions in children will be especially important for informing health promotion initiatives, policy, and prevention efforts following the October 2019 legalization of cannabis edibles, topicals and extracts in Canada.[26]

Aside from inadvertent ingestions, this study also examined patients treated for pediatric poisoning in the ED following intentional cannabis use—cannabis-only or co-ingestion with other substances. The poisonings were commonly reported on weekdays and involved the inhalation of cannabis. Also, a higher proportion of

TABLE 1
Demographics of patients seen at the emergency department of British Columbia Children's Hospital for poisonings due to the intentional ingestion of cannabis or co-ingestions, CHIRPP, January 2016 to December 2018

Descriptives	Substance used				χ^2	df	*p*-value
	Cannabis		Co-ingestion				
	n	%	n	%			
	33	28.9	81	71.1			
Median age in years (IQR)	15 (14–15)		15 (14–16)				
Sex							
Male	16	48.5	48	59.3	1.11	1	.293
Female	17	51.5	33	40.7			
Intent of poisoning							
Unintentional	45	97.8	59	86.8	—	—	—
Intentional self-harm	*	*	6	8.8			
Other intents	*	*	*	*			
Patient disposition							
No treatment (advice only, diagnostic testing, referred to GP)	7	21.2	19	23.5	—	—	—
Treated, follow-up may or may not be required	7	21.2	27	33.3			
Observation, follow-up may or may not be required	16	48.5	26	32.1			
Admittance into hospital for treatment	*	*	8	9.9			
Other treatments	*	*	*	*			

Abbreviations: CHIRPP, Canadian Hospitals Injury Reporting and Prevention Program; df, degrees of freedom; GP, general practitioner; IQR, interquartile range.

Notes: Dashes indicate the absence of a χ^2 test, due to the violation of one or more assumptions of the test. Asterisks (*) indicate absolute frequencies of fewer than five. "Other intents" are unspecified assault or event of undetermined intent. "Other treatments" are admitted primarily for reason other than injury treatment, left without being seen by physician, referred to other hospital or specialist clinic for injury treatment.

patients reported consuming the substances with peers and in residential spaces. Together with the finding that most poisonings were unintentional in nature and required minimal treatment in the ED, these trends may be indicative of the lack of awareness of harm reduction methods concerning cannabis use. Prior research has shown that Canadian children and youth who use cannabis are more likely to downplay the harms of its use compared to those who don't use cannabis.[3,4] When this lack of awareness is combined with the risks inherent in purchasing cannabis of varying quality from illicit markets, the chances that people will experience adverse effects may be dramatically increased.[27] With the legalization of recreational cannabis, it has become more important than ever to educate children about the risks of cannabis and harm reduction behaviours.

While patients' lack of understanding of their own tolerance for cannabis might have been the cause of some of the pediatric poisonings, it should be noted that there were twice as many co-ingestion poisonings treated at the ED as cannabis-only poisonings. Alcohol was identified as the predominant substance in co-ingestion cannabis poisonings. Numerous studies have reported on the practice of mixing cannabis with alcohol among student populations to accelerate and prolong the euphoric experience.[28,29] In vivo studies have confirmed the impact of alcohol on increasing blood THC levels.[30] Our study extended these findings by comparing the proportion of cannabis-only poisonings seen in the ED with co-ingestion poisonings. This information provides a basis for discussion of how government policies can work towards discouraging polydrug use involving cannabis among children.

Other key topics we examined were the individual seeking medical treatment for the poisoning patient, and the location of the patient when the poisoning event was recognized. This framework has been used extensively to study the overdose response in the opioid crisis,[31-33] resulting in valuable data for emergency responders on when and where overdoses are most likely to occur. In our study, a higher proportion of cannabis-only poisoning patients presenting at the BCCH ED sought medical treatment for themselves or received help from family or friends, as compared to receiving help from a bystander. This is consistent with the finding that cannabis-only use and subsequent poisoning often occurred within private, residential homes rather than in public spaces. In contrast, patients with co-ingestion poisonings were often helped to hospital by bystanders. These poisonings often occur in public spaces, and therefore co-ingestion patients may be more likely to be noticed by bystanders than if the poisonings occur in secluded locations such as private homes. Further studies are needed to understand the individual factors and decisions that contribute to whether a bystander, family member or friend acts to intervene during a cannabis poisoning event. Our findings suggest that it may be helpful to educate the public about responding to cannabis poisonings in children so that bystanders are more likely to offer assistance when required.

TABLE 2
Temporal distribution of cannabis and co-ingestion poisonings due to intentional ingestions seen at the emergency department of British Columbia Children's Hospital, CHIRPP, January 2016 to December 2018

Descriptives	Substance used				χ^2	df	*p*-value
	Cannabis		Co-ingestion				
	n	%	n	%			
	33	28.9	81	71.1			
Time							
Morning	*	*	19	23.5	**11.86**	**2**	**.003**
Afternoon	15	45.5	13	16.0			
Evening	14	42.4	47	58.0			
Unknown	*	*	*	*			
Time in the week							
Weekday	30	90.9	56	69.1	**6.00**	**1**	**.014**
Weekend	*	9.1	25	30.9			
Season							
Spring	5	15.2	23	28.4	7.76	3	.051
Summer	10	30.3	18	22.2			
Autumn	8	24.2	30	37.0			
Winter	10	30.3	10	12.3			
Year							
2016	8	24.2	27	33.3	1.20	2	.549
2017	10	30.3	25	30.9			
2018	15	45.5	29	35.8			

Abbreviations: CHIRPP, Canadian Hospitals Injury Reporting and Prevention Program; df, degrees of freedom.

Notes: Dashes indicate the absence of a χ^2 test, due to the violation of one or more assumptions of the test. Bolded values indicate significant findings at the $p < .05$ level. Asterisks (*) indicate absolute frequencies of fewer than five. Time: morning = 12:00 a.m.– 11:59 a.m; afternoon = 12:00 p.m.–5:59 p.m; evening = 6:00 p.m.–11:59 p.m. Weekdays are Monday, Tuesday, Wednesday, Thursday, and Friday. Weekends are Saturday and Sunday. Season: spring = March to May; summer = June to August; autumn = September to November; winter = December to February.

Strengths and limitations

To date, only a handful of papers have documented the injury landscape of Canadian children poisoned from the inadvertent consumption or intentional use of cannabis, and few studies have attempted to conduct a review of patients' medical records in order to understand the narrative taking place before and after the poisoning event. By utilizing multiple data sources such as CHIRPP, the hospital's electronic health information system and patients' health records, this study was able to describe a population frequently overlooked in the literature and provide context on the circumstances of cannabis poisoning among Canadian children prior to the legalization of recreational cannabis use. The next step will be to continue surveillance of these pediatric cannabis poisonings in order to understand how legalization influences cannabis poisonings in children resulting in ED visits.

The major limitation of this study stems from the reliance on self-reported data by the patients, caregivers, EHS and ED staff regarding the circumstances of the poisoning events. Missing data were most common for the location of consumption, the location of poisoning and the treatment-seeking individual.

Socioeconomic variables, such as ethnicity, education level and household income, and details on cannabis use (including source and strain of cannabis and frequency of use) were also unavailable. Our sample also represents a small proportion of Canadian children who were treated at one hospital in BC; results may not be representative of youth aged 17 years or older, children declared deceased at the scene of the poisoning, populations in rural areas or those residing in other Canadian provinces and territories.

Conclusion

The vast majority of cannabis poisonings seen in the ED were among patients aged 12 to 16 years who intentionally used cannabis in combination with other psychoactive substances. This study sets a baseline for pediatric cannabis poisonings in the ED, and highlights the need for post-legalization surveillance in order to inform future prevention efforts.

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TABLE 3
Characteristics of cannabis and co-ingestion poisonings from intentional ingestions, patients' health records, British Columbia Children's Hospital's electronic health information system, January 2016 to December 2018

Characteristics	Substance used				χ^2	df	*p*-value
	Cannabis		Co-ingestions				
	n	%	n	%			
	33	28.9	81	71.1			
Method of cannabis use							
Inhalation	23	69.7	65	80.2	—	—	—
Ingestion	10	30.3	*	*			
Multiple	*	*	*	*			
Unknown	*	*	12	14.8			
Peer substance use							
No	11	33.3	13	16.0	2.93	1	.087
Yes	18	54.5	49	60.5			
Unknown	*	*	19	23.5			
Location of consumption							
Residential spaces	11	33.3	20	24.7	3.29	2	.193
Other private spaces	6	18.2	*	*			
Public spaces	*	*	12	14.8			
Unknown	12	36.4	45	55.6			
Location of poisoning							
Residential spaces	13	39.4	31	38.3	**9.91**	**2**	**.007**
Other private spaces	9	15.2	7	8.6			
Public spaces	5	15.2	31	38.3			
Unknown	6	18.2	12	14.8			
Treatment-seeking individual							
Bystander	*	*	32	39.5	**9.14**	**2**	**.010**
Patient	8	24.2	9	11.1			
Family or friends	15	45.4	28	34.5			
Unknown	6	18.2	9	14.8			
Mode of ED arrival							
EHS	23	69.7	72	88.9	—	—	—
Family	7	21.2	5	6.2			
Other(s)	*	*	*	*			
Unknown	*	*	*	*			

Abbreviations: ED, emergency department; EHS, emergency health services.

Notes: Dashes indicate the absence of a χ^2 test due to the violation of one or more assumptions of the test. Bolded values indicate significant findings at the $p < .05$ level. Asterisks (*) indicate absolute frequencies of fewer than five. "Inhalation methods" refers to the consumption of cannabis either through a blunt, bong, joint, pipe or vaporizer. "Ingestion methods" involve the ingestion of brownies, cookies, chocolate, or gummies. "Other private spaces" include concerts and festivals, commercial and retail spaces, educational institutions, police stations and major transit stations. "Public spaces" include parks, beaches, roads, streets, libraries and community centres. "Other modes of ED arrival" are self-admittance, with social worker and with friends.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Authors' contributions and statement

AZ and SB conceptualized the plan and objectives for this study. AZ and PC led the data collection. PC conducted the analyses and interpretation of the results, and drafted the manuscript. FR provided assistance with the analysis and interpretation of the manuscript. KT provided support with the ethics application. PC, FR, KT and SB contributed to the review and revision of the manuscript. All authors read and approved the final manuscript.

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Original quantitative research

Autonomy, competence and relatedness and cannabis and alcohol use among youth in Canada: a cross-sectional analysis

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This article has been peer reviewed.

Abstract

Introduction: There has been increasing attention on preventing problematic youth substance use in light of concerns about rates of use and policy changes in Canada. Strengths-based approaches that emphasize protective factors, including positive mental health, are at the forefront of current prevention recommendations. However, there is a dearth of research on the association between positive mental health and substance use among youth. This study examines the associations between cannabis and alcohol use among youth and positive mental health as measured through the lens of self-determination theory.

Methods: Secondary analyses of the 2014/2015 Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS) were conducted. Participating Grade 7 to 12 students residing in Canada completed the Children's Intrinsic Needs Satisfaction Scale (CINSS), which measures autonomy, competence and relatedness, and answered questions that measure past 30-day and more frequent cannabis use, alcohol use and binge-drinking. The associations between autonomy, competence and relatedness and substance use, stratified by sex, were examined using logistic regression.

Results: Fully adjusted models revealed that relatedness and competence were associated with lower odds of 30-day and more frequent cannabis use, alcohol use and binge-drinking. Higher autonomy was associated with higher odds of these behaviours. All associations were significant with the exception of competence and more frequent cannabis use among boys, and autonomy and more frequent alcohol use among girls.

Conclusion: The findings offer new evidence on the associations between positive mental health and substance use among youth, specifically how autonomy, competence and relatedness are associated with cannabis use, alcohol use and binge-drinking. This evidence can be used to inform health promotion and substance use prevention programs.

Keywords: *adolescents, positive mental health, substance use, cannabis, alcohol*

Highlights

- In multivariate models, youth with higher levels of relatedness and competence had lower odds of 30-day and more frequent cannabis use, alcohol use and binge-drinking (except for more frequent cannabis use and relatedness among boys).
- In contrast, in fully adjusted models, youth with higher levels of autonomy had higher odds of the substance use outcomes examined (except for more frequent alcohol use and autonomy among girls).
- Higher relatedness was associated with lower odds of substance use for both girls and boys, although there was a significant interaction between a number of positive mental health concepts and substance use behaviours. This highlights the need to examine these associations separately by sex.

Introduction

Alcohol and substance use are most commonly initiated during adolescence.[1] In 2016–2017, almost half (44%) of students in Grades 7 to 12 consumed alcohol in the past year, and one-quarter of students reported drinking five or more drinks on one occasion.[2] Just under one in five students (17%) reported cannabis use in the past year.[2] Adolescence is a critical period of cognitive and psychosocial development, and substance use may be associated with disrupted patterns of behaviours and longer-term risks such as problematic substance use later in life.[3] Alcohol and cannabis use in adolescence has been associated with increased likelihood of injury, impaired driving and negative social, psychological and legal consequences.[4,5]

Changes in alcohol and drug policies in Canada, and concerns about rates of youth substance use[2] have highlighted the need to understand and prevent problematic substance use among young people. Recent changes in policies in some

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jurisdictions, for example, the expansion of the sale of some forms of alcohol into grocery stores and the reduction of the minimum price of beer in Ontario, have changed the availability of alcohol.[6,7] Such policy changes increase exposure to alcohol marketing in stores, which may increase the odds of adolescent alcohol consumption.[8]

Preventing the sale and promotion of cannabis to youth was among the public health objectives of the recent legalization of cannabis in Canada.[9] While the *Cannabis Act* is the "legal framework for controlling the production, distribution, sale and possession of cannabis across Canada," provinces and territories determine how, where and by whom cannabis can be sold. After the legalization of nonmedical cannabis use in the state of Washington, the perceived harmfulness of cannabis use decreased and cannabis use increased among youth.[10] Further evidence is needed to understand youth substance use and inform prevention in the current Canadian context.

Current recommendations highlight strengths-based approaches to preventing problematic substance use among youth.[11,12] Strengths-based approaches include programs such as school-based prevention and comprehensive well-being initiatives. Rather than focussing on deficits, strengths-based approaches draw on protective factors, such as individual capabilities and aspects of positive development, which may include positive mental health.[11,12]

The Public Health Agency of Canada defines positive mental health as "the capacity of each and all of us to feel, think, act in ways that enhance our ability to enjoy life and deal with the challenges we face. It is a positive sense of emotional and spiritual well-being that respects the importance of culture, equity, social justice, interconnections and personal dignity."[13]

The potential role of positive mental health as a protective factor for youth substance use has been inadequately studied. Furthering our knowledge of this association will help inform strengths-based prevention programs that focus on supporting positive mental health.

The present study measures positive mental health through the lens of the self-determination theory. This theory proposes that there are three basic psychological needs that contribute to overall well-being: competence, autonomy and relatedness.[14] Competence refers to a sense of self-efficacy or mastery to act in one's environment. Autonomy refers to the perceived choice and control over the activities one completes. Relatedness involves a sense of closeness and belonging with others. Positive mental health, as conceptualized through the self-determination theory as these three needs, maps onto the psychological (i.e. autonomy and competence) and social (i.e. relatedness) well-being outcomes defined in the Positive Mental Health Surveillance Indicator Framework.[15]

There is a dearth of research on how these three positive mental health needs impact behaviour, including substance use behaviours, in youth. However, some aspects of psychological well-being that overlap conceptually with the definition of positive mental health provided above, such as life satisfaction, locus of control (i.e. autonomy), resilience and positive affect, have been associated with drug and alcohol use among adolescents.[16-18] Two studies examined flourishing, which is a measure of overall positive mental health, among Grade 9 to 12 students in British Columbia and Ontario. These studies found that flourishing was associated with a lower likelihood of cannabis use but was not significantly associated with binge-drinking.[19,20]

Overall, there has been little investigation of positive mental health and substance use, with most previous studies focussing on adults and postsecondary students.[21,22] The purpose of this study was to examine the associations between the positive mental health concepts, as conceptualized through the self-determination theory, of competence, relatedness and autonomy and substance use, including alcohol use, binge-drinking and cannabis use, among youth. Based on the authors' knowledge, the associations between competence, relatedness and autonomy and substance use in youth across Canada have not previously been investigated; thus, this study will contribute to addressing this knowledge gap.

Methods

We analyzed data from the 2014/2015 Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS) public use microdata file.[23] CSTADS is a national, biennial survey on tobacco, alcohol and drug use among Canadian youth. This school-based survey is administered to a sample of students in Grades 6 to 12 (Grades 6 to secondary V in Quebec). In 2014/2015, a provincially generalizable sample was achieved in all provinces except New Brunswick.[23] The population consisted of students attending private or public schools. Schools in the Canadian territories, special schools (e.g. virtual schools, schools on military bases, schools on First Nations reserves or schools for students with visual or hearing impairment or special needs) and schools with fewer than 20 students enrolled in at least one eligible grade were excluded. Schools were selected using a stratified single-stage cluster design based on health-region smoking rate and type of schools (elementary or secondary). Random sampling within each stratum was used to select schools. All eligible students in the selected school were invited to participate.[23,24]

A total of 336 schools and 42 094 students participated in the CSTADS, representing 47% and 66% participation rates, respectively. Data collection was completed between October 2014 and May 2015.[23,24] Participants completed a paper-and-pencil questionnaire during class-time. Students could decline participating in the survey at the time of data collection. The survey took approximately 30 minutes to complete. Teachers provided instructions on how to complete the survey, but did not circulate the room during the administration to protect confidentiality.

Questions about alcohol and cannabis use were only asked of students in Grades 7 to 12,[23,24] and Grade 6 students were excluded from the analyses. The resulting sample size was 36 665.

Health Canada Research Ethics Board, the University of Waterloo and the ethics review boards of the participating school boards provided ethics approval.

Measures

Alcohol use

Alcohol use in the past 30 days was measured with two questions in a skip pattern, beginning with the following yes/no item: "Have you ever had a drink of alcohol that was more than just a sip?"

Respondents who indicated "yes" were then asked: "In the last 30 days, how often did you have a drink of alcohol that was more than just a sip?" Response options included: "I did not drink alcohol in the last 30 days (coded as no)"; "Once or twice," "Once or twice a week," "3–4 times a week," "5–6 times a week," "Every day (all coded as yes)"; and "I don't know." "I don't know" responses for all substance use questions were treated as "not stated" based on guidance in the CSTADS users' guide,[24] and excluded from analyses. A second variable representing more frequent alcohol use was created. Those who responded that they drank once or twice a week or less often were coded as less frequent use; those responding 3–4 times a week or more were coded as more frequent use. The CSTADS defined a drink of alcohol as "1 regular sized bottle, can, or draft of beer; 1 glass of wine; 1 bottle of cooler; 1 shot of liquor (rum, whisky, Baileys®, etc.); or 1 mixed drink (1 shot of liquor with pop, juice, energy drink, etc.)."

Binge-drinking

Binge-drinking in the past 30 days was measured with the following item: "In the last 30-days, how often did you have 5 or more drinks of alcohol on one occasion?" Participants chose one of the following responses: "I have never done this" or "I did not have 5 or more drinks on one occasion in the last 30 days" (coded as no); "once," "2 times," "3 times," "4 times" or "5 times or more" (all coded as yes); or "I don't know" (excluded from analysis). A second variable representing more frequent binge-drinking was also created. Those responding that they did not drink to those binge-drinking once or twice in the past 30 days were coded as less frequent; those responding 3 times or more were coded as more frequent.

Cannabis use

Two questions measured cannabis use in past 30 days. First, respondents were asked: "Have you ever used or tried marijuana or cannabis (a joint, pot, weed, hash, or hash oil)?" Possible responses were either "yes" or "no." Students who responded "yes" were then asked: "In the last 30 days, how often did you use marijuana or cannabis?" Response categories included: "I did not use marijuana in the last 30 days" (coded as no); "Once or twice," "Once or twice a week," "3–4 times a week," "5–6 times a week" or "Every day" (all coded as yes); or "I don't know" (excluded from analysis). A second variable representing frequent cannabis use was also created. Those responding that they did not use cannabis to those responding once or twice a week were coded as less frequent; those responding 3–4 times a week or more were coded as more frequent.

Children's Intrinsic Needs Satisfaction Scale

The Children's Intrinsic Needs Satisfaction Scale (CINSS)[25] is an 18-item scale that consists of three subscales (the need for autonomy, competence and relatedness), which each contain six items. The CINSS includes questions to assess the satisfaction with each need in three different contexts (with peers, at home and at school). These result in 2 items per context/concept pair. Example items include: "I feel I do things well at home" (competence/at home) and "I feel free to express myself at school" (autonomy/at school). Response categories for each statement include "really false for me," "sort of false for me," "sort of true for me" or "really true for me." The CINSS has been validated in a sample of Canadian students, demonstrating good internal consistency and criterion-related and factorial validity.[26]

Scores on each of the three subscales were summed and transformed to create continuous total scores for competence, relatedness and autonomy that range between 10 and 40. Higher scores indicate greater satisfaction with the measured need. Variables for high and low autonomy, competence and relatedness were created by ascribing a high value to those with a mean score of 3 or above on the six items in each scale and a low value to those with a mean score of 0 to less than 3.[27] The continuous scores are used throughout the analyses, except for the initial descriptive analyses of the prevalence of substance use behaviours by high versus low autonomy, competence and relatedness.

Demographics

Demographic content included current grade (Grades 6–12; Quebec secondary I, II, III, IV and V were coded as Grades 7–11, respectively) and sex (male, female). Socioeconomic status was defined by the median household income for each participating school's region. This variable was obtained using the Canadian 2011 census data on household income by the first three digits of each school's postal code (forward sortation area). Urban/rural region was categorized based on whether a participant's school was located in an urban or rural region.[23]

Analysis

We generated descriptive statistics to describe the study sample and prevalence of cannabis use, alcohol use and binge-drinking for the whole sample, by grade and by sex. The prevalence of substance use by high versus low autonomy, competence and relatedness was examined. We used chi-square tests to determine differences in substance use by sex, and the Cochran–Armitage test for trend to test whether substance use systematically increased with grade level. Bonferroni corrections were applied.

We conducted a series of logistic regressions to test the associations between autonomy, competence and relatedness and substance use variables. The first regression model included continuous CINSS subscale scores as predictor variables and past month alcohol use as the outcome variable. We then repeated the regression model for each of the remaining outcome variables: past month cannabis use; past month binge-drinking and more frequent alcohol use; cannabis use; and binge-drinking in the past month. This series of regressions were then repeated with grade, urban versus rural location and area-based household income included as control variables. We also conducted a sensitivity analysis to test for provincial status as a control; no changes in the data were found.

To identify differences between boys and girls in the associations between autonomy, competence and relatedness and substance use, interaction terms by sex were first examined in the logistic regression models. When interactions terms were significant, models were stratified by sex. Interaction terms were not interpreted; however, coefficients are presented in Table 3 to justify sex-stratified analyses.

Analyses were conducted in statistical package SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, USA), using the PROC SURVEY suite of commands. Bootstrapping and survey weights were applied to account for the complex sample design of the CSTADS.[23] Complete case analysis was conducted to exclude cases with missing data on the study variables.

Results

Prevalence of cannabis and alcohol use and binge-drinking

Based on the 2014/2015 CSTADS data, 10.8% of students in Canada between Grades 7 and 12 reported using cannabis at least once in the past 30 days (Table 1). The prevalence of alcohol use within the past month was 27.0%, and 16.0% of Grade 7–12 students reported binge-drinking in the same period. Cochran–Armitage tests for trend revealed significant associations (all $p < .001$) between increasing substance use and grade, with the highest prevalence of cannabis use (21.3%), alcohol use in the past month (47.3%) and binge-drinking in the past month (32.6%) observed among Grade 12 students.

The prevalence of more frequent use was lower than that of any 30-day use, at 3.7%, 1.9% and 4.9% for more frequent cannabis use, alcohol use and binge-drinking, respectively. Consistent with past 30-day use, the highest prevalence of more frequent use was among Grade 12 students, at 8.1%, 3.9% and 12.4% for cannabis use, alcohol use and binge-drinking, respectively.

In all cases, the prevalences of past 30-day and more frequent cannabis use, alcohol use and binge-drinking were higher among those with low levels of autonomy ($p < .001$), relatedness ($p < .001$) and competence ($p < .001$) than among those with high levels (Table 2). However, the magnitude of these differences varied by substance and by measured need. For example, the prevalence of more frequent binge-drinking was almost twice as high among those with low competence (7.9%) than those with high competence (4.1%), while the difference was smaller between the prevalence of more frequent cannabis use among those with low versus high autonomy (3.4% and 3.0%, respectively).

Results of logistic regression models

In models of autonomy, competence and relatedness and substance use that included sex as an interaction term, many associations demonstrated a significant interaction with sex. Interactions between sex and competence, as well as between sex and relatedness, for all three 30-day substance use behaviours were significant. (See Table 3 for unexponentiated estimates and their standard errors.) The interaction between sex and autonomy was also significant for 30-day binge-drinking. Interactions between sex and competence were significant for all more frequent substance use behaviours. In addition, the interaction between sex and autonomy was significant for more frequent cannabis use. No interactions between sex and relatedness were significant for more frequent substance use variables. All subsequent models are stratified by sex.

In unadjusted models that examined autonomy, competence and relatedness separately with 30-day cannabis use, alcohol use and binge-drinking, all odds ratios were significant for both girls and boys; higher scores were associated with lower odds of each of these behaviours (Table 4). The same pattern was observed for more frequent cannabis use, alcohol use and binge-drinking (Table 5).

After adjusting for grade, income and urban versus rural school location and including continuous scores of autonomy, competence and relatedness in the model simultaneously, higher competence and relatedness continued to be associated with a significantly lower odds of 30-day substance use, while autonomy was

TABLE 1
Prevalence of any 30-day and more frequent cannabis and alcohol use behaviours by sex, grade and urban/rural status, CSTADS, 2014–2015 (*n* = 36 665)

Description	Any 30-day use			More frequent use		
	Cannabis use	Alcohol use	Binge-drinking	Cannabis use	Alcohol use	Binge-drinking
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
All	10.8 (10.6–11.1)	27.0 (26.5–27.6)	16.0 (15.7–16.4)	3.7 (3.5–3.9)	1.9 (1.8–2.0)	4.9 (4.8–5.1)
Sex						
Female	10.2 (9.8–10.5)	27.4 (26.8–27.9)	15.7 (15.3–16.1)	2.9 (2.7–3.2)	1.5 (1.4–1.6)	4.7 (4.5–4.9)
Male	11.5 (11.1–11.9)*	26.7 (26.1–27.3)*	16.4 (15.9–16.8)*	4.5 (4.3–4.7)*	2.4 (2.2–2.5)*	5.2 (4.9–5.4)*
Grade						
7	0.9 (0.8–1.1)	5.8 (5.3–6.3)	1.4 (1.2–1.6)	0.2 (0.1–0.2)	0.2 (0.1–0.2)	0.2 (0.2–0.2)
8	3.4 (3.0–3.7)	11.3 (10.6–12.0)	4.4 (4.0–4.8)	1.1 (0.9–1.2)	0.8 (0.1–0.9)	1.1 (0.9–1.3)
9	7.4 (6.8–8.0)	21.3 (20.1–22.4)	10.3 (9.7–10.9)	2.4 (2.0–2.8)	1.2 (1.1–1.3)	2.7 (2.5–2.9)
10	12.4 (11.8–13.0)	33.1 (32.4–33.9)	19.1 (18.4–19.9)	4.5 (4.2–4.8)	2.0 (1.8–2.2)	4.4 (4.1–4.7)
11	18.9 (18.4–19.4)	41.5 (40.4–42.7)	28.0 (27.1–28.9)	5.8 (5.5–6.1)	3.3 (3.0–3.6)	8.8 (8.2–9.4)
12	21.3 (20.3–22.4)**	47.3 (46.0–48.7)**	32.6 (31.5–33.6)**	8.1 (7.6–8.6)**	3.9 (3.3–4.5)**	12.4 (11.7–13.1)**
Urban/rural status[a]						
Urban	10.4 (10.1–10.8)	24.1 (23.2–24.9)	14.1 (13.5–14.6)	3.6 (3.4–3.8)	1.7 (1.6–1.9)	4.2 (4.0–4.4)
Rural	12.4 (11.7–13.1)*	38.4 (37.0–40.0)*	23.8 (22.7–25.0)*	4.1 (3.6–4.6)*	2.6 (2.4–2.8)*	8.0 (7.5–8.5)*

Abbreviations: CI, confidence interval; CSTADS, Canadian Student Tobacco, Alcohol and Drugs Survey.

Note: Prevalences based on weighted data.

[a] The urban/rural status is assigned based on the location of the school.

* Chi square, $p < .05$.

** Cochran–Armitage test for trend < 0.001.

TABLE 2
Prevalence[a] of any 30-day and more frequent cannabis use, alcohol use and binge-drinking by low versus high autonomy, competence and relatedness, CSTADS, 2014–2015 (*n* = 36 665)

	Any 30-day use			More frequent use		
	Cannabis use	Alcohol use	Binge-drinking	Cannabis use	Alcohol use	Binge-drinking
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Autonomy						
Low[b]	14.1 (13.7–14.5)	29.9 (29.3–30.5)	18.0 (17.5–18.6)	3.4 (3.1–3.7)	5.1 (4.9–5.4)	6.2 (5.8–6.6)
High[b]	9.3 (9.0–9.6)*	25.9 (25.2–26.5)*	15.2 (14.8–15.6)*	3.0 (2.8–3.2)*	1.4 (1.3–1.5)*	4.4 (4.3–4.6)*
Competence						
Low[b]	18.5 (17.8–19.2)	35.3 (34.7–36.0)	22.0 (21.7–22.7)	6.6 (6.2–7.0)	3.9 (3.7–4.2)	7.9 (7.5–8.3)
High[b]	8.7 (8.5–9.0)*	24.8 (24.2–25.5)*	14.5 (14.0–14.9)*	2.7 (2.6–2.9)*	1.4 (1.3–1.5)*	4.1 (4.0–4.3)*
Relatedness						
Low[b]	19.0 (18.4–19.7)	36.2 (35.5–36.8)	23.3 (22.8–23.8)	7.6 (7.2–8.0)	4.2 (3.9–4.5)	7.9 (7.5–8.4)
High[b]	8.7 (8.5–9.0)*	25.0 (24.4–25.6)*	14.4 (14.0–14.8)*	2.6 (2.5–2.8)*	1.4 (1.3–1.5)*	4.3 (4.1–4.4)*

Abbreviations: CI, confidence interval; CSTADS, Canadian Student Tobacco, Alcohol and Drugs Survey.

[a] Prevalences based on weighted data.

[b] Variables for high and low autonomy, competence and relatedness were created by ascribing a high value to those with a mean score of 3 or above on the six items in each scale and a low value to those with a mean score of 0 to less than 3.

* Chi square, $p < .05$.

associated with a significantly higher odds, for both boys and girls (Table 4). For each unit increase in relatedness, the odds of cannabis use, alcohol use and binge-drinking decreased by 8%, 5% and 4% for girls and 2%, 3% and 2% for boys, respectively. For each unit increase in competence, the odds of cannabis use, alcohol use and binge-drinking decreased by 7%, 4% and 4% for girls and 9%, 5% and 7% for boys, respectively. In contrast, for each unit increase in autonomy, the odds of cannabis use, alcohol use and binge-drinking increased by 6%, 4% and 4% for girls and 5%, 4% and 6% for boys, respectively (Table 4).

Results of models of more frequent cannabis use, alcohol use and binge-drinking were similar to those for 30-day substance use (Table 5). Again, higher levels of competence and relatedness were associated with significantly lower odds of more frequent cannabis use, more frequent alcohol use and more frequent binge-drinking, for both girls and boys. The only exception was for the association between competence and more frequent cannabis use, which was not significant for boys (Table 5). Higher levels of autonomy were associated with significantly higher odds of more frequent cannabis use, more frequent alcohol use and more frequent binge-drinking for boys and girls. The exception was more frequent alcohol use among girls, where the association was not significant.

Discussion

This study provides national estimates of past 30-day and more frequent cannabis use, alcohol use and binge-drinking use in relation to levels of autonomy, competence and relatedness among youth. Higher levels of competence, a sense of self-efficacy or mastery to act in one's environment, was associated with a lower odds of each of three 30-day substance use behaviours and a lower odds of all but one more frequent substance use behaviours.

These results align with those of studies that have suggested an association between greater self-efficacy and lower

TABLE 3
Unexponentiated estimates, standard errors and *p* values for logistic regression interaction terms between sex and autonomy, competence and relatedness for 30-day and more frequent cannabis use, alcohol use and binge-drinking, CSTADS, 2014–2015 (*n* = 36 665)

	Cannabis			Alcohol			Binge-drinking		
	Estimate	SE	*p* value	Estimate	SE	*p* value	Estimate	SE	*p* value
Any 30-day use									
Autonomy	0.002	0.003	.38	0.000	0.002	.94	−0.009	0.003	< .001
Competence	−0.030	0.002	< .0001	−0.014	0.002	< .0001	−0.021	0.003	< .0001
Relatedness	0.009	0.003	.01	0.006	0.002	.01	0.015	0.003	< .0001
More frequent use									
Autonomy	0.016	0.004	< .0001	0.007	0.008	.36	0.002	0.004	.65
Competence	−0.042	0.006	< .0001	0.008	0.009	< .0001	−0.010	0.003	.01
Relatedness	0.009	0.005	.07	−0.031	0.007	.36	−0.005	0.004	.24

Abbreviations: CSTADS, Canadian Student Tobacco, Alcohol and Drugs Survey; SE, standard error.

TABLE 4
Unadjusted and fully adjusted odds ratios of any 30-day cannabis use, alcohol use and binge-drinking by autonomy, competence and relatedness, stratified by sex, CSTADS, 2014–2015 (*n* = 36 665)

		30-day cannabis use		30-day alcohol use		30-day binge-drinking	
		OR (95% CI) *		OR (95% CI) *		OR (95% CI) *	
Unadjusted odds ratios							
Girls	Autonomy	0.95	(0.94–0.95)	0.97	(0.97–0.98)	0.97	(0.96–0.97)
	Competence	0.91	(0.91–0.92)	0.95	(0.94–0.95)	0.94	(0.94–0.95)
	Relatedness	0.91	(0.90–0.91)	0.94	(0.94–0.94)	0.94	(0.93–0.94)
Boys	Autonomy	0.97	(0.97–0.98)	0.98	(0.98–0.99)	0.99	(0.99–0.99)
	Competence	0.94	(0.94–0.95)	0.95	(0.95–0.96)	0.96	(0.96–0.96)
	Relatedness	0.93	(0.93–0.94)	0.95	(0.94–0.95)	0.95	(0.95–0.96)
Fully adjusted odds ratios							
Girls	Autonomy	1.06	(1.05–1.06)	1.04	(1.03–1.05)	1.04	(1.03–1.04)
	Competence	0.92	(0.91–0.93)	0.95	(0.94–0.95)	0.94	(0.94–0.95)
	Relatedness	0.93	(0.92–0.94)	0.96	(0.95–0.97)	0.96	(0.95–0.97)
Boys	Autonomy	1.05	(1.04–1.06)	1.04	(1.03–1.05)	1.06	(1.05–1.06)
	Competence	0.98	(0.97–0.99)	0.97	(0.97–0.98)	0.98	(0.97–0.99)
	Relatedness	0.91	(0.90–0.92)	0.95	(0.94–0.95)	0.93	(0.93–0.94)

Abbreviations: CI, confidence interval; CSTADS, Canadian Student Tobacco, Alcohol and Drugs Survey; OR, odds ratio.
Note: Fully adjusted for grade, urban/rural location of school and median household income of school area.
* $p < .05$.

levels of substance use among adolescents.[28,29] Our finding that relatedness, a greater sense of closeness and belonging with others, was associated with lower odds of all 30-day and more frequent substance use behaviours is consistent with previous research that has noted the importance of social relationships with peers and family in preventing youth substance use.[30,31] The findings for relatedness and competence are consistent with studies demonstrating a link between higher overall scores of positive mental health, such as flourishing, and lower levels of substance use.[19,21,22]

TABLE 5
Unadjusted and fully adjusted odds ratios of more frequent cannabis, alcohol use and binge-drinking by autonomy, competence and relatedness, stratified by sex, CSTADS, 2014–2015 (*n* = 36 665)

		More frequent cannabis use		More frequent alcohol use		More frequent binge-drinking	
		OR (95% CI)		OR (95% CI)		OR (95% CI)	
Unadjusted odds ratios							
Girls	Autonomy	0.94	(0.93–0.94)	0.92	(0.91–0.93)	0.96	(0.95–0.97)
	Competence	0.91	(0.90–0.91)	0.90	(0.89–0.91)	0.93	(0.93–0.94)
	Relatedness	0.90	(0.89–0.90)	0.89	(0.88–0.90)	0.93	(0.92–0.93)
Boys	Autonomy	0.96	(0.95–0.96)	0.94	(0.93–0.95)	0.97	(0.97–0.98)
	Competence	0.94	(0.93–0.94)	0.92	(0.92–0.93)	0.95	(0.94–0.95)
	Relatedness	0.92	(0.92–0.93)	0.91	(0.91–0.92)	0.95	(0.94–0.95)
Fully adjusted odds ratios							
Girls	Autonomy	1.07	(1.05–1.08)	1.03	(1.00–1.07)**	1.04	(1.03–1.06)
	Competence	0.93	(0.92–0.94)	0.92	(0.90–0.94)	0.93	(0.93–0.94)
	Relatedness	0.91	(0.90–0.92)	0.94	(0.91–0.96)	0.95	(0.94–0.96)
Boys	Autonomy	1.03	(1.02–1.05)	1.02	(1.00–1.03)	1.04	(1.03–1.05)
	Competence	1.01	(0.99–1.03)**	0.98	(0.96–1.00)	0.95	(0.94–0.96)
	Relatedness	0.89	(0.88–0.90)	0.92	(0.91–0.94)	0.96	(0.95–0.98)

Abbreviations: CI, confidence interval; CSTADS, Canadian Student Tobacco, Alcohol and Drugs Survey; OR, odds ratio.
Note: Fully adjusted for grade, urban/rural location of school and median household income of school area.
** All $p < .05$, unless noted by **.

Given the large number of significant interactions between positive mental health concepts and sex for substance use behaviours, examining these differences is an important area of future research, as the small body of past research on this subject have not noted any sex/gender differences.[19,21,22]

Without accounting for grade, urban/rural location, income, competence and relatedness, higher autonomy was associated with a lower prevalence of substance use. However, after controlling for covariates, higher autonomy was significantly related with higher odds of all substance use behaviours except for more frequent alcohol use among girls.

The change in the association between higher autonomy and lower odds of substance use in the unadjusted findings to higher autonomy and higher odds of substance use in the adjusted model was unexpected. Conclusions are mixed on whether youth autonomy and substance use is significantly associated and whether higher autonomy is associated with higher or lower substance use.[32-34] Having a sense of choice and control is an aspect of positive mental health and fosters a healthy transition through adolescence to adulthood. The timing of adolescent autonomy may be pertinent, as one study suggested that early development is linked with increased substance use among youth.[34] However, autonomy may also be a factor that could be leveraged in substance use prevention.

Some prevention efforts have focussed on supporting youth autonomy in decision-making about substance use. A systematic review of mass media campaigns that aim to prevent substance use revealed four interventions that had some evidence of beneficial effects.[35] Two of these four interventions emphasized non-use of drugs as a means to support autonomy. The two interventions included the "Be Under Your Own Influence" and "Above the Influence" media campaigns in the United States, which have been associated with lower use of cannabis.[36] However, another media campaign that emphasized self-efficacy ("My Anti Drug"), which was included in the same systematic review by Allara et al., was among the interventions associated with harmful effects.[35] Overall, the evidence supporting the effectiveness of mass media campaigns to prevent drug use is weak.[35] The association between autonomy and youth substance use appears to be a nuanced one that may involve developmental and contextual factors and warrants further research.

The findings we present in this article provide new insight into the associations between autonomy, competence and relatedness and recent substance use among youth, based on analysis of a large, representative survey. This information is particularly relevant in the current context of changing alcohol and drug policies and trends in youth substance use.

The 2018 Chief Public Health Officer report highlighted the role of prevention, including the importance of promoting resilience and protective factors, in addressing problematic substance use among youth.[37] Strengths-based approaches to prevention have come to the forefront of many recommendations, emphasizing the need to better understand protective factors in relation to problematic substance use among youth in Canada.[12,38] The findings from the present study further support the potential roles of competence and relatedness as protective factors for substance use. They are consistent with, for example, the Ontario Ministry of Health and Long-Term Care guideline on substance use prevention and harm reduction, which gives examples of protective factors that may decrease the likelihood of substance use and related harms.[38] Examples include competence and factors that align with relatedness (i.e. positive parent relationships and positive teacher and social connectedness at school).[38]

A systematic literature review of strengths-based youth development programs that promote the positive development of "skills, attitudes, relationships and identities" and include factors that align with relatedness and competence was recently conducted. This review identified several mechanisms through which these programs may reduce substance use. These include enhancing protective factors in general to buffer against risk factors for substance use, enhancing a specific protective factor to reduce a specific risk behaviour and "piling up" multiple protective factors.[39] Whether relatedness and competence act through one or several of these mechanism warrants future research.

Strengths and limitations

There are limitations that should be considered when interpreting the results of this study.

The findings presented are observational, and further investigation is needed to draw conclusions on the causal role of autonomy, competence and relatedness in problematic substance use prevention. Each of the three subscales combined scores across three contexts (home, school and with peers) and the present study was limited to include scores combined across contexts. Further investigation into the associations between substance use and autonomy between contexts may be warranted.

The present study was limited to cannabis and alcohol use, including binge-drinking; other forms of substance use were not examined.

Complete case analysis, which confines analyses to cases with complete data, was used to handle missing data. This may have resulted in bias due to the loss of information.

The analyses were conducted with the 2014/2015 cycle of the CSTADS, rather than the 2016/2017 cycle, due to data availability at the time the project was initiated. However, these analyses examined associations, not prevalence; we would not expect notable changes in the associations between variables between data collection cycles. Future research may investigate if associations are moderated by time.

Items on substance use and positive mental health relied on self-report and may have been subject to social desirability bias. The active consent process may have introduced bias into the sample, or may have affected participants' responses.[40]

Less than half of schools participated, which may have also biased the sample. As this analysis was conducted with a cross-sectional survey, no inferences about causality can be made. However, to our knowledge, this is the first research using a large, representative sample of Canadian youth to examine the association between positive mental health and substance use, using a measure that has been validated in this age group.[26]

Conclusion

These findings provide evidence to further elucidate the associations between aspects of positive mental health and substance

use among youth in Canada. The results of this study provide contextual evidence that can be used to further our understanding of risk and protective factors associated with substance use, inform health promotion and substance use prevention programs and prevent or reduce problematic substance use among youth.

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Conflict of interest

The authors have no conflicts of interest to disclose.

Authors' contributions and statement

AE and HO conceived the project.

AE conducted the analysis.

AE and HO interpreted the results.

AE drafted the article and HO critically revised the article.

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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Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals. Look for the following articles published in 2019 and 2020:

Brenner DR, Weir HK, **Demers AA**, […] **Shaw A**, et al. Projected estimates of cancer in Canada in 2020. CMAJ. 2020;192(9):E199-E205. doi:10.1503/cmaj.191292.

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