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Original quantitative research

Do demographic and socioeconomic characteristics underpin differences in youth smoking initiation across Canadian provinces? Evidence from the Canadian Community Health Survey (2015–2018)

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Abstract

Introduction: Youth initiation may drive differences in smoking prevalence across Canadian provinces. Provincial differences in initiation relate to tobacco control strategies and public health funding, but have also been attributed to population characteristics. We test this hypothesis by examining the extent to which seven characteristics—immigration, language, family structure, education, income, home ownership and at-school status—explain differences in initiation across provinces.

Methods: We used data from 16 897 youth aged 12 to 17 years in the Canadian Community Health Survey collected from 2015 to 2018. To examine the proportion of provincial differences explained by population characteristics, we compared average marginal effects (AMEs) from partially and fully adjusted models regressing "having ever initiated" on province and other characteristics. We also tested interactions to examine differences in the association between population characteristics and initiation across provinces.

Results: Initiation varied from 4% in British Columbia to 10% in Quebec. Being born in Canada, speaking French, not living in a two-parent household, being in the lowest household income quintile, having parents without postsecondary education, living in rented accommodation and not being in school were each associated with initiation. Taking these results into consideration, the AME of residing in another province compared with Quebec was attenuated by between 3% and 9%. Family structure and household income were more strongly associated with initiation in the Atlantic region and Manitoba, but not in Quebec.

Conclusion: Differences in initiation between Quebec and other provinces are unlikely to be substantially explained by their demographic or socioeconomic composition. Reprioritizing tobacco control and public health funding are likely key in attaining the "tobacco endgame" across provinces.

Keywords: Canada, youth, smoking initiation, socioeconomic factors, Canadian Community Health Survey

Highlights

- Smoking initiation rates vary substantially across Canadian provinces and are highest in Quebec.
- Initiation is strongly associated with demographic (e.g. immigration) and socioeconomic (e.g. household income) characteristics.
- Differences in these characteristics, however, explained less than 10% of differences in initiation between Quebec and other provinces.
- The lack of an explanation based on demographic and socioeconomic composition highlights the need of a coordinated national strategy.

Introduction

In most countries, smoking is strongly geographically distributed, with differences potentially attributable to context (i.e. tobacco control legislation and enforcement) and composition (i.e. inhabitants' characteristics). In Canada, Quebec has consistently had among the highest levels of smoking prevalence across the 10 Canadian provinces. Between 2001 and 2019, the prevalence declined from 30% to 17% in Quebec, but remained higher than in most other Canadian provinces (e.g. British Columbia: 21% to 11%; Ontario: 25% to

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14%).[1] More Canadians who initiate their first cigarette do so after reaching the age of 18.[2] However, a study examining initiation and cessation rates in different age groups since the mid-2000s suggested that Quebec's higher prevalence may be driven in part by a higher initiation rate among youth aged 12 to 17 years. While initiation to a first cigarette in this age group decreased at a similar pace across provinces over the past decade, it has remained consistently higher in Quebec (e.g. for past-year initiation: 5% in Quebec vs. 3% in the rest of Canada in 2017–2018).[3]

Several mechanisms could underpin persistent differences in initiation across provinces. Tobacco control policies, including minimum age for legal access, tobacco tax rates and adequate enforcement of legislation, are likely key. According to federal regulations, the minimum legal age to purchase tobacco across Canada (including in Quebec) is 18, although Ontario, British Columbia and several of the Atlantic provinces have raised their minimum age to 19, and Prince Edward Island raised it to 21 in 2020.[4] This is relevant to youth initiation because increasing the minimum age to above 18 limits the number of young adults that minors can reach to access cigarettes.[5] Tobacco tax rates have been lowest in Quebec for decades, in part due to a tax reduction in the 1990s in response to anti-taxation lobbying and fears about increasing contraband activities.[6] While taxation increases have been relatively small across provinces over the past 15 years, persistent differences in taxation are likely to contribute to higher initiation rates, as cheaper cigarettes are more accessible to youth.[7-9] For enforcement, although it is prohibited to sell or supply cigarettes to minors across Canada, the proportion of adolescents in Quebec who buy cigarettes in stores is higher than in other provinces. In 2010–2011, 36% of high school students who smoked reported buying cigarettes from stores in Quebec compared to 16% in British Columbia and 20% in Ontario.[10] Other relevant policy differences include smoke-free policies in public and private spaces, regulation of electronic cigarettes, and overall public health expenditure. In 2019, Quebec was second-last in the proportion of health expenditure spent on public health across provinces.[11]

Differences in initiation rates across provinces may also relate to underlying population characteristics. In 1997, Wharry alluded to differences in language and culture, highlighting the failure of public health to adapt its tobacco control efforts to the francophones who are the majority in this province.[12] The extent to which these explanations are relevant in more recent years is unclear. In a study using 2016 data, adult smokers in Quebec were found to be more supportive of "endgame" tobacco legislation measures than in other provinces.[13]

A second historical explanation considers socioeconomic factors. In 1998, Aubin and Caouette suggested that Quebec's higher smoking prevalence related to its lower levels of income compared to other provinces.[14] Similar to many Western countries, inequalities in smoking by educational attainment, occupation and income have been identified among Canadians.[15-17] Supporting inequalities in initiation, one study found that between 1999 and 2011, lifetime initiation in those aged 20 to 24 was consistently more prevalent among those with less than a high school diploma.[17] Supporting this hypothesis in more recent years, Quebec has had the second-lowest median household income across provinces and the highest high school dropout rate among males.[18,19]

Beyond differences in tobacco control policies, risk factors of initiation that may explain differences across provinces therefore can include cultural factors (e.g. immigration, language), parents' circumstances (e.g. two-parent family, parental employment) and adolescents' educational trajectory.[20]

Although previous studies have investigated the role of population characteristics in explaining differences in adult smoking across jurisdictions in Canada and other countries, no study to date has done so regarding youth initiation across Canadian provinces. Chahine et al., exploring variation in adult smoking at different geographical levels in the United States, found that nine characteristics—age, sex, education, household income, employment and occupation, immigration, ethnicity, marital status, and household size—explained 41% of the variation in smoking at the state level.[21] Using a similar approach, Corsi et al. found that a similar set of characteristics explained 21% of the variation in smoking across Canadian provinces.[22] Beard et al. examined the contribution of age, sex, ethnicity and socioeconomic status to differences across government office regions in England, and found that the magnitude of differences in smoking explained by these factors varied across comparison pairs: differences between the "South West" region and the three most Northern regions (North West, North East, and Yorkshire and the Humber) were completely attenuated when considering these characteristics, whereas differences between the South West and the Greater London region were not attenuated at all.[23] They also found that the association between these characteristics and smoking varied significantly across regions (e.g. socioeconomic inequalities in smoking were larger in the North of England than the rest of the country), suggesting that the role of differences in both prevalence and the association between population characteristics and smoking should be considered across jurisdictions.

Objectives

The aim of this study was to quantify the contribution of population characteristics to differences in youth initiation between the Canadian province with the highest prevalence of initiation—Quebec—and other provinces, using data from a nationally representative dataset of youth aged 12 to 17 collected between 2015 and 2018. The specific objectives were to: (1) describe the distribution of population characteristics (i.e. immigration, language, two-parent family, household income, household education, home ownership and at-school status) associated with initiation across provinces; (2) examine the extent to which differences in initiation between Quebec and other provinces vary as a function of differences in the prevalence of these characteristics; and (3) examine whether associations between population characteristics and initiation vary across Quebec and other provinces (i.e. to assess whether effect modification in these associations also contributes to explaining differences in initiation).

Methods

Data

We used data from four annual cycles (2015–2018) of the Canadian Community Health Survey (CCHS) public use microdata files (PUMF). CCHS is the largest repeat cross-sectional health survey in Canada. It collects data on health status,

health care utilization and health determinants in the Canadian population annually. It incorporates a large sample designed to include 10 000 youth aged 12 to 17 every year and provide reliable estimates at the health region level (i.e. geographical units within provinces) every two years. The two-year national response proportion was 60% in 2015–2016 and 61% in 2017–2018. In total, 16 897 youth aged 12 to 17 were recruited across the 10 provinces between 2015 and 2018.

Statistics Canada releases survey weights and bootstrap replicate weights to ensure representative estimates of the Canadian population that consider the CCHS sampling design. A detailed description of the sampling methodology is available elsewhere.[24]

In keeping with the 2014 Canadian Tri-Council Policy Statement, this study did not require ethical review since the data are legally accessible to the public and appropriately protected by law.

Variables

We used "having ever smoked a whole cigarette" (yes, no) as a proxy for initiation. This was defined as: (1) self-identification as a smoker in the item "At the present time, do you smoke cigarettes daily, occasionally or not at all?"; (2) if not at all, agreeing with the item "Have you smoked more than 100 cigarettes (about 4 packs) in your life?" (yes, no); and (3) if not, agreeing with the item "Have you ever smoked a whole cigarette?" (yes, no).

Population characteristics were defined in seven variables: (1) immigration, (2) language, (3) family structure, (4) household income, (5) household education, (6) home ownership and (7) at-school status. "Immigration status" was coded by Statistics Canada based on the country of birth (born in Canada, not born in Canada). "Language" was coded based on the language most often spoken at home (English, French, other). To increase cell sizes across provinces, we included those reporting both French and English in the household in the French category. "Family structure" was based on data describing the nature of the relationship between respondents and other household members in a household grid questionnaire (living with two parents, living with one parent, other). The large majority (88%)

of those in the "other" category represent youth living with one or two parents and other household members that are not siblings. These may include grandparents and other family members, nonfamily members, or participants' own partner and/or children.

"Household education" was based on the highest level of education completed among household members (secondary education or less, postsecondary education completed). Notably, education systems vary across provinces, and Quebec has a unique postsecondary degree between high school and university (*Collège d'enseignement général et professionnel*; CEGEP). CCHS does not release data on the educational attainment of other household members, precluding us from distinguishing between parents with a university degree or lower postsecondary qualifications. "Household income" was coded by Statistics Canada using data on income, household size and community size into a decile ranking which represents a relative measure of household income compared to other households at the national level (living in a household in the bottom income quintile, not living in a household in the bottom income quintile). "Home ownership" was measured by asking whether the dwelling was owned by a household member (even if it was still being paid for) or rented (even if no cash rent was being paid) (owner, renter).

"At-school status" was based on the items "Last week, was your main activity working at a paid job or business, looking for paid work, going to school, caring for children, household work, retired or something else?" and "Are you currently attending school, college, CEGEP or university?" (attending school, not attending school). CCHS public-use files code all respondents aged 12 to 14 years to be attending school as a form of disclosure control. Missingness across variables is detailed in the supplementary material.

Models also controlled for age group (12–14, 15–17), sex (male, female) and cycle (2015–2016, 2017–2018).

Statistical analysis

To examine the extent to which initiation and population characteristics varied among youth aged 12 to 17 across provinces, we first described prevalence estimates in the full sample and in the provinces. To

ensure sufficient cell sizes, we pooled the four provinces of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador into a single "Atlantic" category (see sample sizes in the supplementary material).

To examine the extent to which population characteristics were related to initiation, we reported initiation across categories of population characteristics and unadjusted prevalence ratios (PR) using Poisson regression in the full sample.[25] To examine the extent to which population characteristics associated with initiation could explain differences in initiation across provinces, we then produced two models: a first "base model" regressing initiation on province of residence controlling for survey cycle only, and a second "fully adjusted model" also including age, sex and the seven population characteristics. We reported both the prevalence ratio and the average marginal effect (AME) in these models (i.e. the absolute difference between the average marginal probabilities estimated from these models).[26,27]

Since regression estimates from logistic models may vary between models even when the added covariates are not associated with the predictor of interest (i.e. province of residence), we compared the PRs and AMEs between the partially and fully adjusted models to derive the proportion of differences in initiation between provinces that could be attributed to differences in population characteristics.[28,29]

Finally, to test differences in the association of population characteristics with initiation across provinces, we added separate sets of interaction terms for each population characteristic after the fully adjusted model (see results in the supplementary material). We did not test the interaction for the language variable because too few youth spoke French at home in some provinces to reliably examine this. To better interpret models with significant interactions, we reported average marginal probabilities of initiation across the categories of population characteristics in each province.

Regression analyses were done in the complete-case sample of 15 252 participants (90.3% of full sample). All estimates were systematically adjusted for the CCHS survey weight and 1000 bootstrap

replicate weights provided by Statistics Canada. All estimates were produced in Stata 16.[30] All supplementary files are uploaded on the Open Science Framework.

Results

Sample characteristics

Table 1 presents the distribution of initiation and selected characteristics in the full sample and across Canadian provinces. Initiation of a first cigarette among youth averaged 6.9% (95% CI: 6.3–7.5) and varied significantly across provinces: it was highest in Quebec (10.2%; 95% CI: 8.8–11.6) and lowest in British Columbia (4.2%; 95% CI: 3.2–5.2). Population characteristics each varied across provinces except for at-school status ($p = 0.130$). Immigration status was highest in Alberta (17%) and lowest in the Atlantic region (3%). The prevalence of French as the language most spoken at home varied from 86% in Quebec to 2% in Alberta, whereas the prevalence of the "other" language category varied from 11% in Manitoba to 2% in the Atlantic region. The proportion living with two parents varied from 73% in Alberta to 67% in Ontario and British Columbia. The proportion with parents who completed postsecondary education varied from 87% in Quebec to 78% in Manitoba. The proportion of youth in the bottom household income quintile varied from 38% in Ontario to 17% in Saskatchewan. The proportion of youth out of school averaged 4% across provinces. While the global test for differences in at-school status was not significant, its proportion in Ontario (2.9%) was significantly lower compared with Quebec (4.5%) in post-hoc tests ($p = 0.007$).

Explaining differences in youth initiation across Canadian provinces

Table 2 presents the prevalence of initiation and unadjusted PRs across population characteristics in the full sample. These were each associated with the risk of initiation. Being born in Canada was associated with a 126% higher risk of initiation. Compared to English, speaking French at home was associated with a 48% higher risk of initiation, whereas speaking another language at home was associated with a 51% lower risk of initiation. Compared with living with both parents, living with one parent was associated with a 76% higher risk of initiation. Having

parents who did not complete postsecondary education was associated with a 54% higher risk of initiation. Living in a household in the bottom income quintile was associated with a 28% higher risk of initiation and living in a rented dwelling was associated with a 54% higher risk of initiation. Finally, not being at school was associated with a 266% higher risk of initiation.

Table 3 presents the PRs of the association between province of residence and initiation in the complete-case sample, using Quebec as the reference category. In the base model, Saskatchewan was the only province with a nonsignificant lower risk of initiation (PR = 0.92, 95% CI: 0.67–1.28). Comparing AMEs across models, the absolute differences across provinces increased by 2% for the Atlantic region (i.e. 3.44/3.36) and decreased by between 3% and 9% for Ontario, Manitoba, Alberta and British Columbia when including the population characteristics. The increase in the Atlantic region may be attributable to differences in demographic characteristics less common in this region compared with Quebec (i.e. being born outside Canada, speaking another language at home). The decrease in differences with other provinces may include both differences in (1) demographic variables (i.e. Quebec had relatively fewer immigrants, more French-speaking youth and fewer speaking another language at home) and (2) socioeconomic variables (i.e. Quebec had relatively more youth living in low-income households and in rented accommodation, and more who were not in school).

Testing differences in the association of population characteristics with initiation across provinces, we found that the strength of the association with initiation differed across provinces for two characteristics: family structure ($p = 0.022$) and household income ($p = 0.028$). Figures 1 and 2 report the average marginal probabilities (i.e. adjusted for other covariates) of initiation across family structure categories and across household income categories, respectively. Compared with living with two parents, the association of living with one parent with initiation was higher in Manitoba (relative difference = 2.30), Alberta (1.98) and British Columbia (1.68), and the association of living in other arrangements with initiation was higher in the Atlantic region (2.53) and Manitoba (3.90). Compared with those in the four highest income quintiles, the

association between living in the bottom income quintile and initiation was higher in the Atlantic region (rel. diff. = 2.19), Manitoba (2.48) and Alberta (1.50).

Discussion

The prevalence of smoking has consistently been higher in Quebec than in the rest of Canada, with differences driven in part by higher youth initiation rates in Quebec.[3] In our study, initiation of a first cigarette among adolescents varied substantially across Canadian provinces, with Quebec's estimate being 79% higher than that of Ontario and 143% higher than that of British Columbia. We examined the extent to which demographic and socioeconomic factors underpinned these differences and observed two key findings.

First, whereas each population characteristic studied varied across provinces, collectively these differences did not explain a large proportion of the variability in initiation between Quebec and the other provinces. This contrasts with previous work in adult populations, which suggests that a meaningful proportion of regional differences in smoking prevalence was explained by these characteristics.[21-23] It may be that the role of demographic and socioeconomic characteristics becomes more important in adulthood, as inequalities in smoking increase across the stages of progression to established smoking.[31] Beyond what was available in the CCHS, other measures such as food insecurity might have yielded a stronger portrait of adolescents' socioeconomic circumstances across provinces.[32]

Alternatively, some of the variability in youth initiation could also be explained by other social and cultural characteristics, such as self-imposed smoking bans in the household and antismoking social norms, that were not captured by the population characteristics studied.[21,22,33] These mechanisms may be assessed by exploring provincial differences in smoking permissiveness and exposure to second-hand smoke at home and in public spaces, perceived stigma and other smoking-related social norms and general dispositions towards risk-taking behaviour.

Second, whereas we found differences in the associations between initiation and each of family structure and household income across provinces, the effect-modification hypothesis also did not contribute to explaining the higher prevalence

TABLE 1
Study sample characteristics, Canadians aged 12 to 17 years, 2015 to 2018, CCHS PUMF (n = 16 897)

Characteristics	Full sample	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	Atlantic[a]
	W%[b]	W%[b]	W%[b]	W%[b]	W%[b]	W%[b]	W%[b]	W%[b]
Sample size (n)	16 897	2275	2055	814	911	5117	3470	2255
Initiation of a first cigarette								
Yes	6.9	4.2	6.9	9.9	6.6	5.7	10.2	7.5
Never	93.1	95.8	93.1	90.1	93.4	94.3	89.8	92.5
Age (years)								
12–14	50.6	50.8	50.4	51.2	49.0	51.0	50.2	50.4
15–17	49.4	49.2	49.6	48.8	51.0	49.0	49.8	49.6
Sex								
Male	51.3	51.4	51.3	51.6	51.5	51.3	51.2	51.4
Female	48.7	48.6	48.7	48.4	48.5	48.7	48.8	48.6
Immigration status								
Not born in Canada	13.4	14.6	16.8	10.4	20.9	14.7	10.5	2.9
Born in Canada	86.6	85.4	83.2	89.6	79.1	85.3	89.5	97.1
Language most spoken at home								
English	70.6	86.9	88.2	91.4	86.3	86.0	9.5	87.6
French	21.3	2.6	1.9	2.4	2.7	4.8	85.5	10.7
Other	8.0	10.6	9.9	6.2	11.0	9.1	5.0	1.7
Family structure								
Living with both parents	69.1	67.0	72.5	72.3	70.1	67.3	70.6	70.6
Living with one parent	20.4	20.5	17.8	20.0	18.8	20.5	22.0	20.5
Other living arrangements	10.5	12.5	9.6	7.7	11.1	12.1	7.4	8.8
Household education								
Postsecondary not completed	15.5	15.6	18.6	19.7	22.4	15.2	12.6	14.1
Postsecondary completed	84.5	84.4	81.4	80.3	77.6	84.8	87.4	85.9
Household income								
In the bottom income quintile	25.0	24.4	17.4	16.6	22.6	38.1	27.6	18.0
Not in the bottom income quintile	75.0	75.6	82.6	83.4	77.4	71.9	72.4	82.0
Home ownership								
Owner	79.1	76.6	82.2	80.4	83.9	79.6	74.7	86.6
Renter	20.9	23.4	17.8	19.6	16.1	20.4	25.3	13.4
At-school status								
In school	96.4	96.5	96.0	95.3	95.9	97.1	95.5	96.1
Not in school	3.6	3.5	4.0	4.7	4.1	2.9	4.5	3.9

Abbreviations: CCHS, Canadian Community Health Survey; PUMF, public use microdata file; W, weighted.

[a] Atlantic region: New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador.

[b] Prevalence estimates (W%) include the survey weight and 1000 bootstrap replicate weights produced by Statistics Canada.

TABLE 2
Initiation of a first cigarette by sample characteristics, Canadians aged 12 to 17 years, 2015 to 2018, CCHS PUMF (n = 16 897)

	Initiation W%	Unadjusted PR	95% CI
National prevalence	6.9		
Immigration status			
Not born in Canada (ref)	3.3	—	—
Born in Canada	7.5	2.26	1.50–3.41
Language most spoken at home			
English (ref)	6.5	—	—
French	9.6	1.48	1.23–1.77
Other	3.2	0.49	0.30–0.80
Family structure			
Living with both parents (ref)	5.9	—	—
Living with one parent	10.3	1.76	1.44–2.15
Other living arrangements	6.8	1.16	0.89–1.51
Household education			
Postsecondary completed (ref)	6.4	—	—
Postsecondary not completed	9.9	1.54	1.28–1.86
Household income			
Not in the bottom income quintile (ref)	6.4	—	—
In the bottom income quintile	8.2	1.28	1.06–1.55
Home ownership			
Owner (ref)	6.2	—	—
Renter	9.6	1.54	1.27–1.86
At-school status			
In school (ref)	6.2	—	—
Not in school	22.8	3.66	2.76–4.84

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval; PR, prevalence ratio; PUMF, public use microdata file; ref, reference category; W, weighted.

Note: Prevalence estimates (W%) and ratios are weighted using the survey weight and 1000 bootstrap weights provided by Statistics Canada.

of smoking initiation in Quebec compared to other provinces. However, we warn that our sample size precluded us from reliably testing differences in the role of language spoken at home in initiation across provinces, despite it being a potentially meaningful factor for understanding Quebec's higher initiation rate.

Specifically, our findings indicated that adolescents who were not living with two parents or were living in a household in the bottom income quintile were more likely to initiate a first cigarette if they lived in the Atlantic region and Manitoba (compared to Quebec or other provinces). In England, Beard et al. found that among adults, the association between socioeconomic status and smoking was stronger in more deprived regions.[23] Possible explanations included that more deprived areas had: (1) fewer public health services,

necessitating that smokers use their own resources to quit smoking; (2) more positive smoking-related social norms that promote the modelling of other smokers' behaviour; and (3) a higher prevalence of other behaviours associated with smoking, such as alcohol consumption.

Supporting this in Canada, we found that inequalities were larger in the four provinces with the lowest gross domestic product (GDP) value per capita, that is, three Atlantic provinces (Prince Edward Island, Nova Scotia and New Brunswick) and Manitoba (comparatively, Quebec is the fifth-poorest province based on this indicator). While this may not explain Quebec's disadvantage, the findings do suggest that the association of demographic and socioeconomic characteristics with initiation varies across jurisdictions and may be stronger in the poorest

regions. These regions may therefore benefit particularly from prioritizing the reduction of inequalities in youth initiation.

Strengths and limitations

This study builds on the large sample and methodological strengths of the Canadian Community Health Survey to provide representative estimates of youth initiation across Canadian provinces. The cross-sectional design precludes establishing the temporality of associations, preventing causal inference statements. It is also possible that the measure of lifetime initiation captured cohort effects that differed across provinces over the previous two decades. Statistics Canada public use files limit release of data on residential information, so characteristics such as urbanicity and area deprivation could not be investigated. Other variables that could not be investigated include alcohol consumption, illicit drug use and e-cigarette use, since data on these variables were not systematically collected from all minors in the CCHS 2015–2016 and 2017–2018 cycles.

Conclusion

Although smoking prevalence has decreased over time, continued efforts are needed to sustain this decline. An under-investigated realm is identifying factors underpinning variability in smoking prevalence across Canadian provinces, which could guide or redirect tobacco control efforts. Our findings are among the first to suggest that, although youth differ across provinces in demographic and socioeconomic characteristics, these differences are unlikely to be a key reason why youth in the province with the highest smoking initiation rate are more likely to initiate a first cigarette compared to other provinces. New research directions include replicating these findings using a longitudinal design, corroborating whether the predictors of initiation across provinces are also predictors of the transition from initiation to the sustained use of cigarettes, and exploring the contextual factors that actually drive these provincial differences using techniques such as multilevel modelling. Although our results cannot lead directly to intervention, they offer clear direction for future research (i.e. to confirm the benefits of new tobacco strategies to be implemented) and tobacco control action (i.e. to coordinate advocacy around stronger tobacco control strategies) in provinces with higher smoking initiation rates, at least in the Canadian context.

TABLE 3
Prevalence ratios of youth smoking initiation across Canadian provinces, before and after adjustment for sample characteristics, Canadians aged 12 to 17 years, 2015 to 2018, CCHS PUMF (n = 15 252)

Variables	Model 1 Base model			Model 2 Full model			Relative change in AMEs
	PR	95% CI	AME	PR	95% CI	AME	%
Province (ref: Quebec)							
British Columbia	0.39	0.29–0.52	−6.48	0.40	0.26–0.61	−6.25	3.5
Alberta	0.66	0.51–0.85	−3.61	0.68	0.45–1.04	−3.28	9.1
Saskatchewan	0.92	0.67–1.28	−0.81	0.88	0.56–1.39	−1.24	−53.1
Manitoba	0.60	0.40–0.88	−4.25	0.62	0.38–1.02	−3.98	6.4
Ontario	0.54	0.42–0.87	−4.80	0.55	0.38–0.80	−4.65	3.1
Atlantic[a]	0.68	0.54–0.87	−3.36	0.67	0.46–0.98	−3.44	−2.4

Abbreviations: AME, average marginal effect; CCHS, Canadian Community Health Survey; CI, confidence interval; PR, prevalence ratio; PUMF, public use microdata file.

Notes: Estimates are weighted using the survey weight and 1000 bootstrap weights provided by Statistics Canada. The base model is adjusted for cycle (2015–2016 and 2017–2018). The full model is adjusted for cycle, age, sex, immigration status, language most spoken in the household, living arrangements, household income, household education, home ownership and at-school status. The "relative change in AMEs" represents the percent change in the size of the average marginal effects between models: positive values indicate a decrease in differences across models, whereas negative values indicate an increase in difference across models. Estimates for covariates in the full model are provided in the supplementary material.

[a] Atlantic region: New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

Conflicts of interest

We declare no conflicts of interest.

Authors' contributions and statement

TG designed the study, prepared the data, performed the analyses, interpreted the results, drafted the first version of the manuscript and contributed to the final

FIGURE 1
Adjusted marginal probabilities of youth smoking initiation by family structure, Canadians aged 12 to 17 years, 2015 to 2018, CCHS PUMF (n = 15 252)
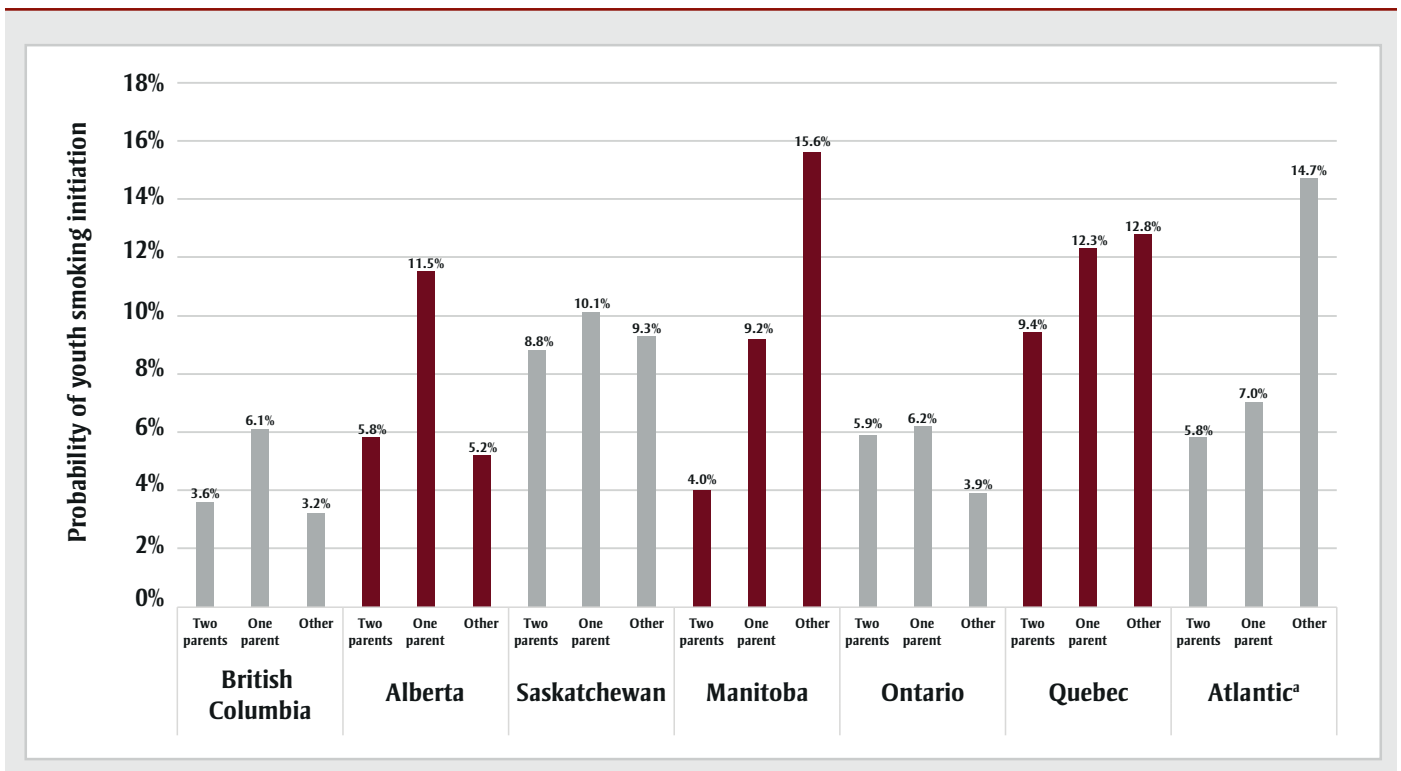
Abbreviations: CCHS, Canadian Community Health Survey; PUMF, public use microdata file.

[a] Atlantic region: New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

FIGURE 2
Adjusted marginal probabilities of youth smoking initiation by household income, Canadians aged 12 to 17 years, 2015 to 2018, CCHS PUMF (n = 15 252)
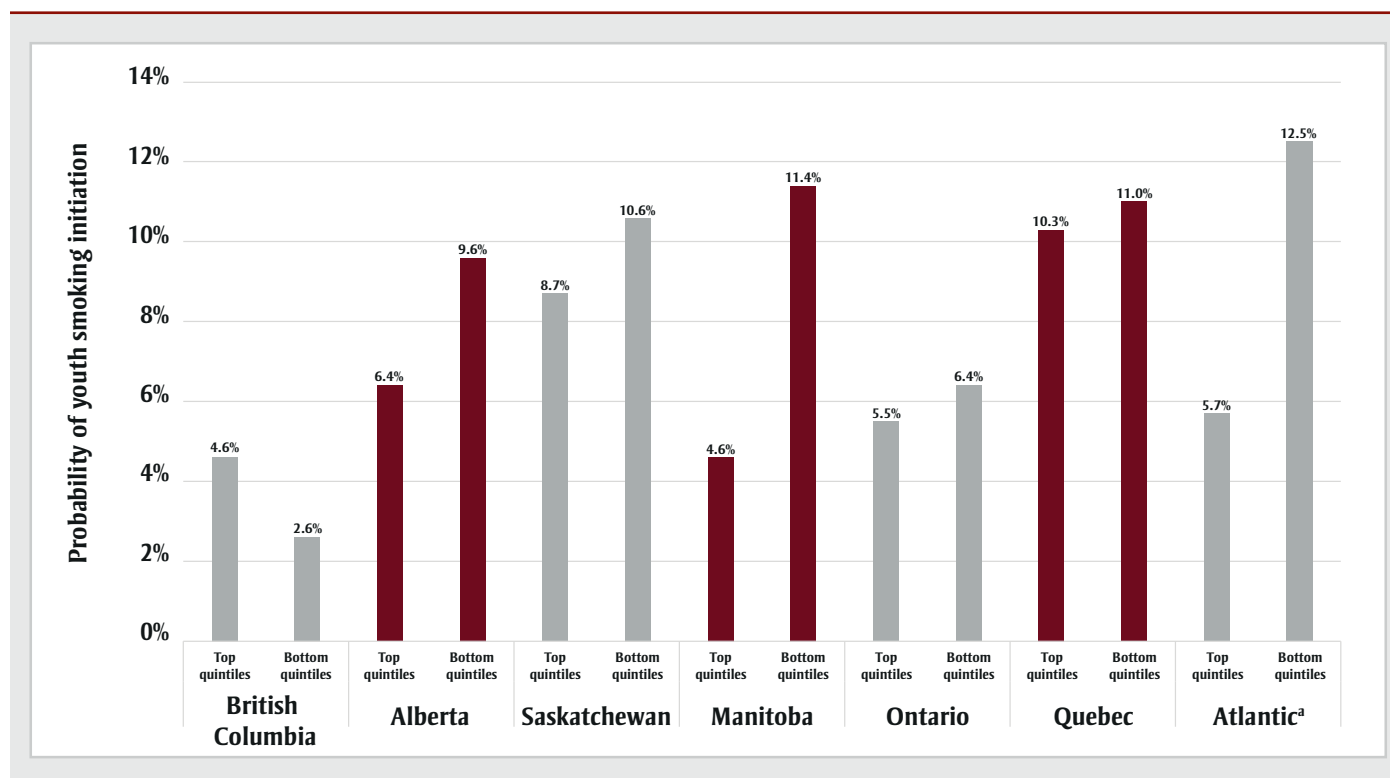
Abbreviations: CCHS, Canadian Community Health Survey; PUMF, public use microdata file.

[a] Atlantic region: New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

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References

1. Statistics Canada. Smoking, 2019 [Internet]. Ottawa (ON): Government of Canada; 2020 [cited 2021 May 11]. Available from: https://www150.statcan.gc.ca/n1/pub/82-625-x/2020001/article/00003-eng.htm

2. Gagné T, Veenstra G. Trends in smoking initiation in Canada: does non-inclusion of young adults in tobacco control strategies represent a missed opportunity? Can J Public Health. 2017;108(1):e14-e20. https://doi.org/10.17269/cjph.108.5839

3. Pelekanakis A, O'Loughlin J, Gagné T, Callard C, Frohlich K. Initiation or cessation: what keeps the prevalence of smoking higher in Quebec than in the rest of Canada? Health Promot Chronic Dis Prev Can. 2021;41(10):306-14. https://doi.org/10.24095/hpcdp.41.10.05

4. Canadian Cancer Society. Overview summary of federal, provincial, and territorial tobacco control legislation in Canada. Toronto (ON): Canadian Cancer Society; 2017.

5. Apollonio DE, Glantz SA. Minimum ages of legal access for tobacco in the United States from 1863 to 2015. Am J Public Health. 2016;106(7):1200-1207. https://doi.org/10.2105/AJPH.2016.303172

6. Breton E, Richard L, Gagnon F, Jacques M, Bergeron P. Fighting a tobacco-tax rollback: a political analysis of the 1994 cigarette contraband crisis in Canada. J Public Health Policy. 2006;27(1):77-99. https://doi.org/10.1057/palgrave.jphp.3200060

7. Manivong P, Harper S, Strumpf E. The contribution of excise cigarette taxes on the decline in youth smoking in Canada during the time of the Federal Tobacco Control Strategy (2002–2012). Can J Public Health. 2017;108(2):e117-e123. https://doi.org/10.17269/CJPH.108.5705

8. Bader P, Boisclair D, Ferrence R. Effects of tobacco taxation and pricing on smoking behavior in high risk populations: a knowledge synthesis. Int J Environ Res Public Health. 2011;8(11):4118-39. https://doi.org/10.3390/ijerph8114118

9. Sharbaugh MS, Althouse AD, Thoma FW, Lee JS, Figueredo VM, Mulukutla SR. Impact of cigarette taxes on smoking prevalence from 2001-2015: a report using the Behavioral and Risk Factor Surveillance Survey (BRFSS). PLoS ONE. 2018;13(9):e0204416. https://doi.org/10.1371/journal.pone.0204416

10. Minaker LM, Soni S, Nguyen N, Manske S. Youth retail tobacco access in Canada: regional variation, perceptions, and predictors from YSS 2010/2011. Addict Behav. 2015;51:1-6. https://doi.org/10.1016/j.addbeh.2015.06.047

11. Canadian Institute for Health Information (CIHI). National health expenditure trends [Internet]. Ottawa (ON): CIHI; 2021 Nov 4 [cited 2022 July 22]. Available from: https://www.cihi.ca/en/national-health-expenditure-trends

12. Wharry S. Canada a country of two solitudes when smoking rates among anglophones, francophones compared. CMAJ. 1997;156(2):244-5.

13. Chung-Hall J, Fong GT, Driezen P, Craig L. Smokers' support for tobacco endgame measures in Canada: findings from the 2016 International Tobacco Control Smoking and Vaping Survey. CMAJ Open. 2018;6(3):E412-E422. https://doi.org/10.9778/cmajo.20180025

14. Aubin J, Caouette L. L'usage de la cigarette au Québec de 1985 à 1994: une comparaison avec le Canada. Can J Public Health. 1998;89(1):22-27. https://doi.org/10.1007/BF03405789

15. Reid JL, Hammond D, Boudreau C, Fong GT, Siahpush M. Socioeconomic disparities in quit intentions, quit attempts, and smoking abstinence among smokers in four western countries: findings from the International Tobacco Control Four Country Survey. Nicotine Tob Res. 2010;12(Suppl 1): S20-S33. https://doi.org/10.1093/ntr/ntq051

16. Smith P, Frank J, Mustard C. Trends in educational inequalities in smoking and physical activity in Canada: 1974–2005. J Epidemiol Community Health. 2009;63(4):317-23. https://doi.org/10.1136/jech.2008.078204

17. Corsi DJ, Boyle MH, Lear SA, Chow CK, Teo KK, Subramanian SV. Trends in smoking in Canada from 1950 to 2011: progression of the tobacco epidemic according to socioeconomic status and geography. Cancer Causes Control. 2014;25(1):45-57. https://doi.org/10.1007/s10552-013-0307-9

18. Uppal S. Young men and women without a high school diploma [Internet]. Ottawa (ON): Statistics Canada; 2017 [cited 2022 Jul 25]. Available from: https://www150.statcan.gc.ca/n1/pub/75-006-x/2017001/article/14824-eng.htm

19. Zhang X. Census in brief: children living in low-income households: census of population, 2016. Ottawa (ON): Statistics Canada; 2017. [Statistics Canada Catalogue No.: 98-200-X2016012]. 10 p.

20. Wellman RJ, Dugas EN, Dutczak H, et al. Predictors of the onset of cigarette smoking: a systematic review of longitudinal population-based studies in youth. Am J Prev Med. 2016;51(5): 767-78. https://doi.org/10.1016/j.amepre.2016.04.003

21. Chahine T, Subramanian SV, Levy JI. Sociodemographic and geographic variability in smoking in the U.S.: a multilevel analysis of the 2006-2007 Current Population Survey, Tobacco Use Supplement. Soc Sci Med. 2011; 73(5):752-8. https://doi.org/10.1016/j.socscimed.2011.06.032

22. Corsi DJ, Chow CK, Lear SA, Subramanian SV, Teo KK, Boyle MH. Smoking in context: a multilevel analysis of 49,088 communities in Canada. Am J Prev Med. 2012;43(6):601-10. https://doi.org/10.1016/j.amepre.2012.08.023

23. Beard E, Brown J, West R, Angus C, Kaner E, Michie S. Healthier central England or North–South divide? Analysis of national survey data on smoking and high-risk drinking. BMJ Open. 2017;7(3):e014210. https://doi.org/10.1136/bmjopen-2016-014210

24. Statistics Canada. Canadian Community Health Survey–Annual Component (CCHS) [Internet]. Ottawa (ON): Statistics Canada; 2019 [cited 2021 Jun 22]. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226

25. McNutt L-A, Wu C, Xue X, Hafner JP. Estimating the relative risk in cohort studies and clinical trials of common outcomes. Am J Epidemiol. 2003; 157(10):940-3. https://doi.org/10.1093/aje/kwg074

26. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. Stata J. 2012;12(2):308-31. https://doi.org/10.1177/1536867X1201200209

27. Muller CJ, MacLehose RF. Estimating predicted probabilities from logistic regression: different methods correspond to different target populations. Int J Epidemiol. 2014;43(3):962-70. https://doi.org/10.1093/ije/dyu029

28. Allison PD. Comparing logit and probit coefficients across groups. Sociol Methods Res. 1999;28(2):186-208. https://doi.org/10.1177/0049124199028002003

29. Mize TD, Doan L, Long JS. A general framework for comparing predictions and marginal effects across models. Sociol Methodol. 2019;49(1):152-89. https://doi.org/10.1177/0081175019852763

30. StataCorp. Stata statistical software: release 16. College Station (TX): StataCorp LLC.; 2019.

31. Gilman S, Abrams D, Buka S. Socioeconomic status over the life course and stages of cigarette use: initiation, regular use, and cessation. J Epidemiol Community Health. 2003; 57(10):802-8. https://doi.org/10.1136/jech.57.10.802

32. Mark S, Lambert M, O'Loughlin J, Gray-Donald K. Household income, food insecurity and nutrition in Canadian youth. Can J Public Health. 2012;103(2):94-99. https://doi.org/10.1007/BF03404210

33. East K, McNeill A, Thrasher JF, Hitchman SC. Social norms as a predictor of smoking uptake among youth: a systematic review, meta-analysis and meta-regression of prospective cohort studies. Addiction. 2021; 116(11):2953-67. https://doi.org/10.1111/add.15427

Original quantitative research

Investigating the association between sleep and aspects of mental health in children: findings from the Canadian Health Survey on Children and Youth

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Abstract

Introduction: Sufficient sleep and good quality sleep are crucial aspects of children's healthy development. While previous research has suggested associations between sleep and positive mental health, few studies have been conducted in Canadian children.

Methods: This study used data from the 2019 Canadian Health Survey on Children and Youth. Parents of children aged 5 to 11 years (N = 16 170) reported on their children's sleep habits and mental health. Descriptive statistics were used to calculate means and percentages for sleep and mental health indicators. Logistic regression was used to compare mental health outcomes by meeting sleep duration recommendations (9–11 hours of sleep vs. < 9 or > 11 hours of sleep), sleep quality (difficulties getting to sleep) and having enforced rules for bedtime.

Results: Overall, 86.2% of children aged 5 to 11 years met sleep duration recommendations (9–11 hours of sleep), 90.0% had high sleep quality and 83.1% had enforced rules for bedtime. While 83.0% of children had high general mental health, mental health diagnoses were reported for 9.5% of children, and 15.8% of children required or received mental health care. High sleep quality was consistently associated with better mental health, enforced rules for bedtime were associated with some negative mental health outcomes and meeting sleep duration recommendations tended not to be associated with mental health outcomes.

Conclusion: Sleep quality was strongly associated with mental health among children in this study. Future research should explore longitudinal associations between sleep and mental health in Canadian children.

Keywords: *sleep, sleeplessness, mental health, anxiety, depression, child functioning, Canadian children*

Introduction

Adequate nighttime sleep is important for optimal physical and mental development in children.[1] In 2016, the *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity,* *Sedentary Behaviour, and Sleep* were released. These guidelines provide evidence-based recommendations for sleep, including sleeping an uninterrupted 9 to 11 hours per night for children aged 5 to 13 years, with consistent bed- and wake-up times.[2] Based on data from 2014–2015,

84% of Canadian children meet sleep duration recommendations.[3] Insufficient sleep in children has been associated with a range of negative outcomes, including obesity, lower academic achievement and lower health-related quality of life.[1,4,5]

Among children, good sleep health includes not only sleep duration but consideration of sleep quality (i.e. difficulties in getting to sleep) and sleep hygiene (i.e. practices that are conducive to sleep).[6] Data from 2014–2015 indicate that 8% of Canadian children have difficulties falling asleep or staying asleep most nights.[3] Like insufficient sleep, poor sleep quality is associated with a broad range of negative outcomes in children, including obesity, lower health-related quality of life and

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reduced cognitive development.[7-12] Enforcement of proper sleep hygiene in the form of consistent bedtime routines is associated with longer sleep duration and better sleep quality.[13]

Mental health difficulties are also a concern among children, with first onset of lifetime mental disorders typically occurring in childhood or adolescence.[14] One study found that 20% of Ontario children have parent- or teacher-reported symptoms of mental disorder.[15] An emerging body of evidence demonstrates associations between insufficient sleep duration, poor sleep quality and negative mental health outcomes (i.e. mental disorders and psychosocial difficulties) across childhood. Longitudinal studies have found that children with disturbed sleep have increased odds of depression compared to those without disturbed sleep.[16] Shorter sleep duration and lower sleep quality during childhood have been associated with greater internalizing symptoms (i.e. anxiety and depression) and inattention and/or hyperactivity both cross-sectionally[17,18] and into adulthood.[19] The associations between a child's sleep and mental health may be bidirectional, with some evidence of negative mental health outcomes predicting poor sleep.[20-22] Overall, sleep can have substantial implications for children's short- and long-term mental health and development.

The absence of mental disorders does not imply complete mental health.[23,24] Complete mental health comprises both the absence of mental disorders and the presence of well-being or positive mental health.[23] Well-being is modifiable, even in the presence of mental disorders.[24,25] Several studies have examined associations between children's sleep and positive mental health outcomes.[26-28] Both longer sleep duration and fewer sleep disturbances have been cross-sectionally associated with higher psychosocial well-being in children.[26] While meeting sleep duration recommendations has not been associated with fewer psychosocial difficulties in Canadian children, in Canadian youth, meeting sleep duration recommendations has been associated with higher life satisfaction, fewer emotional problems, higher self-rated mental health and higher prosocial behaviour.[27]

To our knowledge, no studies to date have examined associations between other sleep indicators (e.g. sleep quality and sleep hygiene) and positive or negative mental health in Canadian children. This research is needed to provide a more nuanced view of how sleep and children's mental health are intertwined, and to inform the development of targeted strategies for improving sleep and mental health outcomes in Canadian children.

The aim of this study is to examine the associations between three sleep indicators (meeting sleep duration recommendations, sleep quality and rules around bedtime) and indices of positive and negative mental health in a sample of Canadian children aged 5 to 11 years. This study also provides pre COVID-19 pandemic estimates on various sleep and mental health indicators among a sample of Canadian children.

Methods

Data source

Data used in this study are from the 2019 Canadian Health Survey on Children and Youth (CHSCY). CHSCY was a voluntary, cross-sectional survey conducted by Statistics Canada. It covered a sample of children and youth aged 1 to 17 years living in every province and territory in Canada, but excluded those living on First Nations reserves and other Indigenous settlements, those living in foster homes and the institutionalized population. The sampling frame comprised beneficiaries of the Canada child benefit, which covers 98% of the Canadian population aged 1 to 17 years in all provinces and 96% in all territories. Data collection occurred between February and August 2019. Data for children aged 1 to 11 years were collected by electronic questionnaires or telephone interviews, with the "person-most-knowledgeable" as the respondent. The person-most-knowledgeable was most often a parent of the child (98%).

This study focussed on children aged 5 to 11 years. Although nighttime sleep data were also collected for children aged 3 to 4 years, they were excluded from analyses because of high variability in responses (large coefficients of variation) and small sample sizes for this age range. Additionally, the Canadian sleep recommendations for this age range include naps, which were not assessed in the 2019 CHSCY.[29]

The overall response rate for children aged 5 to 11 years in the 2019 CHSCY was 57.8%. Statistics Canada generated sampling weights for each respondent based on the probability of selection, including an adjustment factor to attempt to account for nonresponse. Further details on the calculation of sampling weights are provided elsewhere.[30] There were 20 113 respondents on behalf of children aged 5 to 11 years; 16 170 (80.4%) respondents had complete sociodemographic and sleep data, and were included in this study. Approval for the conduct of CHSCY was obtained from Health Canada's Research Ethics Board, and informed consent and assent were obtained from all participants.

Measures

Sleep
Meeting sleep duration recommendations
Respondents were asked for the usual time their child fell asleep and woke up on weekdays and weekends. Average sleep duration was calculated as a weighted average over weekdays and weekends of the number of hours between sleep and wake time. Children were classified as meeting sleep duration recommendations if their average sleep duration was between 9 hours and 0 minutes and 11 hours and 0 minutes, and as not meeting recommendations if their average sleep duration was outside this range.[2] As a sensitivity analysis, children were classified as above sleep duration recommendations if their average sleep duration was over 11 hours and 0 minutes, and as below sleep duration recommendations if their average sleep duration was below 9 hours and 0 minutes.

Sleep quality
Respondents were asked how often their child had difficulties in getting to sleep in the past six months. High sleep quality was defined as having difficulties rarely or never, about once a month, or about once a week. Low sleep quality was defined as having difficulties getting to sleep more than once a week or most days. This coding aligns with the diagnostic criteria for insomnia (sleep difficulty ≥ 3 times a week)[31] and other studies.[32]

Rules around bedtime
Respondents were asked if there were rules for the time their child goes to bed (yes/no) and whether these rules were usually enforced (yes/no) as a measure of sleep hygiene.[33,34] Those with enforced

rules were considered to have rules around bedtime, while those without rules or with unenforced rules were considered not to have rules around bedtime.

Mental health
Overall mental health indicators
General mental health
Respondents were asked how their child's mental health was in general (excellent, very good, good, fair, or poor). Following the coding of a similar variable in the Positive Mental Health Surveillance Indicator Framework,[35] high general mental health was defined as excellent or very good. Further details on the development of this framework are provided elsewhere.[36]

Low anxiousness and sadness
Respondents were asked how often their child seemed very anxious, nervous or worried, as well as how often their child seemed very sad or depressed (daily, weekly, monthly, a few times a year, or never). Daily or weekly was classified as high anxiousness or high sadness; less often was classified as low anxiousness or low sadness. These items were from the Washington Group/UNICEF Module on Child Functioning.[37] Further details on its development are provided elsewhere.[38] The module only classifies "daily" responses as high anxiousness or sadness; however, we also classified "weekly" as high anxiousness or sadness based on response distributions, and to assess both severe and less severe emotional difficulties.

Psychosocial difficulty indicators
Psychosocial difficulties
Respondents were asked the degree to which their child had difficulties with (1) concentrating on an activity that they enjoy doing; (2) accepting changes in their routine; (3) controlling their behaviour compared to other children of the same age; and (4) making friends (no difficulty, some difficulty, a lot of difficulty, or cannot do at all). These items were from the Washington Group/UNICEF Module on Child Functioning. While this module classifies no or some difficulty as low difficulty, we classified children as having no difficulties versus any difficulties (some, a lot, or cannot do at all) based on response distributions, and to assess both severe and less severe psychosocial difficulties.

Mental health diagnoses and care indicators
Mood/anxiety/attention disorder diagnosis
Respondents were asked if their child had ever been diagnosed with (1) a mood disorder (e.g. depression, bipolar disorder, mania, dysthymia); (2) an anxiety disorder (e.g. phobia, obsessive-compulsive disorder, panic disorder); and (3) an attention deficit disorder or attention deficit hyperactivity disorder. If respondents answered yes to any of these questions, the child was coded as having been diagnosed with a mood/attention/anxiety disorder. These disorders were grouped together in the reporting of associations with sleep because there were few children diagnosed with each disorder.

Requiring/receiving mental health care
Respondents were asked if their child required or received services in the past 12 months for mental health issues or difficulties focussing or controlling behaviour, or from a psychologist, counsellor or psychiatrist. If respondents answered yes to any of these questions, the child was coded as requiring/receiving mental health care. These variables were grouped together because there were few children who required or received services.

Covariates
Several covariates were identified as potential confounders of the relationship between sleep and mental health: age (in years), sex, household income quintile, racialized group status, immigrant status and self-reported mental health of the person-most-knowledgeable.

Household income quintile
Respondents were asked for their total household income. Quintiles were calculated using sampling weights to account for the survey design. Income was determined using donor imputation for those who did not respond (8% of participants). Household income is a measure of socioeconomic status, which has been associated with both sleep[39] and mental health.[40]

Racialized group status
Respondents were asked about their child's cultural or ethnic background. Those who identified as White were classified as not part of a racialized group. Those who identified as having other backgrounds, including Indigenous, were designated as part of a racialized group. Racialized group status has been associated with both sleep and mental health.[41,42]

Immigrant status
Individuals were asked whether their child had ever been a landed immigrant (vs. born in Canada or had never been a landed immigrant). Immigrant status has been associated with both sleep and mental health.[42,43]

Self-reported mental health of person-most-knowledgeable
Respondents were asked how their mental health was in general (excellent, very good, good, fair, or poor). High general mental health was defined as excellent or very good. Parents' mental health has been associated with both their child's sleep and mental health.[44,45]

Analysis

Descriptive statistics were used to calculate means, percentages and 95% confidence intervals (CIs) for sociodemographic characteristics and sleep and mental health indicators overall and by sex (male, female). Overall percentages were also calculated for certain mental health indicators (low anxiousness, sadness and psychosocial difficulties) using the Washington Group/UNICEF Module on Child Functioning classification. Two-tailed hypothesis tests were used to identify differences between sexes under a significance level of 0.05.

Logistic regression was used to determine whether children who met sleep duration recommendations, when compared to children who did not meet recommendations, were more likely to have high general mental health, low anxiousness and low sadness, less likely to have psychosocial difficulties and a mood/anxiety/attention disorder diagnosis, and less likely to have required or received mental health care services in the past year. Sensitivity analyses were conducted comparing mental health outcomes between children who were above sleep duration recommendations with those who met recommendations, and children who were below sleep duration recommendations with those who met recommendations. Separate logistic regression analyses were also conducted using sleep quality and rules around bedtime as predictor variables.

Both unadjusted analyses and analyses with adjustment for potential confounders (age of child [in years], sex of child, household income quintile, racialized group status, immigrant status and self-reported mental health of the person-most-knowledgeable) were conducted. Significant differences by sex were assessed by including an interaction term between each sleep variable and sex in

the adjusted analyses. Sex-stratified analyses were also conducted. Associations were presented as odds ratios with 95% CIs. Associations with CIs that excluded the null odds ratio of 1.00 were considered statistically significant. Sensitivity analyses were conducted for the associations between sleep indicators and certain mental health indicators (low anxiousness, sadness and psychosocial difficulties) using the Washington Group/UNICEF Module on Child Functioning classification.

Sampling weights provided by Statistics Canada were used to attempt to account for nonresponse. Variance was estimated using the bootstrap resampling method with 1000 replications to account for the complex sampling design. Analyses were conducted in SAS Enterprise Guide version 7.1 (SAS Institute, Cary, NC, USA).

Results

Descriptive statistics for sleep, sociodemographic characteristics and mental health outcomes are presented in Table 1. Overall, 86.2% of children aged 5 to 11 years met sleep duration recommendations, with an average sleep duration of 10.2 hours (range: 5.5–14.2 hours). More children exceeded recommendations (10.3%) than were below recommendations (3.5%). High sleep quality was reported for 90.0% of children, and enforcement of bedtime rules was reported for 83.1% of children. There were no sex differences for any of these sleep measures.

The majority of children were reported as having high general mental health (83.0%), low anxiousness (82.7%; 95.0% using original Washington Group/UNICEF module classification) and low sadness (93.9%; 98.9% using original classification). The most commonly reported psychosocial issues were difficulty accepting changes in routine (32.3%; 5.3% using original classification), followed by difficulty controlling behaviour (28.3%; 4.3% using original classification), difficulty making friends (17.1%; 3.1% using original classification) and difficulty concentrating (9.2%; 1.2% using original classification). Mood/anxiety/attention disorder diagnoses were reported for 9.5% of children, with attention disorders being most common (7.6%) followed by anxiety (3.2%) and mood disorders (0.6%), and 15.8% of children required or received mental health care in the past 12 months. High general mental health was more common

in females (85.3%) than males (80.8%). Psychosocial difficulties, mood/anxiety/attention disorder diagnoses, and requiring or receiving mental health care in the past year were more common in males than females. The sex difference for mood/anxiety/attention disorders was largely driven by a relatively high proportion of males having been diagnosed with attention disorders (10.8% vs. 4.2% for females).

Associations between mental health outcomes and meeting, exceeding or being below sleep duration recommendations are presented as odds ratios in Table 2. Children who met recommendations were less likely to have difficulty concentrating, accepting change and controlling behaviour, but not after covariates were controlled for. Meeting sleep duration recommendations was not associated with any other mental health outcomes overall. However, females who met recommendations were more likely to have high general mental health than females who did not meet recommendations, and males who met recommendations were less likely to have difficulty concentrating than males who did not meet recommendations in adjusted analyses (although interaction terms between sex and meeting sleep duration recommendations were not statistically significant for these outcomes). There were no other associations when stratified by sex. In sensitivity analyses, not getting enough sleep tended to be more highly associated with poorer mental health than getting too much sleep.

Associations between mental health outcomes and sleep quality are presented in Table 3. Children with high sleep quality were more likely to have high general mental health, low anxiousness and low sadness, and less likely to have psychosocial difficulties, to have a mood/anxiety/attention disorder diagnosis and to have required or received mental health care in the past year both overall (unadjusted and adjusted for covariates) and when stratified by sex.

Associations between mental health outcomes and enforced rules around bedtime are presented in Table 4. Children with enforced rules around bedtime were more likely to have a mood/anxiety/attention disorder diagnosis, require or receive mental health care, have high anxiousness,

and have difficulty accepting changes in routine and controlling their behaviour both overall (unadjusted and adjusted for covariates) and when stratified by sex. Having enforced rules around bedtime was associated with difficulty making friends overall, but not when stratified by sex. Having enforced rules around bedtime was not associated with general mental health, sadness, or difficulty concentrating overall or when stratified by sex.

When certain mental health outcomes (low anxiousness, low sadness, and psychosocial difficulties) were defined using the Washington Group/UNICEF Module on Child Functioning classification, associations with sleep quality were in the same direction but of a larger magnitude than the primary results (data not shown due to high sampling variability). Associations with meeting sleep duration recommendations and enforced rules around bedtime were similar to the primary results.

Discussion

The objective of this study was to assess associations between sleep indices and mental health measures in children aged 5 to 11 years. Overall, high sleep quality was consistently associated with better mental health, enforcement of bedtime rules was associated with some negative mental health outcomes, and meeting sleep duration recommendations tended to not be associated with mental health outcomes. Although males generally had lower mental health than females, sex tended to not moderate the association between sleep and mental health in this study (except for high sleep quality's negative association with some psychosocial difficulties and mood/anxiety/attention disorder diagnoses being stronger for males than females).

The *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep* recommend that children aged 5 to 13 years obtain 9 to 11 hours of uninterrupted sleep per night for optimal health benefits, with consistent bed and wake times.[2] Most previous studies, but not all, have found associations between longer sleep duration and better emotional regulation (e.g. less stress and anxiety, and fewer depressive symptoms) in children.[1] Meeting sleep duration recommendations was associated with higher life satisfaction,

TABLE 1
Descriptive statistics for sleep variables, mental health outcomes and covariates for children aged 5 to 11 years, 2019 CHSCY

	Overall (N = 16 170)			Female (N = 7831)			Male (N = 8339)			Sex comparison (significance level)[a]
	%	95% CI Lower	95% CI Upper	%	95% CI Lower	95% CI Upper	%	95% CI Lower	95% CI Upper	
Total	100.0	N/A	N/A	48.8	48.6	50.0	51.2	51.0	51.4	
Sleep										
Met sleep duration recommendations (9–11 hours per night)	86.2	85.4	86.9	85.4	84.3	86.4	86.9	85.9	88.0	*
Exceeded sleep duration recommendations (> 11 hours per night)	10.3	9.6	10.9	11.2	10.2	12.1	9.4	8.6	10.3	**
Below sleep duration recommendations (< 9 hours per night)	3.5	3.1	3.9	3.5	2.8	4.1	3.6	3.0	4.2	
High sleep quality (difficulties getting to sleep ≤ once a week)	90.0	89.3	90.7	90.0	89.0	91.0	90.1	89.1	91.0	
Enforced rules around bedtime	83.1	82.3	83.9	82.5	81.3	83.7	83.6	82.5	84.7	
Child mental health										
Overall mental health										
High general mental health (excellent or very good mental health)	83.0	82.2	83.9	85.3	84.2	86.5	80.8	79.6	82.0	***
Low anxiousness (seems very anxious, nervous, or worried less than weekly)	82.7	81.9	83.5	83.8	82.6	84.9	81.7	80.4	82.9	**
Low sadness (seems very sad or depressed less than weekly)	93.9	93.4	94.5	94.7	94.0	95.4	93.2	92.4	94.0	*
Psychosocial difficulties										
At least some difficulty concentrating	9.2	8.5	9.9	7.3	6.5	8.2	11.0	10.0	12.1	***
At least some difficulty accepting changes in routine	32.3	31.3	33.3	28.6	27.2	30.0	35.8	34.3	37.3	***
At least some difficulty controlling behaviour	28.3	27.3	29.3	21.2	19.9	24.5	35.0	33.5	36.5	***
At least some difficulty making friends	17.1	16.2	17.9	14.8	13.7	15.9	19.2	18.0	20.4	***
Mental health diagnoses and care										
Mood/anxiety/attention disorder diagnosis	9.5	8.9	10.2	6.0	5.2	6.8	12.9	11.8	14.0	***
Mood disorder diagnosis	0.6	0.4	0.8	0.3[c]	0.1	0.4	0.9[c]	0.7	1.2	***
Anxiety disorder diagnosis	3.2	2.8	3.6	2.5	2.0	3.0	3.9	3.3	4.5	***
Attention disorder diagnosis	7.6	7.0	8.2	4.2	3.5	4.9	10.8	9.8	11.8	***
Required/received mental health care in the past 12 months	15.8	14.9	16.6	11.7	10.7	12.8	19.6	18.3	20.9	***
Covariates										
Racialized group	33.3	32.2	34.3	32.5	31.1	34.0	33.9	32.5	35.4	
Immigrant	7.7	7.1	8.4	7.8	7.0	8.6	7.7	6.8	8.6	
Person-most-knowledgeable self-rated high mental health (excellent or very good mental health)	71.5	70.6	72.5	71.4	70.0	72.8	71.7	70.3	73.1	
Median household income[b] (CAD)	89 963	49 834	139 909	89 926	49 403	139 740	90 931	50 982	144 758	

Abbreviations: CAD, Canadian dollars; CHSCY, Canadian Health Survey on Children and Youth; CI, confidence interval.

[a] Significance level for the difference between females and males.

[b] The median household income (CAD), quartile 1, and quartile 3 are presented in place of %, 95% CI lower and 95% CI upper.

[c] Estimate should be interpreted with caution due to high sampling variability.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

TABLE 2

TABLE 2
Odds ratios for mental health among children aged 5 to 11 years by whether they meet sleep duration recommendations (9–11 hours of sleep per night), 2019 CHSCY

	Univariate models			Adjusted models									Sex comparison (significance level)[a]
	Both sexes (N = 16 170)			Both sexes (N = 16 170)			Females (N = 7831)			Males (N = 8339)			
	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	
Meeting vs. not meeting sleep duration recommendations													
Overall mental health													
High general mental health (excellent or very good mental health)	1.12	0.94	1.34	1.15	0.94	1.40	**1.40**	1.04	1.88	0.98	0.75	1.27	
Low anxiousness (seems very anxious, nervous or worried less than weekly)	0.95	0.80	1.13	0.97	0.80	1.16	1.02	0.78	1.35	0.92	0.72	1.18	
Low sadness (seems very sad or depressed less than weekly)	0.94	0.71	1.22	0.89	0.67	1.18	0.83	0.56	1.23	0.93	0.63	1.38	
Psychosocial difficulties													
At least some difficulty concentrating	**0.78**	0.62	0.97	0.81	0.65	1.01	0.92	0.64	1.32	**0.74**	0.56	0.98	
At least some difficulty accepting changes in routine	**0.86**	0.75	0.99	0.88	0.77	1.01	0.83	0.68	1.01	0.94	0.78	1.13	
At least some difficulty controlling behaviour	**0.84**	0.73	0.67	0.87	0.75	1.01	0.85	0.68	1.06	0.89	0.73	1.08	
At least some difficulty making friends	1.01	0.85	1.19	0.99	0.83	1.18	0.94	0.71	1.24	1.04	0.83	1.31	
Mental health diagnoses and care													
Mood/anxiety/attention disorder diagnosis	0.96	0.77	1.20	0.83	0.66	1.04	0.80	0.53	1.22	0.85	0.65	1.12	
Required/received mental health care in the past 12 months	0.94	0.79	1.13	0.88	0.73	1.06	0.85	0.62	1.15	0.91	0.71	1.15	
Exceeding vs. meeting sleep duration recommendations													
General mental health													
High general mental health (excellent or very good mental health)	**1.25**	1.01	1.54	1.04	0.82	1.31	0.99	0.68	1.45	1.07	0.79	1.44	
Low anxiousness (seems very anxious, nervous or worried less than weekly)	**1.23**	1.01	1.51	1.13	0.91	1.40	1.14	0.83	1.57	1.11	0.83	1.49	
Low sadness (seems very sad or depressed less than weekly)	1.33	0.96	1.85	1.33	0.95	1.88	1.71	0.98	3.00	1.12	0.73	1.72	
Psychosocial difficulties													
At least some difficulty concentrating	1.19	0.93	1.54	1.17	0.90	1.53	1.03	0.68	1.57	1.29	0.92	1.81	
At least some difficulty accepting changes in routine	1.09	0.94	1.26	1.06	0.91	1.23	1.22	0.98	1.52	0.91	0.74	1.13	
At least some difficulty controlling behaviour	1.12	0.96	1.31	1.07	0.90	1.26	1.10	0.85	1.41	1.04	0.83	1.31	
At least some difficulty making friends	0.85	0.69	1.05	0.92	0.74	1.16	0.98	0.69	1.40	0.88	0.67	1.16	

Continued on the following page

TABLE 2 (continued)

Odds ratios for mental health among children aged 5 to 11 years by whether they meet sleep duration recommendations (9–11 hours of sleep per night), 2019 CHSCY

	Univariate models			Adjusted models									Sex comparison (significance level)[a]
	Both sexes (N = 16 170)			Both sexes (N = 16 170)			Females (N = 7831)			Males (N = 8339)			
	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	
Mental health diagnoses and care													
Mood/anxiety/attention disorder diagnosis	**0.64**	0.47	0.86	0.97	0.71	1.32	1.03	0.55	1.91	0.93	0.66	1.32	
Required/received mental health care in the past 12 months	0.88	0.71	1.08	1.10	0.88	1.37	1.18	0.83	1.69	1.04	0.77	1.39	
Being below vs. meeting sleep duration recommendations													
Overall mental health													
High general mental health (excellent or very good mental health)	**0.44**	0.33	0.58	**0.63**	0.45	0.90	**0.39**	0.23	0.65	0.95	0.58	1.56	**
Low anxiousness (seems very anxious, nervous or worried less than weekly)	**0.72**	0.53	0.97	0.86	0.62	1.19	0.69	0.43	1.11	1.04	0.68	1.58	
Low sadness (seems very sad or depressed less than weekly)	0.67	0.44	1.02	0.82	0.53	1.23	0.66	0.39	1.11	0.99	0.49	2.01	
Psychosocial difficulties													
At least some difficulty concentrating	**1.58**	1.05	2.36	1.40	0.93	2.10	1.26	0.62	2.56	1.49	0.90	2.46	
At least some difficulty accepting changes in routine	**1.38**	1.06	1.80	**1.36**	1.04	1.78	1.15	0.76	1.75	**1.55**	1.09	2.20	
At least some difficulty controlling behaviour	**1.40**	1.07	1.83	**1.40**	1.06	1.86	1.45	0.92	2.28	1.37	0.95	1.96	
At least some difficulty making friends	**1.47**	1.11	1.96	1.21	0.90	1.62	1.30	0.84	2.00	1.14	0.76	1.72	
Mental health diagnoses and care													
Mood/anxiety/attention disorder diagnosis	**2.43**	1.74	3.41	**1.58**	1.13	2.21	1.57	0.89	2.77	**1.58**	1.02	2.43	
Required/received mental health care in the past 12 months	**1.67**	1.22	2.27	1.22	0.88	1.68	1.18	0.68	2.05	1.24	0.82	1.89	

Abbreviations: CHSCY, Canadian Health Survey on Children and Youth; CI, confidence interval; OR, odds ratio.

Notes: Adjusted models for both sexes, females and males included age of child in years, racialized group status, immigrant status, household income quintile and person-most-knowledgeable self-rated mental health as covariates. The both-sexes adjusted models also included sex as a covariate.
Bolded estimates have confidence intervals that exclude the null odds ratio of 1.00, and are considered statistically significant.

[a] Significance level for a difference in odds ratio by sex, based on including a sex interaction term in the both-sexes adjusted model.

* *p* < 0.05

** *p* < 0.01

*** *p* < 0.001

fewer emotional problems and higher pro-social behaviour in a representative sample of Canadians aged 10 to 17 years,[28] although it was not associated with psychosocial difficulties in Canadians aged 5 to 11 years using national data from 2015.[27] We found little evidence of associations between meeting sleep duration recommendations and mental health. However, sensitivity analyses showed

some associations between not getting enough sleep and poorer mental health. Mental health difficulties tend to manifest and be diagnosed later in childhood,[15] and more Canadian children meet sleep duration recommendations than youth.[27] Therefore, associations with sleep duration recommendations may be less apparent in the 5 to 11 years age group.

Consistent with prior research,[9,21,26] high sleep quality was associated with better mental health. Associations were strongest for mood/anxiety/attention disorder diagnosis and requiring/receiving mental health care. These were indicative of more severe mental health difficulties, while general mental health, anxiousness and sadness, and psychosocial difficulties grouped those with both severe and less

TABLE 3

Odds ratios for mental health among children aged 5 to 11 years with high sleep quality (difficulties getting to sleep ≤ once a week) versus low sleep quality (difficulties getting to sleep ≥ 3 times per week), 2019 CHSCY

	Univariate models			Adjusted models									Sex comparison (significance level)[a]
	Both sexes (N = 16 170)			Both sexes (N = 16 170)			Females (N = 7831)			Males (N = 8339)			
	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	
Overall mental health													
High general mental health (excellent or very good mental health)	**4.27**	3.62	5.03	**3.40**	2.75	4.19	**3.05**	2.19	4.25	**3.75**	2.84	4.96	
Low anxiousness (seems very anxious, nervous or worried less than weekly)	**4.24**	3.10	4.98	**3.48**	2.92	4.15	**3.21**	2.51	5.27	**3.79**	2.98	4.81	
Low sadness (seems very sad or depressed less than weekly)	**4.39**	3.51	5.47	**3.56**	2.83	4.49	**2.95**	2.10	4.15	**4.20**	3.08	5.72	
Psychosocial difficulties													
At least some difficulty concentrating	**0.32**	0.26	0.39	**0.38**	0.31	0.47	**0.42**	0.31	0.56	**0.36**	0.27	0.47	
At least some difficulty accepting changes in routine	**0.34**	0.29	0.39	**0.39**	0.33	0.46	**0.50**	0.40	0.62	**0.30**	0.24	0.38	**
At least some difficulty controlling behaviour	**0.29**	0.25	0.34	**0.33**	0.28	0.38	**0.38**	0.30	0.48	**0.28**	0.22	0.35	*
At least some difficulty making friends	**0.38**	0.32	0.45	**0.45**	0.38	0.53	**0.57**	0.44	0.73	**0.37**	0.29	0.46	**
Mental health care and diagnoses													
Mood/anxiety/attention disorder diagnosis	**0.20**	0.16	0.24	**0.24**	0.19	0.29	**0.30**	0.21	0.41	**0.20**	0.16	0.26	*
Required/received mental health care in the past 12 months	**0.17**	0.13	0.21	**0.23**	0.18	0.29	**0.22**	0.15	0.32	**0.23**	0.17	0.32	

Abbreviations: CHSCY, Canadian Health Survey on Children and Youth; CI, confidence interval; OR, odds ratio.

Notes: Adjusted models for both sexes, females and males included age of child in years, racialized group status, immigrant status, household income quintile and person-most-knowledgeable self-rated mental health as covariates. The both-sexes adjusted models also included sex as a covariate.
Bolded estimates have confidence intervals that exclude the null odds ratio of 1.00, and are considered statistically significant.

[a] Significance level for a difference in odds ratio by sex, based on including a sex interaction term in the both-sexes adjusted model.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

severe difficulties. When psychosocial difficulties were defined using the Washington Group/UNICEF Module classification (i.e. focussing on severe difficulties), associations were of similar magnitude as those for mood/anxiety/attention disorder diagnosis and requiring/receiving mental health care. Notably, associations between sleep quality and outcomes grouping severe and less severe difficulties were still of large magnitude.

Research suggests that associations between sleep quality and children's positive and negative mental health outcomes may be bidirectional.[20,21] Longitudinal studies, as opposed to cross-sectional studies, are needed to ascertain directionality. A systematic review found that most longitudinal studies supported a bidirectional relationship between insomnia and anxiety and depression, sleep quality and depression/anxiety and sleep quality and mental health status.[46] However, studies looking specifically at children identified unidirectional relationships between sleep problems and depression/anxiety.[46] The directionality between sleep quality and mental health may also depend on the mental health outcome being measured. Studies have found bidirectional relationships between childhood sleep problems and externalizing difficulties[21] as well as behavioural difficulties.[47] Although more longitudinal research is needed, current evidence suggests that both mental and sleep health promotion are important for optimal health and well-being.

Sleep hygiene was assessed in this study by the enforcement of rules around bedtime. Consistent bedtimes are a commonly recommended practice to promote longer and better quality sleep in children.[13,33] Having enforced rules for bedtime has been associated with longer sleep duration and higher sleep quality in American children,[33] and with meeting sleep recommendations on weekdays in a study of 1622 Ontario parents and their children.[34] Inconsistent sleep and wake times have been associated with emotional difficulties in Australian children.[48] Inconsistent sleep times were also associated with

TABLE 4
TABLE 4
Odds ratios for mental health among children aged 5 to 11 years with enforced rules for bedtime versus no enforced rules for bedtime, 2019 CHSCY

	Univariate models			Adjusted models									Sex comparison (significance level)[a]
	Both sexes (N = 16 170)			Both sexes (N = 16 170)			Females (N = 7831)			Males (N = 8339)			
	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper	
Overall mental health													
High general mental health (excellent or very good mental health)	0.85	0.72	1.00	0.92	0.75	1.12	0.89	0.67	1.19	0.95	0.73	1.23	
Low anxiousness (seems very anxious, nervous or worried less than weekly)	**0.58**	0.48	0.69	**0.65**	0.54	0.78	**0.63**	0.48	0.83	**0.66**	0.51	0.84	
Low sadness (seems very sad or depressed less than weekly)	1.04	0.81	1.35	1.10	0.84	1.44	1.27	0.88	1.83	0.96	0.67	1.38	
Psychosocial difficulties													
At least some difficulty concentrating	1.02	0.82	1.28	0.94	0.75	1.19	1.02	0.71	1.46	0.90	0.66	1.23	
At least some difficulty accepting changes in routine	**1.56**	1.37	1.79	**1.41**	1.22	1.63	**1.32**	1.07	1.63	**1.49**	1.23	1.81	
At least some difficulty controlling behaviour	**1.49**	1.30	1.71	**1.36**	1.16	1.58	**1.45**	1.14	1.85	**1.29**	1.05	1.59	
At least some difficulty making friends	**1.27**	1.08	1.50	**1.23**	1.03	1.45	1.22	0.93	1.59	1.23	0.98	1.55	
Mental health care and diagnoses													
Mood/anxiety/attention disorder diagnosis	**1.65**	1.28	2.13	**1.49**	1.13	1.97	**1.70**	1.03	2.79	**1.41**	1.00	1.97	
Required/received mental health care in the past 12 months	**1.69**	1.40	2.06	**1.48**	1.19	1.83	**1.73**	1.22	2.44	**1.34**	1.02	1.77	

Abbreviations: CHSCY, Canadian Health Survey on Children and Youth; CI, confidence interval; OR, odds ratio.

Notes: Adjusted models for both sexes, females and males included age of child in years, racialized group status, immigrant status, household income quintile and person-most-knowledgeable self-rated mental health as covariates. The both-sexes adjusted models also included sex as a covariate.
Bolded estimates have confidence intervals that exclude the null odds ratio of 1.00, and are considered statistically significant.

[a] Significance level for a difference in odds ratio by sex, based on including a sex interaction term in the both-sexes adjusted model.

[*] $p < 0.05$

[**] $p < 0.01$

[***] $p < 0.001$

behavioural difficulties among children in the UK, and improvements in sleep time consistency were associated with behavioural improvements.[49] While the promotion of consistent sleep could have mental health benefits, we found that having enforced rules around bedtime was associated with high anxiety, difficulty accepting changes in routine and controlling behaviour, mood/anxiety/attention disorder diagnosis, and requiring/receiving mental health care.

The manner in which rules for bedtime are enforced may inform their associations with negative mental health outcomes. For example, harsh parenting (e.g. enforcing rules through raising one's voice/scolding/yelling) and highly controlling parenting have been linked to negative mental health outcomes in children and adolescents, particularly among males.[50-52] Meanwhile, authoritative parenting (enforcement of rules combined with parental warmth) has been linked to less negative outcomes.[52] These associations may be bidirectional, as there is evidence that parents of children who are known to have mental health difficulties are more likely to enforce rules harshly relative to those without difficulties.[51-53] Further research is needed in this area to best guide sleep hygiene recommendations.

Strengths and limitations

A major strength of the current study is the use of a survey that collected data on numerous sleep and mental health indicators among children aged 5 to 11 years living in every province and territory in Canada. These estimates can be used as a baseline to compare sleep and mental health outcomes before, during and after the COVID-19 pandemic. To our knowledge, this study was also the first to assess the association between multiple sleep indicators (meeting sleep duration recommendations, sleep quality and enforced rules around bedtime) and mental health in this population. Multiple covariates were controlled for, including the person-most-knowledgeable's self-reported mental health.

However, the cross-sectional study design prevents inferences on causality and the

directionality between sleep and mental health. The observed associations are likely a combination of the effects of sleep on mental health and mental health on sleep, as well as residual confounding of other factors related to both sleep and mental health (e.g. by physical activity, family structure, stress, trauma). Furthermore, sleep and mental health measures were reported by the person-most-knowledgeable, and may be prone to social desirability and recall biases as well as measurement error.[54] While self-reported and parent-reported measures of child mental health are positively associated, the correlation is not perfect[55] and initial analyses of the 2019 CHSCY suggest that discrepancies between youth and person-most-knowledgeable perceptions of youth general mental health are not uncommon.[56] The assessment of mental health may be affected by sociodemographic characteristics that we did not account for (e.g. education).

Sleep quality can be assessed in multiple ways, including difficulties falling or staying asleep, sleep efficiency (ratio of total sleep time to time in bed), time taken to fall asleep and the number and length of awakenings overnight.[6] This study was only able to assess difficulties falling asleep, as reported by the person-most-knowledgeable. Similarly, sleep hygiene encompasses a variety of practices that promote sleep, including consistent bedtimes, daytime exercise and limiting screen time.[57] This study only assessed the enforcement of rules around bedtime, which were associated with some negative mental health outcomes. Ascertaining the manner in which rules are enforced (e.g. harshly or warmly) may provide more context to the observed associations. Assessing additional sleep quality measures and sleep hygiene practices in future studies would better inform the relationship between sleep and mental health.

Despite the large sample size, there were few children who were diagnosed with a mood, anxiety or attention disorder, and few children who required or received services from a psychologist, counsellor or psychiatrist, or for mental health issues or difficulty focussing or controlling behaviour. Diagnosed mood disorder in particular had a low prevalence of 0.6%. Therefore, these variables were grouped together and results should not be interpreted as being applicable to a specific mental health disorder or service.

Assessing these variables individually could provide more information about associations between sleep and specific mental health disorders and services.

Furthermore, a large majority of children met sleep duration recommendations and had high sleep quality and enforced rules around bedtime, high mental health and low psychosocial difficulties. Oversampling children with mental health difficulties in subsequent surveys and studying longitudinal associations between childhood sleep and mental health at later ages (e.g. adolescence) may provide more insight into the relationship between sleep and mental health.

Finally, the majority of mental health outcomes we examined were negative outcomes. Future research should target additional positive mental health outcomes (e.g. life satisfaction).[25]

Conclusion

In this sample of Canadian children aged 5 to 11 years, high sleep quality was strongly and consistently associated with better mental health outcomes. In contrast, the enforcement of bedtime rules was modestly associated with some negative mental health outcomes, and meeting sleep duration recommendations tended not to be associated with the examined mental health outcomes. These findings suggest that poor sleep quality may be associated with severe and less severe mental health difficulties during childhood. Given their potentially bidirectional relationship, as documented in other literature, this highlights the importance of promoting both good sleep health and mental health in children. Future research should explore longitudinal associations between sleep and mental health in this population.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Authors' contributions and statement

RLD, CAC, KCR and MTB conceptualized the study. CW, RLD, CAC, KCR and MTB designed the study and analytic approach. CW conducted the statistical analyses. CW, RLD, ZMC and CAC interpreted the results. CW, RLD and ZMC drafted the

initial manuscript. All authors contributed to reviewing and editing the manuscript. All authors approved the manuscript for publication.

References

1. Chaput J-P, Gray CE, Poitras VJ, et al. Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. Appl Physiol Nutr Metab. 2016;41(6 Suppl. 3):S266-S282. https://doi.org/10.1139/apnm-2015-0627

2. Tremblay MS, Carson V, Chaput J-P, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2016;41(6 Suppl 3):S311-S327. https://doi.org/10.1139/apnm-2016-0151

3. Centre for Surveillance and Applied Research, Public Health Agency of Canada. Physical activity, sedentary behaviour and sleep (PASS) indicators data tool, 2021 edition [Internet]. [Public Health Infobase.] Ottawa (ON): Public Health Agency of Canada. Available from: https://health-infobase.canada.ca/pass/data-tool

4. Cappuccio FP, Taggart FM, Kandala N-B, et al. Meta-analysis of short sleep duration and obesity in children and adults. Sleep. 2008;31(5):619-26. https://doi.org/10.1093/sleep/31.5.619

5. Short M, Bartel K, Carskadon M. Sleep and mental health in children and adolescents. In: Grandner MA, editor. Sleep and health. London (UK): Academic Press; 2019:435-45.

6. Meltzer LJ, Williamson AA, Mindell JA. Pediatric sleep health: it matters, and so does how we define it. Sleep Med Rev. 2021;57:101425. https://doi.org/10.1016/j.smrv.2021.101425

7. Bertocci MA, Dahl RE, Williamson DE, et al. Subjective sleep complaints in pediatric depression: a controlled study and comparison with EEG measures of sleep and waking. J Am Acad Child Adolesc Psychiatry. 2005;44(11):1158-66. https://doi.org/10.1097/01.chi.0000179057.54419.17

8. Fatima Y, Doi SAR, Mamun AA. Sleep quality and obesity in young subjects: a meta-analysis. Obes Rev. 2016;17(11):1154-66. https://doi.org/10.1111/obr.12444

9. Magee CA, Robinson L, Keane C. Sleep quality subtypes predict health-related quality of life in children. Sleep Med. 2017;35:67-73. https://doi.org/10.1016/j.sleep.2017.04.007

10. Xiao Q, Chaput J-P, Olds T, et al. Sleep characteristics and health-related quality of life in 9- to 11-year-old children from 12 countries. Sleep Health. 2020;6(1):4-14. https://doi.org/10.1016/j.sleh.2019.09.006

11. Simola P, Liukkonen K, Pitkäranta A, Pirinen T, Aronen ET. Psychosocial and somatic outcomes of sleep problems in children: a 4-year follow-up study. Child Care Health Dev. 2014;40(1):60-7. https://doi.org/10.1111/j.1365-2214.2012.01412.x

12. Dewald JF, Meijer AM, Oort FJ, Kerkhof GA, Bögels SM. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: a meta-analytic review. Sleep Med Rev. 2010;14(3):179-89. https://doi.org/10.1016/j.smrv.2009.10.004

13. Mindell JA, Meltzer LJ, Carskadon MA, Chervin RD. Developmental aspects of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America Poll. Sleep Med. 2009;10(7):771-9. https://doi.org/10.1016/j.sleep.2008.07.016

14. Kessler RC, Amminger GP, Aguilar-Gaxiola S, Alonso J, Lee S, Ustun TB. Age of onset of mental disorders: a review of recent literature. Curr Opin Psychiatry. 2007;20(4):359-64. https://doi.org/10.1097/YCO.0b013e32816ebc8c

15. Comeau J, Georgiades K, Duncan L, Wang L, Boyle MH, 2014 Ontario Child Health Study Team. Changes in the prevalence of child and youth mental disorders and perceived need for professional help between 1983 and 2014: evidence from the Ontario Child Health Study. Can J Psychiatry. 2019;64(4):256-64. https://doi.org/10.1177/0706743719830035

16. Marino C, Andrade B, Campisi SC, et al. Association between disturbed sleep and depression in children and youths: a systematic review and meta-analysis of cohort studies. JAMA Netw Open. 2021;4(3):e212373. https://doi.org/10.1001/jamanetworkopen.2021.2373

17. Ivanenko A, Johnson K. Sleep disturbances in children with psychiatric disorders. Semin Pediatr Neurol. 2008;15(2):70-8. https://doi.org/10.1016/j.spen.2008.03.008

18. Paavonen EJ, Porkka-Heiskanen T, Lahikainen AR. Sleep quality, duration and behavioral symptoms among 5-6-year-old children. Eur Child Adolesc Psychiatry. 2009;18(12):747-54. https://doi.org/10.1007/s00787-009-0033-8

19. Gregory AM, Van der Ende J, Willis TA, Verhulst FC. Parent-reported sleep problems during development and self-reported anxiety/depression, attention problems, and aggressive behavior later in life. Arch Pediatr Adolesc Med. 2008;162(4):330-5. https://doi.org/10.1001/archpedi.162.4.330

20. Leahy E, Gradisar M. Dismantling the bidirectional relationship between paediatric sleep and anxiety. Clin Psychol. 2012;16(1):44-56. https://doi.org/10.1111/j.1742-9552.2012.00039.x

21. Quach JL, Nguyen CD, Williams KE, Sciberras E. Bidirectional associations between child sleep problems and internalizing and externalizing difficulties from preschool to early adolescence. JAMA Pediatr. 2018;172(2):e174363. https://doi.org/10.1001/jamapediatrics.2017.4363

22. Chorney DB, Detweiler MF, Morris TL, Kuhn BR. The interplay of sleep disturbance, anxiety, and depression in children. J Pediatr Psychol. 2008;33(4):339-48. https://doi.org/10.1093/jpepsy/jsm105

23. Iasiello M, Agteren J van, Muir-Cochrane E. Mental health and/or mental illness: a scoping review of the evidence and implications of the dual-continua model of mental health. Evid Base. 2020;2020(1):1-45.

24. Keyes CLM. Promoting and protecting mental health as flourishing: a complementary strategy for improving national mental health. Am Psychol. 2007;62(2):95-108. https://doi.org/10.1037/0003-066X.62.2.95

25. van Agteren J, Iasiello M, Lo L, et al. A systematic review and meta-analysis of psychological interventions to improve mental wellbeing. Nat Hum Behav. 2021;5(5):631-52. https://doi.org/10.1038/s41562-021-01093-w

26. Thumann BF, Börnhorst C, Michels N, et al. Cross-sectional and longitudinal associations between psychosocial well-being and sleep in European children and adolescents. J Sleep Res. 2019;28(2):e12783. https://doi.org/10.1111/jsr.12783

27. Bang F, Roberts KC, Chaput J-P, Goldfield GS, Prince SA. Physical activity, screen time and sleep duration: combined associations with psychosocial health among Canadian children and youth. Health Rep. 2020;31(5):9-16. https://doi.org/10.25318/82-003-x202000500002-eng

28. Janssen I, Roberts KC, Thompson W. Is adherence to the Canadian 24-Hour Movement Behaviour Guidelines for Children and Youth associated with improved indicators of physical, mental, and social health? Appl Physiol Nutr Metab. 2017;42(7):725-31. https://doi.org/10.1139/apnm-2016-0681

29. Tremblay MS, Chaput J-P, Adamo KB, et al. Canadian 24-hour movement guidelines for the early years (0-4 years): an integration of physical activity, sedentary behaviour, and sleep. BMC Public Health. 2017;17(Suppl 5):874. https://doi.org/10.1186/s12889-017-4859-6

30. Statistics Canada. Canadian Health Survey on Children and Youth (CHSCY) [Internet]. Ottawa (ON): Government of Canada; 2019 [cited 2021 Dec 26]. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5233

31. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. (DSM-5). Arlington (VA): APA; 2013.

32. Nunes S, Campbell MK, Klar N, Reid GJ, Stranges S. Relationships between sleep and internalizing problems in early adolescence: results from Canadian National Longitudinal Survey of Children and Youth. J Psychosom Res. 2020;139:110279. https://doi.org/10.1016/j.jpsychores.2020.110279

33. Buxton OM, Chang A-M, Spilsbury JC, Bos T, Emsellem H, Knutson KL. Sleep in the modern family: protective family routines for child and adolescent sleep. Sleep Health. 2015;1(1):15-27. https://doi.org/10.1016/j.sleh.2014.12.002

34. Pyper E, Harrington D, Manson H. Do parents' support behaviours predict whether or not their children get sufficient sleep? A cross-sectional study. BMC Public Health. 2017;17:432. https://doi.org/10.1186/s12889-017-4334-4

35. Public Health Agency of Canada, Centre for Surveillance and Applied Research. Positive Mental Health Surveillance Indicator Framework [Internet]. Ottawa (ON): PHAC; 2022 [modified 2022 Mar 10; cited 2022 Apr 12]. Available from: https://health-infobase.canada.ca/positive-mental-health/

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

37. WG/UNICEF Child Functioning Module (CFM). Hyattsville (MD): The Washington Group on Disability Statistics; 2017 [cited 2021 Dec 26]. Available from: https://www.washingtongroup-disability.com/question-sets/wg-unicef-child-functioning-module-cfm/

38. Loeb M, Cappa C, Crialesi R, de Palma E. Measuring child functioning: the UNICEF/Washington Group Module. Salud Publica Mex. 2017;59(4):485-7. https://doi.org/10.21149/8962

39. Jarrin DC, McGrath JJ, Quon EC. Objective and subjective socioeconomic gradients exist for sleep in children and adolescents. Health Psychol. 2014;33(3):301-5. https://doi.org/10.1037/a0032924

40. Reiss F. Socioeconomic inequalities and mental health problems in children and adolescents: a systematic review. Soc Sci Med. 2013;90:24-31. https://doi.org/10.1016/j.socscimed.2013.04.026

41. Spilsbury JC, Storfer-Isser A, Drotar D, et al. Sleep behavior in an urban US sample of school-aged children. Arch Pediatr Adolesc Med. 2004;158(10):988-94. https://doi.org/10.1001/archpedi.158.10.988

42. Samaan RA. The influences of race, ethnicity, and poverty on the mental health of children. J Health Care Poor Underserved. 2000;11(1):100-10. https://doi.org/10.1353/hpu.2010.0557

43. Varin M, Baker M, Palladino E, Lary T. At-a-glance – Canadian Chronic Disease Indicators, 2019 – updating the data and taking into account mental health. Health Promot Chronic Dis Prev Can. 2019;39(10):281-8. https://doi.org/10.24095/hpcdp.39.10.02

44. Smaldone A, Honig JC, Byrne MW. Sleepless in America: inadequate sleep and relationships to health and well-being of our nation's children. Pediatrics. 2007;119 Suppl 1:S29-S37. https://doi.org/10.1542/peds.2006-2089F

45. Leis JA, Heron J, Stuart EA, Mendelson T. Associations between maternal mental health and child emotional and behavioral problems: does prenatal mental health matter? J Abnorm Child Psychol. 2014;42(1):161-71. https://doi.org/10.1007/s10802-013-9766-4

46. Alvaro PK, Roberts RM, Harris JK. A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. Sleep. 2013;36(7):1059-68. https://doi.org/10.5665/sleep.2810

47. Liu J, Glenn AL, Cui N, Raine A. Longitudinal bidirectional association between sleep and behavior problems at age 6 and 11 years. Sleep Med. 2021;83:290-8. https://doi.org/10.1016/j.sleep.2021.04.039

48. Biggs SN, Lushington K, van den Heuvel CJ, Martin AJ, Kennedy JD. Inconsistent sleep schedules and daytime behavioral difficulties in school-aged children. Sleep Med. 2011;12(8):780-6. https://doi.org/10.1016/j.sleep.2011.03.017

49. Kelly Y, Kelly J, Sacker A. Changes in bedtime schedules and behavioral difficulties in 7 year old children. Pediatrics. 2013;132(5):e1184-e1193. https://doi.org/10.1542/peds.2013-1906

50. Kingsbury M, Sucha E, Manion I, Gilman SE, Colman I. Adolescent mental health following exposure to positive and harsh parenting in childhood. Can J Psychiatry. 2020;65(6):392-400. https://doi.org/10.1177/0706743719889551

51. McLeod BD, Wood JJ, Weisz JR. Examining the association between parenting and childhood anxiety: a meta-analysis. Clin Psychol Rev. 2007;27(2):155-72. https://doi.org/10.1016/j.cpr.2006.09.002

52. Pinquart M. Associations of parenting dimensions and styles with externalizing problems of children and adolescents: an updated meta-analysis. Dev Psychol. 2017;53(5):873-932. https://doi.org/10.1037/dev0000295

53. Hudson JL, Rapee RM. Parent–child interactions and anxiety disorders: an observational study. Behav Res Ther. 2001;39(12):1411-27. https://doi.org/10.1016/s0005-7967(00)00107-8

54. Colley RC, Wong SL, Garriguet D, Janssen I, Connor Gorber S, Tremblay MS. Physical activity, sedentary behaviour and sleep in Canadian children: parent-report versus direct measures and relative associations with health risk. Health Rep. 2012;23(2):45-52.

55. De Los Reyes A, Augenstein TM, Wang M, et al. The validity of the multi-informant approach to assessing child and adolescent mental health. Psychol Bull. 2015;141(4):858-900. https://doi.org/10.1037/a0038498

56. Statistics Canada. Canadian Health Survey on Children and Youth, 2019 [Internet]. Ottawa (ON): Statistics Canada [The Daily]; 2020 Jul 23 [cited 2022 Jan 26]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/200723/dq200723a-eng.htm

57. Galland BC, Mitchell EA. Helping children sleep. Arch Dis Child. 2010; 95(10):850-3. https://doi.org/10.1136/adc.2009.162974

Original quantitative research

Perceptions of and adherence to early COVID-19-related restrictions and associations with substance use among youth in Canada

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Abstract

Introduction: As a largely social behaviour, substance use may have decreased for some youth overall in Canada during the COVID-19 pandemic; however, continued use may indicate nonadherence to pandemic-related restrictions and social distancing measures. In a sample of Canadian adolescents (aged 12–19 years), our objective was to examine how substance use (cannabis, binge drinking, cigarettes, vaping) is associated with perceptions of, and adherence to, early COVID-19-related public health measures, taking into consideration sociodemographic factors.

Methods: Cross-sectional data were retrieved from online data collected during Year 8 of the COMPASS school-based study, during the early months of the COVID-19 pandemic (May–July 2020) in British Columbia, Ontario and Quebec. We fitted two models using generalized estimating equations to examine how substance use was associated with separate measures of (1) perceptions of, and (2) adherence to early COVID-19 restrictions.

Results: In our sample, 10% of adolescents perceived COVID-19 restrictions as too weak and 14% perceived them as too strict. Nearly half (46%) reported taking restrictions very seriously, and 5% did not take them seriously at all. Binge drinking, cigarette use and vaping were associated with perceptions that restrictions were too strict and with nonadherence. However, adolescents who used cannabis were less likely to perceive COVID-19-related restrictions as too strict.

Conclusion: This study highlights the association of adolescent substance use with perceptions of, and adherence to, COVID-19-related public health restrictions in Canada. Our findings emphasize a need for continual monitoring of substance use behaviours during the COVID-19 pandemic to better characterize adolescent risk and further inform targeted public health strategies accordingly.

Keywords: COVID-19 pandemic, substance use, adolescent health

Highlights

- Fourteen percent of adolescents perceived COVID-19-related restrictions as too strict; 5% did not take them seriously at all.
- Use of alcohol, cigarettes and vapes was associated with perceptions that COVID-19-related restrictions were too strict, and with nonadherence.
- Adolescents who used cannabis were less likely to perceive COVID-19-related restrictions as too strict compared to those who did not use cannabis.

Introduction

Among adolescents, substance use is largely a social behaviour occurring within peer contexts.[1] The use of some substances, such as alcohol, among adolescents may be especially influenced by social and peer factors.[2] Therefore, the prevalence of substance use for some youth may have decreased during the COVID-19 pandemic as a function of stay-at-home and physical distancing mandates. Pandemic-related restrictions were introduced to curb community spread of the novel SARS-CoV-2 coronavirus, and theoretically might have led to reduced access to substances and fewer opportunities for use among adolescents.

In addition to access, perception of risk is identified as a key determinant of adolescent substance use; adolescents who perceive that using a certain substance carries a higher risk are less likely to use that substance.[3] In general, adolescents tend to underestimate health risks and consequences[4] and are more likely to take risks,[5] especially as a function of social reward.[6] As noted by Dumas and colleagues,[7] adolescents may therefore perceive themselves to be at lower risk for

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COVID-19 and thus may decide not to comply with COVID-19-related restrictions in favour of gathering with peers.

Some emerging research shows trends of decreasing rates of substance use among adolescents in various jurisdictions since March 2020,[8-10] when governments began enacting lockdown measures such as school closures. Findings are indeed heterogenous, and an overall decrease in substance use may not have been the case in other jurisdictions; for example, in the US, adolescent alcohol use appears to have decreased while nicotine use increased.[11] Yet, even among Canadian adolescents, a sizable proportion has reported continued use of substances during the pandemic—even in the presence of public health restrictions intended to limit their interaction with others outside of their home.[7,9] In the US, recent findings showed that despite self-perceived reduced availability of substances, the actual prevalence of cannabis and alcohol use among adolescents did not significantly change during the COVID-19 pandemic.[12]

In response to COVID-19-related stressors and social isolation, youth have reported engaging in substance-related coping[9,11] and other generally maladaptive coping mechanisms during the pandemic.[13] Continued substance use among adolescents despite school closures and social distancing measures may also be indicative of nonadherence to pandemic-related restrictions—given the social nature of substance use behaviours in this population age group.[1] Understanding the risks associated with continued substance use despite pandemic restrictions is therefore important for informing public health measures meant to protect youth from the novel SARS-CoV-2 coronavirus and its variants.

In particular, understanding the association between continued substance use and nonadherence to restrictions could provide context for more fulsome population-level monitoring in order to better characterize adolescents' risk of COVID-19 infection. This evidence could help identify specific groups at high risk for COVID-19, thereby informing targeted strategies for public health measures or programs to reduce their risk. Fendrich and colleagues[14] recently investigated the association between substance use and adherence to COVID-19 public health guidelines in a

sample of US adults. Consistent with their hypothesis, it was found that adults who used cannabis and alcohol were less likely to adhere to COVID-19-related guidelines.[14] To our knowledge, this is the only published study to explore associations between substance use and COVID-19-related policy adherence, and to date no studies have investigated this phenomenon among youth.

Adolescents with greater pandemic knowledge and higher risk perceptions toward COVID-19 may be more likely to comply with preventive measures.[15] Certain factors may influence perceptions of and adherence to COVID-19-related restrictions. Greater nonadherence has been observed among some individuals who are not especially vulnerable to COVID-19 infection or illness,[16] whereas those more vulnerable or at greater risk are more likely to adhere to public health measures.[17] Evidence from previous viral outbreaks indicates that lower risk perceptions are directly associated with lower adherence to preventive efforts.[18,19] Sociodemographic factors such as older age and female cisgender have also been associated with greater adherence.[17-19] Transgender and gender-diverse youth may be at unique risk for the negative residual impacts of COVID-19 due to program and service disruption and inadequate support from their families.[20] In a recent study, 2SLGBTQ youth reported concerns about confinement with unsupportive family members during COVID-19 lockdowns.[21]

Using a substance-specific approach to account for unique social influences on different substance use behaviours, the objective of our study was to examine how substance use (cannabis use, binge drinking, cigarette use and vaping) is associated with adolescents' perceptions of and adherence to early COVID-19-related public health measures, taking into consideration sociodemographic factors. We hypothesized that substance use would be positively associated with perceptions of early COVID-19 restrictions as too strict, while negatively associated with adherence. This research was based on a sample of Canadian secondary school students from the COMPASS study surveyed during the early months of COVID-19 pandemic, between May and July 2020.

Methods

Study design

Data for this study were retrieved from Year 8 (Y_8; 2019/20) of COMPASS—an ongoing prospective cohort study that collects survey data from a rolling sample of secondary school students in Alberta, British Columbia, Ontario and Quebec, Canada.[22] Full-school student samples are invited to participate in COMPASS by completing a behavioural health questionnaire. Data are collected anonymously using a student-generated identification code allowing for data linkage across study cycles. Active-information, passive-consent data collection procedures employed by COMPASS have been approved by the University of Waterloo Office of Research Ethics and participating school boards. Detailed information about COMPASS is available in print[22] and online (http://www.compass.uwaterloo.ca/).

After COVID-19 was declared a pandemic in March 2020, COMPASS data were collected online in British Columbia, Ontario and Quebec, as schools in Canada were closed to in-person learning due to public health measures (data collection in Alberta was not possible during this time). The online COMPASS Student Questionnaire (CQ-o)[23] was adopted and used Qualtrics XM online survey software.[24] Starting 1 May 2020, participating schools emailed a link for the CQ-o to all students, followed by a reminder email one week after the original link was disseminated. The last survey closed on 6 July 2020. Table 1 presents the timing of implementation for different public health restrictions across British Columbia, Ontario and Quebec during this data collection period.

Sample

There were 9630 students who participated in the Y_8 CQ-o across 51 schools in British Columbia, Ontario and Quebec (2 in BC, 20 in ON, 29 in QC). A complete-case analytic sample of 7876 students was used for the current study, after cases with missing data were deleted.

Measures

Dependent variables of interest—perceptions of and adherence to COVID-19 measures

To capture students' perceptions of pandemic-related restrictions, the CQ-o

TABLE 1
Timing of implementation for different public health restrictions across participating provinces during COMPASS Y_8 (May–July 2020)

Pandemic response measure	Province		
	British Columbia	Ontario	Quebec
Provincial state of emergency declared	18 March 2020—ongoing	17 March 2020—ongoing	13 March 2020—ongoing
School closures	18 March–1 June 2020 (at reduced capacity)	14 March 2020 until end of school year	13 March 2020 until end of school year (elementary schools re-opened 11 May except in Montréal)
Recreation closures (facilities, parks, etc.)	8 April 2020—ongoing	17 March 2020—ongoing	15 March 2020—ongoing
Gathering restrictions	16 March 2020—ongoing	13 March 2020—ongoing	13 March 2020—ongoing
Work-from-home recommendations	19 March 2020—ongoing	25 March 2020—ongoing	25 March 2020—ongoing
Use of face masks	10 April 2020—ongoing	20 May 2020—ongoing	7 April 2020—ongoing
Nonessential service restrictions (e.g. restaurants, businesses)	17 March 2020— ongoing	17 March 2020—ongoing	15 March 2020—ongoing

Abbreviation: Y_8, year 8 of the COMPASS survey.

Notes: COMPASS is an ongoing prospective cohort study that collects survey data from a rolling sample of secondary school students in Canada.[22] Data were retrieved from the Canadian Institute for Health information COVID-19 Intervention Timeline in Canada tool (https://www.cihi.ca/en/covid-19-intervention-timeline-in-canada). "Ongoing" refers to the remaining duration of the COMPASS Y_8 data collection period and beyond.

included the question: "How do you feel about the rules that governments have recommended or required to reduce the spread of COVID-19? (e.g. no school, staying at least 2 metres away from people, not going out in public unless you have to)?" Students responded by indicating whether they believed the restrictions to be (1) "too weak"; (2) "appropriate/good"; or (3) "too strict."

Adherence to early COVID-19-related restrictions was assessed by asking students, "How seriously are you taking the new rules laid out by governments to reduce the spread of COVID-19?" There were three response options to this question: (1) "I take them very seriously—I stay home most or all of the time, and do not go within 2 metres of people if I am outside"; (2) "I take them somewhat seriously—I go outside quite a bit and/or I sometimes do not stay a full 2 metres away from people when I am outside"; and (3) "I do not take them seriously—I go out when I want to, visit whomever I want, do not worry about staying 2 meters away from people when I am outside."

Independent variables of interest
Current substance use
Students were asked how often they used cannabis or marijuana (e.g. "a joint," "pot," "weed," "hash") in the past 12 months. Current cannabis use was defined as any use at a frequency of at least once per month. Similarly, students were asked about the frequency with which they participated in binge drinking in the past 12 months; current binge drinking was defined as 5 or more drinks on one

occasion at least once per month. Cigarette and vaping use were captured by asking students on how many of the last 30 days they smoked one or more cigarettes, or used a vape, respectively. Current cigarette or vaping use was defined as use on at least one day in the last 30 days. Measures of student substance use were consistent with national surveillance measures.[25,26]

Sociodemographic factors
Students self-reported their sex/gender in answer to the question "Are you female or male?" with the following response options: "female," "male," "I describe my gender in a different way" and "I prefer not to say." We recategorized students' sex/gender into three levels (male, female, other/prefer not to say). Age was collected in years. Students were asked to describe their ethnicity by selecting one or more of the following categories: Asian, Black, Indigenous (First Nations/Métis/Inuit), Latin American, White, or other, and responses were recategorized as Black/Indigenous/person of colour (BIPOC; i.e. Asian, Black, Indigenous, Latin American, other, mixed/multiple) or White. Students were also asked to report their weekly available spending money (zero, $1–$20, $21–$100, $100+, don't know) as a proxy measure for individual-level socioeconomic status (SES) and part-time employment, given the apparent associations with substance use.[27]

Analyses
We computed descriptive statistics using chi-square (χ^2) and one-way ANOVA (F)

tests to compare students' sociodemographics and current substance use across levels of their perceptions of and adherence to early COVID-19 restrictions. We fitted two models using generalized estimating equations (GEE) to examine how substance use was associated with each dependent variable: perceptions of early COVID-19 restrictions (Model I), and adherence to early COVID-19 restrictions (Model II). Each model also tested for the effects of sociodemographic covariates, controlling for province. A generalized logit link function under the SAS PROC GEE procedure was specified to account for the multinomial distributions of the dependent variables; the referent response categories were "thinks restrictions are appropriate/good" for Model I and "takes restrictions somewhat seriously" for Model II, as neutral midpoints of the response options. According to the computed intraclass correlation coefficients (ICC), school-level clustering accounted for less than 1% of variation observed in each of the dependent variables ($ICC_{Perceptions} = 0.0005$; $ICC_{Adherence} = 0.0016$) but we proceeded to account for the clustered structure of the data using an independent covariance structure in PROC GEE. Estimates and 95% confidence limits were exponentiated to obtain adjusted odds ratios (aORs) with 95% confidence intervals (CIs). We used SAS version 9.4 statistical software.[28]

Results

Sample characteristics are presented for the full study sample (N = 7876) in Table 2. A majority of students in our sample identified

TABLE 2
Sample characteristics of COMPASS Y_8 students (May–July 2020), N = 7876

Measure	N	%
Sex/gender		
Male	2893	36.7
Female	4837	61.4
Other/prefer not to say	146	1.9
Age (years)		
Mean age	15.0	SD = 1.6
Ethnicity		
White	6116	77.6
BIPOC	1760	22.4
Weekly spending money		
Zero	1751	22.2
$1–$20	1565	19.9
$21–$100	1292	16.4
$101+	1387	17.6
Don't know	1881	23.9
Current (≥ once/month) cannabis use		
No	7373	93.6
Yes	503	6.4
Current (≥ once/month) binge drinking		
No	6981	88.6
Yes	895	11.4
Current (≥ once/month) cigarette use		
No	7593	96.4
Yes	283	3.6
Current (≥ once/month) vaping		
No	6869	87.2
Yes	1007	12.8
Perceptions of early COVID-19 restrictions		
Thinks restrictions are **too weak**	809	10.3
Thinks restrictions are **appropriate/good**	5952	75.5
Thinks restrictions are **too strict**	1115	14.2
Adherence to early COVID-19 restrictions		
Takes restrictions **very seriously**	3630	46.1
Takes restrictions **somewhat seriously**	3883	49.3
***Does not* take restrictions seriously**	363	4.6

Abbreviations: BIPOC, Black/Indigenous/person of colour; SD, standard deviation; Y_8, year 8 of the COMPASS survey.

Note: COMPASS is an ongoing prospective cohort study that collects survey data from a rolling sample of secondary school students in Canada.[22]

as female (60%), and 2% identified as other than male or female or reported they preferred not to state a sex or gender. Students were on average 15 (SD ± 1.6) years of age (ranging from 12–19 years), and 22% identified as BIPOC.

Table 3 presents the results of a missing-data analysis showing the student-level factors associated with missingness in the dependent variables. Overall, students were less likely to have missing data if they identified as female compared to male, and were more likely to have missing data if they identified as BIPOC compared to White.

Overall, 6.4% (n = 503) of students reported current use of cannabis, 11.4% (n = 895) reported current binge drinking, 3.6% (n = 283) currently used cigarettes, and 12.8% (n = 1007) reported current vaping. A majority of students in our sample (75.5%) reported that the early COVID-19 restrictions implemented during May to July 2020 were "appropriate/good." Approximately 10% of students felt that the restrictions were "too weak," whereas a greater proportion (14.2%) perceived early COVID-19 restrictions to be "too strict." In terms of students' adherence to early COVID-19 restrictions, roughly half (49.3%) reported taking the restrictions "somewhat seriously," while nearly as many students (46.1%) reported taking them "very seriously." Fewer than 5% of students indicated that they did not take the COVID-19 restrictions seriously.

Students' perceptions of early COVID-19 restrictions differed by all sociodemographic factors and current substance use measures, as shown in Table 4. Similar results are shown across different levels of students' reported adherence to early COVID-19 restrictions (Table 4).

GEE model results

Table 5 presents the results of the GEE models estimating the associations between students' substance use and their perceptions of (Model I) and adherence to (Model II) early COVID-19 restrictions. Model I shows that students who reported engaging in binge drinking (aOR = 1.68; 95% CI: 1.39–2.04) were significantly more likely to perceive the restrictions as too strict compared to those who did not drink. Similarly, compared to students who did not vape, students who reported vaping (aOR = 2.00; 95% CI: 1.61–2.49) were also more likely to perceive early COVID-19 restrictions as too strict. Those who engaged in cannabis use, however, were one-third less likely to report that COVID-19 restrictions were too strict (aOR = 0.66; 95% CI: 0.48–0.91) compared to those who did not engage in cannabis use. Students who reported cigarette use were both more likely to perceive restrictions as too weak (aOR = 1.58; 95% CI: 1.06–2.36) *and* too strict (aOR = 1.80; 95% CI: 1.30–2.48), versus those who did not use cigarettes.

Model II (Table 5) estimated self-reported adherence to early COVID-19 restrictions. Students who engaged in binge drinking and vaping were significantly more likely to report that they do not take COVID-19 restrictions seriously (aOR = 1.66, 95% CI: 1.23–2.23 and aOR = 2.27, 1.69–3.05,

Measure	aOR (95% CI)	
	Model I	Model II
Sex/gender		
Male (ref)	1.00	1.00
Female	**0.72 (0.63–0.81)*****	**0.73 (0.64–0.83)*****
Other/prefer not to say	0.84 (0.54–1.32)	0.86 (0.54–1.35)
Age (years)		
Estimate (SE)	1.02 (0.98–1.07)	1.03 (0.98–1.08)
Ethnicity		
White (ref)	1.00	1.00
BIPOC	**1.28 (1.10–1.48)*****	**1.34 (1.16–1.56)*****
Weekly spending money		
Zero (ref)	1.00	1.00
$1–$20	1.10 (0.90–1.33)	1.08 (0.89–1.32)
$21–$100	1.05 (0.85–1.29)	1.07 (0.87–1.33)
$101+	1.29 (1.06–1.58)*	1.28 (1.04–1.58)*
Don't know	1.24 (1.03–1.49)*	1.25 (1.03–1.51)*

Abbreviations: aOR, adjusted odds ratio; BIPOC, Black/Indigenous/person of colour; CI, confidence interval; ref, reference category; SE, standard error; Y$_8$, year 8 of the COMPASS survey.

Notes: COMPASS is an ongoing prospective cohort study that collects survey data from a rolling sample of secondary school students in Canada.[22] Model I estimates the log-odds of missing data for perceptions of early COVID-19 restrictions; Model II estimates the log-odds of missing data for adherence to early COVID-19 restrictions. For each model outcome, missing = 1 vs. not missing = 0 (ref). Both models are adjusted for province.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

respectively), and were significantly less likely to report adhering to restrictions very seriously (aOR = 0.55, 95% CI: 0.46–0.66 and aOR = 0.37, 95: CI: 0.31–0.45, respectively), compared to those who did not engage in current binge drinking or vaping. Cigarette use was also associated with more than 2.5 times higher odds of not adhering to early COVID-19 restrictions (aOR = 2.65, 95% CI: 1.86–3.78) compared to cigarette non-users. We did not identify any significant associations between cannabis use and adherence to restrictions among students in our sample.

Student sociodemographic covariates were also associated with perceptions of and adherence to early COVID-19 restrictions. Compared to males, students who identified as female were less likely to perceive the restrictions as too weak (aOR = 0.74, 95% CI: 0.65–0.85) or take them seriously (aOR = 0.59, 95% CI: 0.47–0.72). Every unit increase in student age (years) was associated with 14% lower odds of both perceptions of the restrictions as too strict and not taking adherence to the restrictions seriously, and increases in age were associated with greater likelihood that students reported taking the early COVID-19 restrictions very seriously (aOR = 1.12, 95% CI: 1.07–1.16). Students who identified as BIPOC were more likely than White students to report that the restrictions were too weak (aOR = 1.61, 95% CI: 1.37–1.90), and were also more likely to adhere to the restrictions very seriously (aOR = 1.41, 95% CI: 1.23–1.61]). Similarly, BIPOC students were less likely than White students to perceive the restrictions as too strict (aOR = 0.73, 95% CI: 0.57–0.93). Generally, students with greater weekly spending money were more likely to perceive the restrictions as too strict, and increasingly less likely to take them seriously.

Discussion

The objective of our study was to examine associations of substance use and (1) perceptions of and (2) adherence to early COVID-19-related public health measures. While 3 in 4 adolescents in our sample perceived early COVID-19-related restrictions as appropriate, less than half of the sample actually reported taking the restrictions very seriously by adhering to public health guidelines. Fewer adolescents perceived the restrictions as too strict or did not adhere to them—14% and 5%, respectively. As hypothesized, those who engaged in current binge drinking, cigarette use and vaping were significantly more likely to perceive COVID-19-related restrictions as too strict and to report nonadherence, and in some cases were less likely to take the restrictions very seriously. These findings are consistent with the established evidence base surrounding perceptions of risk and risk-taking behaviours among adolescents in relation to substance use, and provide further evidence of an apparent association between substance use and nonadherence to COVID-19-related restrictions.[12] Where youth substance use prevention has been a key public health priority in Canada, understanding its relevance to the current COVID-19 pandemic may be important for attempts to "flatten the curve."[29]

We adopted a substance-specific analytic approach in our study rather than assessing general use of substances and, interestingly, we did not find a significant association between current cannabis use and adherence to COVID-19-related restrictions. In fact, adolescents in our sample who used cannabis were 34% less likely to perceive restrictions as too strict. Since adult recreational cannabis use has been legalized in Canada,[30] normalization among adolescents may partially explain this finding. Cannabis may also serve a different social purpose for some adolescents than other substances. Alcohol use, for example, tends to occur almost exclusively in social settings with peers[31] whereas solitary cannabis use is far more common among adolescents than solitary alcohol use.[32] Additional research is required to validate this finding and longitudinal evidence from future waves of the COMPASS study can be used to do so. Notably, recent findings that account for increases typically observed with age suggest that the early stages of the COVID-19 pandemic were not associated with changes in adolescent cannabis use.[8]

We also found that students who used cigarettes were simultaneously more likely

TABLE 4

TABLE 4
Descriptive comparisons by perceptions of and adherence to early COVID-19 restrictions among COMPASS Y_8 students (May–July 2020), N = 7876

Measure	Perceptions of early COVID-19 restrictions, n (%)					Adherence to early COVID-19 restrictions, n (%)				
	Thinks restrictions are too weak (n = 809, 10%)	Thinks restrictions are appropriate/good (n = 5952, 76%)	Thinks restrictions are too strict (n = 1115, 14%)	χ^2, F	p	Takes restrictions very seriously (n = 3360, 46%)	Takes restrictions somewhat seriously (n = 3883, 49%)	Does not take restrictions seriously (n = 363, 5%)	χ^2, F	p
Sex/gender										
Male	336 (11.6)	2138 (73.9)	419 (14.5)			1292 (44.7)	1435 (49.6)	166 (5.7)		
Female	446 (9.2)	3715 (76.8)	676 (14.0)	23.4	0.001	2263 (46.8)	2391 (49.4)	183 (3.8)	28.9	< 0.001
Other/prefer not to say	27 (18.5)	99 (67.8)	20 (13.7)			75 (51.4)	57 (39.0)	14 (9.6)		
Age (years)										
Mean age (SD)	15.2 (1.6)	15.0 (1.5)	14.8 (1.6)	18.1	< 0.001	15.1 (1.6)	15.0 (1.6)	15.0 (1.5)	2.7	0.064
Ethnicity										
White	533 (8.7)	4629 (75.7)	954 (15.6)	104.8	< 0.001	2648 (43.3)	3174 (51.9)	294 (4.8)	86.0	< 0.001
BIPOC	276 (15.7)	1323 (75.2)	161 (9.1)			982 (55.8)	709 (40.3)	69 (3.9)		
Weekly spending money										
Zero	220 (12.5)	1339 (76.5)	192 (11.0)			979 (55.9)	701 (40.0)	71 (4.1)		
$1–$20	144 (9.2)	1210 (77.3)	211 (13.5)			784 (50.1)	735 (47.0)	46 (2.9)		
$21–$100	132 (10.2)	974 (75.4)	186 (14.4)	50.2	< 0.001	540 (41.8)	687 (53.2)	65 (5.0)	218.1	< 0.001
$101+	145 (10.4)	986 (71.1)	256 (18.5)			444 (32.0)	837 (60.4)	106 (7.6)		
Don't know	168 (8.9)	1443 (76.7)	270 (14.4)			883 (46.9)	923 (49.1)	75 (4.0)		
Current (≥ 1/month) cannabis use										
No	753 (10.2)	5598 (75.9)	1022 (13.9)	9.4	0.009	3491 (47.4)	3593 (48.7)	289 (3.9)	166.3	< 0.001
Yes	56 (11.1)	354 (70.4)	93 (18.5)			139 (27.6)	290 (57.7)	74 (14.7)		
Current (≥ 1/month) binge drinking										
No	738 (10.6)	5355 (76.7)	888 (12.7)	105.4	< 0.001	3423 (49.0)	3317 (47.5)	241 (3.5)	333.6	< 0.001
Yes	71 (7.9)	597 (66.7)	227 (25.4)			207 (23.2)	566 (63.2)	122 (13.6)		
Current (≥ 1/month) cigarette use										
No	773 (10.2)	5791 (76.3)	1029 (13.5)	69.9	< 0.001	3573 (47.1)	3729 (49.1)	291 (3.8)	320.9	< 0.001
Yes	36 (12.7)	161 (56.9)	86 (30.4)			57 (20.2)	154 (54.4)	72 (25.4)		
Current (≥ 1/month) vaping										
No	713 (10.4)	5305 (77.2)	851 (12.4)	138.8	< 0.001	3435 (50.0)	3222 (46.9)	212 (3.1)	511.7	< 0.001
Yes	96 (9.5)	647 (64.3)	264 (26.2)			195 (19.4)	661 (65.6)	151 (15.0)		

Abbreviations: BIPOC, Black/Indigenous/person of colour; SD, standard deviation; Y_8, year 8 of the COMPASS survey.

Notes: COMPASS is an ongoing prospective cohort study that collects survey data from a rolling sample of secondary school students in Canada.[22] Bold values indicate significance at $\alpha < 0.05$.

to perceive COVID-19-related restrictions as too weak compared to appropriate, and too strict. This bifurcation suggests some level of heterogeneity among adolescents who use cigarettes; further research is needed to understand the specific factors which might lead to differences in their perceptions. Antisocial deviance may be a risk factor predicting adolescent tobacco use,[33] and is also associated with increased risk of generalized anxiety.[34] Efforts are required to clarify the role mental health

may play in the associations of substance use and adherence to public health measures. Emerging evidence shows that youth anxiety during COVID-19 may be associated with motivation and adherence to social distancing measures put in place by governments.[35] In one study, those who reported compliance reported greater psychological distress compared to those who did not.[36]

Females were less likely than males to perceive COVID-19-related restrictions as

too weak, yet they were also less likely to report nonadherence. Emerging research conducted within adult populations shows that women report taking the pandemic more seriously than men, and demonstrate higher rates of adherence to public health measures such as physical distancing.[37] Interestingly, findings from Paramita and colleagues[38] suggest that differences may be more closely related to gender psychology and gendered roles; in their study, males were more likely to comply

TABLE 5
Generalized estimating equation model results estimating the odds of perceptions of (Model I) and adherence to (Model II) early COVID-19 restrictions among COMPASS Y$_8$ students (May–July 2020), N = 7876

Measure	aOR (95% CI)			
	MODEL I		MODEL II	
	Perceptions of early COVID-19 restrictions		Adherence to early COVID-19 restrictions	
	Thinks restrictions are too weak[a]	Thinks restrictions are too strict[a]	Takes restrictions very seriously[b]	Does not take restrictions seriously[b]
Sex/gender				
Male (ref)	1.00	1.00	1.00	1.00
Female	**0.74 (0.65–0.85)*****	0.90 (0.79–1.02)	1.12 (0.99–1.26)	**0.59 (0.47–0.72)*****
Other/prefer not to say	1.42 (0.89–2.25)	0.98 (0.56–1.70)	1.39 (0.96–2.03)	1.17 (0.58–2.34)
Age (years)				
Estimate (SE)	1.03 (0.97–1.09)	**0.86 (0.80–0.92)*****	**1.12 (1.07–1.16)*****	**0.86 (0.80–0.93)*****
Ethnicity				
White (ref)	1.00	1.00	1.00	1.00
BIPOC	**1.61 (1.37–1.90)*****	**0.73 (0.57–0.93)****	**1.41 (1.23–1.61)*****	0.99 (0.78–1.28)
Weekly spending money				
Zero (ref)	1.00	1.00	1.00	1.00
$1–$20	**0.75 (0.60–0.94)***	1.17 (0.94–1.46)	**0.79 (0.69–0.91)****	**0.59 (0.42–0.81)****
$21–$100	0.86 (0.67–1.09)	1.26 (0.98–1.63)	**0.59 (0.50–0.69)*****	0.81 (0.56–1.19)
$101+	0.96 (0.79–1.18)	**1.61 (1.30–1.99)*****	**0.44 (0.37–0.52)*****	0.97 (0.73–1.28)
Don't know	**0.78 (0.65–0.94)***	1.25 (0.99–1.57)	**0.71 (0.62–0.81)*****	0.83 (0.64–1.09)
Current (≥ 1/month) cannabis use				
No (ref)	1.00	1.00	1.00	1.00
Yes	0.96 (0.67–1.39)	**0.66 (0.48–0.91)***	0.99 (0.76–1.29)	1.13 (0.79–1.65)
Current (≥1/month) binge drinking				
No (ref)	1.00	1.00	1.00	1.00
Yes	0.76 (0.57–1.01)	**1.68 (1.39–2.04)*****	**0.55 (0.46–0.66)*****	**1.66 (1.23–2.23)*****
Current (≥1/month) cigarette use				
No (ref)	1.00	1.00	1.00	1.00
Yes	**1.58 (1.06–2.36)***	**1.80 (1.30–2.48)*****	0.93 (0.65–1.34)	**2.65 (1.86–3.78)*****
Current (≥1/month) vaping				
No (ref)	1.00	1.00	1.00	1.00
Yes	1.12 (0.82–1.53)	**2.00 (1.61–2.49)*****	**0.37 (0.31–0.45)*****	**2.27 (1.69–3.05)*****

Abbreviations: aOR, adjusted odds ratio; BIPOC, Black/Indigenous/person of colour; CI, confidence interval; ref, reference category; SE, standard error; Y$_8$, year 8 of the COMPASS survey.

Notes: COMPASS is an ongoing prospective cohort study that collects survey data from a rolling sample of secondary school students in Canada.[22] Models estimate the log-odds of students' perceptions of (Model I) and adherence to (Model II) early COVID-19-related restrictions. Both models are adjusted for province.

[a] vs. "appropriate/good."

[b] vs. "somewhat seriously."

[*] $p < 0.05$

[**] $p < 0.01$

[***] $p < 0.001$

with COVID-19-related restrictions if they perceived egalitarian gender roles, and males exhibiting masculine psychology characteristics (e.g. aggressiveness, competitiveness) were less likely to adhere to mask-wearing. Studies examining adherence to COVID-19-related restrictions have largely considered sex/gender as dichotomous (e.g. males/men/boys vs. females/

women/girls).[39-41] Our study did not find a significant association among nonbinary or non-cissexual/non-cisgender adolescents, but we suspect this is due to limited statistical power. More comprehensive definitions of sex and gender should be employed in future research.

Adolescents who identified as BIPOC were more likely than White adolescents to

perceive COVID-19-related restrictions as too weak and less likely to perceive them as too strict. Consistent with evidence that Black, Latinx and Asian adults may be more likely to comply with COVID-19 mask-wearing regulations,[42-44] we also found that BIPOC-identifying adolescents in our sample were more likely to take restrictions very seriously. Racialized and

historically marginalized groups have been disproportionately impacted by COVID-19,[45] and so perceived vulnerability may play an important role in the way that ethnicity shapes adherence.[44] Hearne and Niño[44] further identified that ethnicity can intersect with gender to influence adherence; during April to June 2020 (overlapping with the timeframe in which our data were collected), they found White males to be least likely to wear masks in compliance with COVID-19-related restrictions. While intersectionality was not a direct consideration in our current study, due to limited power to make comparisons, further research is required.

Other sociodemographic factors were associated with perceptions of and adherence to COVID-19-related restrictions. Adherence increased with age, and older adolescents were less likely to perceive restrictions as too strict or to not take them seriously. Younger Canadians may be less likely to adhere to COVID-19-related restrictions.[17,46,47] Lower income levels may also be associated with noncompliance.[46] Essential service workers who cannot work from home also face increased risk of viral exposure, given that the ability to work remotely favours those with higher levels of education and income.[48]

Strengths and limitations

A primary strength of our study is its timely, large COVID-19-related sample size enabled by COMPASS data collection procedures. The use of active-information, passive-consent protocols supports robust self-report research by limiting self-selection and response biases for youth substance use measures.[49,50] Student anonymity encourages honest reporting and helps to mitigate the risk of social desirability bias in COMPASS. Our complex modelling approach represents another key strength by adjusting for student-level clustering to account for shared variation in substance use behaviours among students within the same school environments.[51]

There are, however, certain limitations. First, a notable limitation of this study is its cross-sectional design, which precludes us from making causal or directional inferences about any correlation between substance use and perceptions of or adherence to early COVID-19-related restrictions among adolescents. As noted by Fendrich and colleagues,[14] it is also plausible that adhering to COVID-19-related restrictions such

as physical distancing could increase risk for problematic substance use via social isolation. As longer-term impacts unfold, ongoing COMPASS longitudinal data collection will provide a unique opportunity to fully understand the association between public health restrictions and substance use among adolescents. Since data were collected in the early stages of the pandemic, longitudinal research would better capture any changes in adolescent substance use and restriction perceptions or adherence over time as restrictions evolve.

Second, it is important to note that the questions used in this study to assess COVID-19 restriction perceptions and adherence have not been validated. Given that adolescents' perceptions and adherence might have differed according to specific government restrictions, we recommend future studies consider how adolescents' attitudes and behaviours may have compared in specific instances (e.g. physical distancing from peers vs. elderly family members). Additional research should also further consider the role of substance use as a potential coping method among youth during COVID-19.[9,11] It is a limitation of the current study that analyses do not consider coping motives or mental health as an underlying mechanism of adolescent substance use during COVID-19.

Third, the measure of adolescents' weekly spending money is a limited SES proxy measure better reflecting individuals' available pocket money or part-time employment rather than household SES. While commonly used as a more accessible measure for youth than household income,[52] it is possible that adolescents from higher SES households would report lower weekly spending money and vice versa. However, weekly spending money remains a relevant covariate of these analyses, as it reflects opportunity to purchase substances. Indeed, previous research has shown that greater available spending money is associated with greater likelihood of individual and polysubstance use among adolescents.[51,53-56]

Fourth, it is important to note that the COMPASS participant sample is not representative of all adolescents in Canada. The COMPASS study relies on purposive sampling to achieve a robust sample size. Therefore, findings are not necessarily generalizable.

Fifth, the COVID-19 pandemic has naturally imposed limitations on normal COMPASS data collection procedures. Study protocol changes and implications have been described elsewhere in the literature.[23] The change in survey delivery mode from paper-based to online resulted in a lower-than-normal participation rate, with fewer students completing the survey. Bias due to self-selection should be considered as a possible confounder of the associations observed in this study.

Conclusion

Using data collected in the early months of the COVID-19 pandemic, we sought to examine how substance use is associated with adolescents' perceptions of and adherence to COVID-19-related restrictions in Canada. Adolescents who engaged in current binge drinking, cigarette use and vaping were more likely to perceive COVID-19-related restrictions as too strict and to report nonadherence; however, these associations were not consistent across substances—those who used cannabis were less likely to perceive COVID-19-related restrictions as too strict.

Our findings have implications for public health data collection measures informing COVID-19 preventive practices in Canada. Comprehensive and continual monitoring of adolescent health behaviours during the COVID-19 pandemic can help to better characterize adolescent risk. More specifically, ongoing population-level monitoring should consider adolescent substance use as an important indicator of perceptions and adherence to COVID-19-related public health measures. By identifying specific behavioural risk groups—such as adolescents who engaged in binge drinking, cigarette use and vaping during the early months of COVID-19—this study can directly inform targeted public health measures aimed at reducing the risk and transmission of COVID-19 across communities.

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Conflicts of interest

There are no conflicts of interest to declare.

Scott T. Leatherdale is an Associate Scientific Editor with the HPCDP Journal, but has recused himself from the review process for this paper.

Authors' contributions and statement

IR planned the methodology, conducted the formal analysis, interpreted the results and drafted the manuscript. STL conceptualized the COMPASS study, acquired funding, managed resources, provided supervision for the host study and corresponding data in this manuscript, and revised the manuscript for critical intellectual content. MDG and YJ provided supervision for the analyses and revised the manuscript for critical intellectual content.

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References

1. Ennett ST, Bauman KE, Hussong A, et al. The peer context of adolescent substance use: findings from social network analysis. J Res Adolesc. 2006;16(2):159-86. https://doi.org/10.1111/j.1532-7795.2006.00127.x

2. Wesche R, Kreager DA, Lefkowitz ES. Sources of social influence on adolescents' alcohol use. J Res Adolesc. 2019;29(4):984-1000. https://doi.org/10.1111/jora.12439

3. Lipari RN. Trends in adolescent substance use and perception of risk from substance use. In: The CBHSQ report. Rockville (MD): Substance Abuse and Mental Health Services Administration; 2013. Available from: https://www.ncbi.nlm.nih.gov/books/NBK385059/

4. Steinberg L. A social neuroscience perspective on adolescent risk-taking. Dev Rev. 2008;28(1):78-106. https://doi.org/10.1016/j.dr.2007.08.002

5. Reniers RL, Murphy L, Lin A, Bartolomé SP, Wood SJ. Risk perception and risk-taking behaviour during adolescence: the influence of personality and gender. PLoS One. 2016;11(4):e0153842. https://doi.org/10.1371/journal.pone.0153842

6. Op de Macks ZA, Bunge SA, Bell ON, Kriegsfeld LJ, Kayser AS, Dahl RE. The effect of social rank feedback on risk taking and associated reward processes in adolescent girls. Soc Cogn Affect Neurosci. 2017;12(2):240-50. https://doi.org/10.1093/scan/nsw125

7. Dumas TM, Ellis W, Litt DM. What does adolescent substance use look like during the COVID-19 pandemic? Examining changes in frequency, social contexts, and pandemic-related predictors. J Adolesc Health. 2020;67(3):354-61. https://doi.org/10.1016/j.jadohealth.2020.06.018

8. Leatherdale ST, Bélanger RE, Gansaonré RJ, et al. Examining the impact of the early stages of the COVID-19 pandemic period on youth cannabis use: adjusted annual changes between the pre-COVID and initial COVID-lockdown waves of the COMPASS study. BMC Public Health. 2021;21:1181. https://doi.org/10.1186/s12889-021-11241-6

9. Romano I, Patte KA, de Groh M, et al. Substance-related coping behaviours among youth during the early months of the COVID-19 pandemic. Addict Behav Rep. 2021;14:100392. https://doi.org/10.1016/j.abrep.2021.100392

10. Layman HM, Thorisdottir IE, Halldorsdottir T, Sigfusdottir ID, Allegrante JP, Kristjansson AL. Substance use among youth during the COVID-19 pandemic: a systematic review. Curr Psychiatry Rep. 2022;24(6):307-24. https://doi.org/10.1007/s11920-022-01338-z

11. Pelham III WE, Tapert SF, Gonzalez MR, et al. Early adolescent substance use before and during the COVID-19 pandemic: a longitudinal survey in the ABCD Study Cohort. J Adolesc Health. 2021;69(3):390-7. https://doi.org/10.1016/j.jadohealth.2021.06.015

12. Miech R, Patrick ME, Keyes K, O'Malley PM, Johnston L. Adolescent drug use before and during U.S. national COVID-19 social distancing policies. Drug Alcohol Depend. 2021;226:108822. https://doi.org/10.1016/j.drugalcdep.2021.108822

13. Liang L, Ren H, Cao R, et al. The effect of COVID-19 on youth mental health. Psychiatr Q. 2020;91(3):841-52. https://doi.org/10.1007/s11126-020-09744-3

14. Fendrich M, Becker J, Park C, Russell B, Finkelstein-Fox L, Hutchison M. Associations of alcohol, marijuana, and polysubstance use with non-adherence to COVID-19 public health guidelines in a US sample. Subst Abus. 2021;42(2):220-6. https://doi.org/10.1080/08897077.2021.1891603

15. Bacque Dion C, Bélanger R, Leatherdale ST, Haddad S. Adolescents' adoption of COVID-19 preventive measures during the first months of the pandemic: what led to early adoption? Health Promot Chronic Dis Prev Can. 2021;41(12):423-30. https://doi.org/10.24095/hpcdp.41.12.03

16. Hills S, Eraso Y. Factors associated with non-adherence to social distancing rules during the COVID-19 pandemic: a logistic regression analysis. BMC Public Health. 2021;21(1):352. https://doi.org/10.1186/s12889-021-10379-7

17. Yang XY, Gong RN, Sassine S, et al. Risk perception of COVID-19 infection and adherence to preventive measures among adolescents and young adults. Children. 2020;7(12):311. https://doi.org/10.3390/children7120311

18. Aerts C, Revillaid M, Duval L, et al. Understanding the role of disease knowledge and risk perception in shaping preventive behavior for selected vector-borne diseases in Guyana. PLoS Negl Trop Dis. 2020;14(4): e0008149. https://doi.org/10.1371/journal.pntd.0008149

19. Kim JS, Choi JS. Middle East respiratory syndrome-related knowledge, preventive behaviours and risk perception among nursing students during outbreak. J Clin Nurs. 2016; 25(17-18):2542-9. https://doi.org/10.1111/jocn.13295

20. Hawke LD, Hayes E, Darnay K, Henderson J. Mental health among transgender and gender diverse youth: an exploration of effects during the COVID-19 pandemic. Psychol Sex Orientat Gend Divers. 2021;8(2):180-7. https://doi.org/10.1037/sgd0000467

21. Fish JN, McInroy LB, Paceley MS, et al. "I'm kinda stuck at home with unsupportive parents right now": LGBTQ youths' experiences with COVID-19 and the importance of online support. J Adolesc Health. 2020;67(3):450-2. https://doi.org/10.1016/j.jadohealth.2020.06.002

22. Leatherdale ST, Brown KS, Carson V, et al. The COMPASS study: a longitudinal hierarchical research platform for evaluating natural experiments related to changes in school-level programs, policies and built environment resources. BMC Public Health. 2014; 14:331. https://doi.org/10.1186/1471-2458-14-331

23. Reel B, Battista K, Leatherdale ST. COMPASS protocol changes and recruitment for online survey implementation during the COVID-19 pandemic. Technical Report Series, 7(2). Waterloo (ON): University of Waterloo; 2020. 12 p.

24. Qualtrics XM survey software. Provo (Utah): Qualtrics; 2005.

25. Wong SL, Shields M, Leatherdale S, Malaison E, Hammond D. Assessment of validity of self-reported smoking status. Health Rep. 2012;23(1):47-53.

26. Elton-Marshall T, Leatherdale ST, Manske SR, Wong K, Ahmed R, Burkhalter R. Research methods of the Youth Smoking Survey (YSS). Chronic Dis Inj Canada. 2011;32(1): 47-54.

27. Buja A, Mortali C, Mastrobattista L, et al. Pathways connecting socioeconomic variables, substance abuse and gambling behaviour: a cross-sectional study on a sample of Italian high-school students. BMJ Open. 2019; 9(11):e031737. https://doi.org/10.1136/bmjopen-2019-031737

28. SAS Institute Inc. SAS version 9.4. Cary (NC): SAS Institute Inc; 2016.

29. Thunström L, Newbold SC, Finnoff DC, Ashworth M, Shogren J. The benefits and costs of using social distancing to flatten the curve for COVID-19. J Benefit-Cost Anal. 2020; 11(2):179-95. https://doi.org/10.1017/bca.2020.12

30. Cannabis Act. S.C. 2018, c. 16. Ottawa (ON): Minister of Justice Canada; 2018. Available from: https://laws-lois.justice.gc.ca/PDF/C-24.5.pdf

31. Johnston LD, Bachman JG, O'Malley PM. Monitoring the future: questionnaire responses from the nation's high school seniors, 2011. Ann Arbor (MI): University of Michigan, Institute for Social Research; 2013.

32. Creswell KG, Chung T, Clark DB, Martin CS. Solitary cannabis use in adolescence as a correlate and predictor of cannabis problems. Drug Alcohol Depend. 2015;156:120-5. https://doi.org/10.1016/j.drugalcdep.2015.08.027

33. Weiss B, Nguyen T, Trung L, Ngo V, Lau A. Tobacco smoking and antisocial deviance among Vietnamese, Vietnamese-American, and European-American Adolescents. J Abnorm Child Psychol. 2019;47(1):59-69. https://doi.org/10.1007/s10802-018-0416-8

34. Holliday E, Gould TJ. Nicotine, adolescence, and stress: a review of how stress can modulate the negative consequences of adolescent nicotine abuse. Neurosci Biobehav Rev. 2016: 65:173-84. https://doi.org/10.1016/j.neubiorev.2016.04.003

35. Oosterhoff B, Palmer CA, Wilson J, Shook N. Adolescents' motivations to engage in social distancing during the COVID-19 pandemic: associations with mental and social health. J Adolesc Health. 2020;67(2):179-85. https://doi.org/10.1016/j.jadohealth.2020.05.004

36. Saurabh K, Ranjan S. Compliance and psychological impact of quarantine in children and adolescents due to Covid-19 pandemic. Indian J Pediatr. 2020;87(7):532-6. https://doi.org/10.1007/s12098-020-03347-3

37. Galasso V, Pons V, Profeta P, Becher M, Brouard S, Foucault M. Gender differences in COVID-19 attitudes and behavior: panel evidence from eight countries. Proc Natl Acad Sci USA. 2020;117(44):27285-91. https://doi.org/10.1073/pnas.2012520117

38. Paramita W, Rostiani R, Winahjoe S, Wibowo A, Virgosita R, Audita H. Explaining the voluntary compliance to COVID-19 measures: an extrapolation on the gender perspective. Glob J Flex Syst Manag. 2021;22(Suppl 1):1-18. https://doi.org/10.1007/s40171-021-00261-1

39. Tzur Bitan D, Grossman-Giron A, Bloch Y, Mayer Y, Shiffman N, Mendlovic S. Fear of COVID-19 scale: psychometric characteristics, reliability and validity in the Israeli population. Psychiatry Res. 2020;289:113100. https://doi.org/10.1016/j.psychres.2020.113100

40. Brouard S, Vasilopoulos P, Becher M. Sociodemographic and psychological correlates of compliance with the COVID-19 public health measures in France. Can J Polit Sci. 2020;53(2): 253-8. https://doi.org/10.1017/S0008423920000335

41. Clark C, Davila A, Regis M, Kraus S. Predictors of COVID-19 voluntary compliance behaviors: an international investigation. Glob Transit. 2020; 2:76-82. https://doi.org/10.1016/j.glt.2020.06.003

42. Papageorge NW, Zahn MV, Belot M, et al. Socio-demographic factors associated with self-protecting behavior during the Covid-19 pandemic. J Popul Econ. 2021;34(2):691-738. https://doi.org/10.1007/s00148-020-00818-x

43. Capraro V, Barcelo H. The effect of messaging and gender on intentions to wear a face covering to slow down COVID-19 transmission. J Behav Econ Pol. 2020;4(S2):45-55.

44. Hearne BN, Niño MD. Understanding how race, ethnicity, and gender shape mask-wearing adherence during the COVID-19 pandemic: evidence from the COVID Impact Survey. J Racial Ethn Health Disparities. 2022;9(1):176-83. https://doi.org/10.1007/s40615-020-00941-1

45. Raifman MA, Raifman JR. Disparities in the population at risk of severe illness from COVID-19 by race/ethnicity and income. Am J Prev Med. 2020;59(1):137-9. https://doi.org/10.1016/j.amepre.2020.04.003

46. Nivette A, Ribeaud D, Murray A, et al. Non-compliance with COVID-19-related public health measures among young adults in Switzerland: insights from a longitudinal cohort study. Soc Sci Med. 2021;268:113370. https://doi.org/10.1016/j.socscimed.2020.113370

47. Ontario Ministry of Health. Youth compliance with COVID-19 public health measures [Internet]. Toronto (ON): Government of Ontario; 2020 [cited 2022 Jul 18]. Available from: https://esnetwork.ca/briefings/youth-compliance-with-covid-19-public-health-measures/

48. Bonacini L, Gallo G, Scicchitano S. Working from home and income inequality: risks of a 'new normal' with COVID-19. J Popul Econ. 2021;34:303-60. https://doi.org/10.1007/s00148-020-00800-7

49. Rojas NL, Sherrit L, Harris S, Knight JR. The role of parental consent in adolescent substance use research. J Adolesc Health. 2008;42(2):192-7. https://doi.org/10.1016/j.jadohealth.2007.07.011

50. White VM, Hill DJ, Effendi Y. How does active parental consent influence the findings of drug-use surveys in schools? Eval Rev. 2004;28(3):246-60. https://doi.org/10.1177/0193841X03259549

51. Costello MJE, Leatherdale ST, Ahmed R, Church DL, Cunningham JA. Co-morbid substance use behaviors among youth: any impact of school environment? Glob Health Promot. 2012;19(1):50-9. https://doi.org/10.1177/1757975911429873

52. Elton-Marshall T, Leatherdale ST, Burkhalter R. Tobacco, alcohol and illicit drug use among Aboriginal youth living off-reserve: results from the Youth Smoking Survey. CMAJ. 2011;183(8):E480-6. https://doi.org/10.1503/cmaj.101913

53. Butler A, Romano I, Patte K, et al. Psychological correlates and binge drinking behaviours among Canadian youth: a cross-sectional analysis of the mental health pilot data from the COMPASS study. BMJ Open. 2019;9(6):e028558. https://doi.org/10.1136/bmjopen-2018-028558

54. Czoli CD, Hammond D, Reid JL, Cole AG, Leatherdale ST. Use of conventional and alternative tobacco and nicotine products among a sample of Canadian youth. J Adolesc Health. 2015;57(1):123-5. https://doi.org/10.1016/j.jadohealth.2015.03.006

55. Romano I, Williams G, Butler A, Aleyan S, Patte KA, Leatherdale ST. Psychological and behavioural correlates of cannabis use among Canadian secondary school students: findings from the COMPASS study. Can J Addict. 2019;10(3):10-21. https://doi.org/10.1097/CXA.0000000000000058

56. Zuckermann AM, Gohari MR, Romano I, Leatherdale ST. Changes in cannabis use modes among Canadian youth across recreational cannabis legalization: data from the COMPASS prospective cohort study. Addict Behav. 2021;122:107025. https://doi.org/10.1016/j.addbeh.2021.107025

Original qualitative research

Investigating reports of cancer clusters in Canada: a qualitative study of public health communication practices and investigation procedures

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Abstract

Introduction: Public health officials provide an important public service responding to community concerns around cancer and often receive requests to investigate patterns of cancer incidence and communicate findings with citizens. In this study, we identified procedures Canadian public health officials followed when investigating reports of cancer clusters, and explored the challenges officials faced conducting risk communication with communities.

Methods: Thirteen interviews were administered by telephone with 15 officials across Canadian jurisdictions and analyzed using thematic analysis. A content analysis of procedural documents received from five provinces was also undertaken.

Results: A third of provinces/territories in this study did not use any consistent guidelines to investigate reports of cancer clusters, a third used their own guidelines and a third used guidelines from other countries. Each Canadian jurisdiction identified a different agency or individual responsible for investigating cluster inquiries. Officials in most interviews considered public education to be the primary objective of risk communication during an investigation. Officials in only 4 of 13 interviews cited an overall positive response from the public after investigating reports of a cancer cluster.

Conclusion: Differences in practices used to investigate suspected cancer clusters by public health officials were revealed in this work. Establishing pan-Canadian cancer cluster guidelines could improve procedural consistency across jurisdictions and offer enhanced opportunities to compare cluster responses for evaluation. A reporting system to track reported clusters may improve information sharing between federal, provincial/territorial and local investigators. During formal investigations, face-to-face participatory communication approaches should be explored to improve citizen engagement and manage community concerns.

Keywords: space-time clustering, neoplasms, investigative techniques, guideline adherence, health communication, Canada

Highlights

- This is the first study to explore cluster investigation practices for noncommunicable diseases by public health agencies and officials across Canada.
- Analysis of policy documents revealed inconsistent procedures for investigating clusters in some jurisdictions and a lack of formal protocols and guidelines in others.
- Interviews with health officials revealed a desire for more training for face-to-face risk communication to manage citizen concerns about cancer and improve public trust during full-scale investigations.
- Establishing pan-national cancer cluster guidelines could standardize investigating procedures, enhance comparability between Canadian jurisdictions and lead to the wider-scale adoption of cluster response best practices.

Introduction

Public health officials play a vital role investigating and responding to community reports of space-time disease clustering. Although clusters of various health outcomes including birth defects,[1] neurological diseases such as multiple sclerosis,[2] and cancers[3] have been reported in numerous Canadian communities in recent years, cancer clusters attract an exceptional level of enduring public concern and extensive media interest for a couple of reasons. First, cancer clusters occur when a greater-than-expected number of cases of cancer occur in a group of individuals in a specific geographic area during a particular period of time,[4] and despite the fact that the term "cancer" covers a multitude of diseases with numerous causes, cancer clusters tap into a common anxiety that toxic industrial exposures or environmental pollutants in a geographic location may be to blame.[5] Second, the long latency of cancer makes it particularly challenging to investigate exposures that may no longer be present and reassure community members that their concerns will be addressed.[6]

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These challenges present difficulties for public health officials communicating and engaging with a fearful and distrustful public,[7] and are compounded by the statistical challenges officials face when investigating a small number of cases using analyses with low statistical power.[8] Consequently, in the overwhelming majority of suspected cancer clusters, the role of chance cannot be ruled out when explaining an increase in observed cases of cancer relative to what would be expected, and in very few cases is a link to a specific cause able to be established when they are investigated.[9]

Nonetheless, responding to and investigating reports of cancer clusters remains an important practice for public health officials, who often consider this to be a way of addressing community concerns about cancer incidence[10] without necessitating full-scale, resource-intensive epidemiological studies into disease etiology. Investigating reports of cancer clusters has also been seen as a way to educate citizens on cancer risk factors and known carcinogenic exposures;[11] therefore, it continues to be a public service regularly undertaken by public health agencies and officials in Canada and all over the world.[12]

As health officials are not typically able to establish the true presence of a cancer cluster, either because excess cases have not been confirmed or an etiological linkage to an exposure is not possible, very few investigations into a community's reports of a cluster trigger a full-scale epidemiological study. Still, the process of investigating cancer complaints can provide reassurance to citizens and an opportunity to educate the public, if certain best practices are adopted by public health officials in responding to the community's inquiries about cancer. Indeed, Trumbo noted that although very few of the thousands of cancer cluster complaints in the US end up leading to significant investigations, the interactions with community members that take place during the initial response process provide an opportunity for meaningful public education about cancer.[12]

Cluster response best practices, including incorporating effective risk communication at all stages and supplying concerned citizens with adequate information, are viewed as essential in fostering accurate perceptions of risk.[13] In addition, transparency and open communication around cancer cluster investigation procedures have been shown to be important in promoting beliefs around procedural fairness, which in turn increases citizen satisfaction with the results of full-scale investigations and trust in authorities.[14] Furthermore, confusion around the methodologies used to investigate reported clusters and perceived flaws in the investigation procedure can influence beliefs around expert competency and credibility.[15] For these reasons, the United States and other nations have developed guidelines for investigating cancer cluster inquiries to provide public health officials with a systematic methodology for their analysis and to guide their response to citizen concerns.[16-18]

Researchers have twice studied the state of cancer cluster investigations in the US, once in the 1990s[19] and most recently a decade ago,[9] and each time recommended changes to investigation approaches and priorities. In the absence of national guidelines for investigating reports of cancer clusters in Canada, it is not currently known what cancer cluster investigation procedures are used by public health officials across Canadian jurisdictions.

In this study, we aimed to examine the experiences of public health officials who have investigated suspected cancer clusters, particularly with respect to their approaches to responding to inquiries and communicating the results of investigations and the risk of cancer. Although provincial and territorial jurisdictions are responsible for the provision of most services related to health, there exist considerable divergences in the administration and organization of public health policies and practices between the various Canadian provinces and territories due to their local population and geographic characteristics. Some employ a regionalized approach for the delivery of public health programs and services, while others have opted for a top-down, centralized approach.[20] Therefore, we hypothesized that the primary agencies and officials responsible for investigating reports of cancer clusters would vary significantly across Canada.

Methods

Ethics approval

Ethics approval for this research was obtained from McMaster University's McMaster Research Ethics Board in the summer of 2019 (MREB#: 1763).

Interviews

The participants selected for interviews for this research project were public health officials from various Canadian jurisdictions who either had had experience investigating reports of a cancer cluster in a community or who would be tasked with investigating should a cancer cluster inquiry arise. Between the fall of 2019 and summer of 2020, a total of 13 telephone interviews were conducted and recorded with 15 public health officials across Canada (two interviews had two participants present). The average interview length was 45 minutes (range: 30–65 min).

Key informants to interview for this project were identified using two approaches to achieve representation from most Canadian provinces and one territory. In jurisdictions where the authors had no prior connections or knowledge of suspected cancer cluster investigations, an email was sent to the province's primary health ministry (or public health agency) through their general inquiry web page to receive the contact information for public health officials responsible for investigating. In other jurisdictions where documented or known suspected cancer clusters had been investigated, the authors contacted the lead public health official in charge of investigating directly according to publicly available reports or news articles.

Interviews were semi-structured and carried out by one researcher (CS). Interviewees received the questions prior to the interview. Questions covered four broad topics: the interviewee's jurisdiction's cancer cluster investigation methodologies, the outcomes of the investigations, the challenges public health officials encountered with risk communication, and communication approaches and goals. This research followed a constructivist framework whereby the data gathered from interviews are recognized as personally and socially constructed knowledge reflective of the participants' individual contexts, while the researchers' interpretation of this data is merely an attempt to elucidate the participants' particular realities.[21]

Analysis

Thematic analysis
Interviews were transcribed using Otter, a speech-to-text transcription software (Otter.ai, Los Altos, CA, USA), with occasional

corrections to words transcribed manually by one researcher (CS) to remedy errors in the automatic transcription process. Transcripts were read several times and a thematic analysis of the interview transcripts was carried out using NVivo 12 (QSR International [Americas] Inc., Burlington, MA, USA). Thematic analyses are a common qualitative analytic method to help identify themes from an extensive set of text-based data.

This study used a semantic approach to analyze participant responses; therefore, responses were analyzed as they were recorded in the interviews.[22] One researcher (CS) coded text segments in each interview transcript and categorized codes into common themes that emerged for each question posed to participants to allow for comparisons across interviews. These codes were discussed with the secondary researcher (NY) to assess how well the identified themes related to the research questions of this study and their relation to the dataset. The coding process followed an inductive approach,[23] whereby dominant themes in the data were used to summarize general similarities and differences in investigative practices across Canadian jurisdictions.

Content analysis

In addition to the interview data collected, some officials shared documents summarizing the cancer cluster investigation guidelines or practices used in their jurisdiction. A content analysis of these documents was undertaken using the same coding framework that was used for the interview transcripts to supplement the information that was not already captured in the interviews. The coded themes identified in the thematic analysis of the interview transcripts and the content analysis of the procedural documents were organized and analyzed in an electronic spreadsheet.

Results

Thirteen interviews were conducted with 15 public health officials whose expertise on investigating reports of cancer clusters spanned 7 out of 10 Canadian provinces and one out of three Canadian territories. Additionally, one interview was conducted with a public health official who had investigated a confirmed cancer cluster in a northern Canadian territory while employed under the federal Canadian Public Health Agency's field epidemiology program, which occasionally deploys epidemiologists to investigate cancer clusters when a provincial or territorial government requests assistance. Four interviews were conducted with participants who had investigated reports of cancer clusters in Ontario, two in Manitoba and one each in Alberta, British Columbia, Saskatchewan, Quebec, New Brunswick, Northwest Territories and in Canada investigated by federal officials.

The job titles of the participants interviewed for this research varied: five were senior epidemiologists at a public health department or agency; five were medical officers of health or chief medical officers at a municipal, regional, provincial or territorial level; four held senior management roles in cancer data analytics departments at a public health agency; and one was a specialist in environmental health at a local public health department. The findings from this study are summarized according to three main themes: investigation procedures, investigation characteristics and communication approaches.

Investigation procedures for responding to reports of cancer clusters

Investigation procedures into suspected cancer clusters by Canadian jurisdiction are summarized in Table 1. Three out of nine jurisdictions (New Brunswick, Northwest Territories and Canada) did not strictly adhere to any one protocol and did not design their own guidelines for investigating reports of cancer clusters. Another three out of nine jurisdictions (British Columbia, Alberta and Manitoba) had each produced their own procedural guidelines to use for investigating reports of cancer clusters. In two jurisdictions, Ontario and Quebec, cluster investigation guidelines from other nations (the US Centers for Disease Control and Prevention [CDC] and France's National Public Health Agency) served as the primary guidance that officials consulted in those provinces to investigate suspected cancer clusters. In Saskatchewan, a procedural document authored by the lead investigating agency was not shared with the researchers and could not be analyzed as part of this study; however, the interviewee there described guidelines that were based largely on those authored by the US CDC.

Of the jurisdictions that shared procedural documents (n = 5), three (Ontario, British Columbia and Quebec) followed a four-step investigation procedure, while the remaining two (Alberta and Manitoba) followed three- and five-step procedures, respectively. All five procedural documents described a primary evaluation stage in which investigators collected information from inquirers about the reported clustering of cancer cases in order to assess the scope of the investigation required. According to the participants we interviewed, most community cancer cluster inquiries do not meet established plausibility criteria based on the information collected about the type(s) and number of cancer cases reported, the geographic boundaries, the timing of diagnoses and any community risk factors; therefore, further assessment (i.e. case evaluation and incidence evaluation using data from a cancer registry) as part of a larger-scale investigation are not typically pursued. Only four jurisdictions followed guidelines that explicitly referenced risk communication in their procedures and of these four, three included risk communication at every step of their investigation.

Interviewees from each jurisdiction described a different lead investigating agency or individual responsible for responding to cancer cluster inquiries. The lead agencies included local, regional and territorial public health departments or agencies (Ontario, Quebec, Northwest Territories) and cancer-specific agencies or departments (British Columbia, Saskatchewan and New Brunswick). In Manitoba, however, the medical officer of health from the regional health authority where the inquiry originated assumes primary responsibility over investigating the complaint, with support from provincial agencies. In Alberta's guidelines, a lead investigating agency or individual is not specified. The procedures there suggest that the initial agency contacted by the citizen may remain involved in either a lead or liaison role while investigating the reported cluster, which is in contrast to the procedures followed in the other eight jurisdictions that have identified one main lead agency or individual in charge.

Investigation characteristics of suspected cancer clusters

Characteristics of the investigations into suspected cancer clusters carried out by the public health officials interviewed for this work are summarized in Table 2. Nearly all officials stated that local

TABLE 1
Characteristics of investigation procedures into suspected cancer clusters and methodologies by Canadian jurisdiction (n = 9)

Jurisdiction	Lead investigating agency	Other agencies and actors that may be involved in the investigation	Document type consulted	Year produced	Procedural authoring agency	Other guidelines referenced in procedures	Steps defined as part of the procedure	Risk communication included in procedure
Ontario	Local public health department	Provincial public health agency; provincial cancer agency; provincial ministry of environment; provincial ministry of labour	Guideline	2013	US CDC	None	1. Initial contact and response 2. Assessment 3. Determining feasibility of conducting an epidemiological study 4. Conducting an epidemiological investigation	Yes—at every stage
British Columbia	Cancer control and research department of provincial cancer agency	Local medical health officer; provincial ministry of health; regional First Nations Health Authority	Guideline	1998	British Columbia Cancer Agency	None	1. Initial contact and response 2. Assessment and case evaluation 3. Determine feasibility of epidemiological study 4. Etiological investigation	No
Alberta	Not defined—guidelines state the lead may be whichever initial agency was contacted, the regional Medical Officer of Health, the cancer surveillance department at Alberta Health Services or the surveillance unit of Alberta Health and Wellness	Provincial authority for health service delivery; provincial ministry of health; regional Medical Officer of Health; federal health ministry (for on-reserve investigations)	Guideline	2011	Alberta Health and Wellness; Alberta Health Services	US CDC; New Zealand; Europe	1. Primary evaluation and collection of data from requestor 2. Secondary evaluation and assessment of cases for further action 3. Tertiary evaluation involving ongoing surveillance or etiological investigation	Yes—at every stage
Quebec	Regional public health agency	Provincial public health agency; local health or public health professionals; provincial cancer registry; expert advisory committee consisting of medical and public health professionals and toxicologists; provincial ministry of environment; provincial ministry of labour	Guideline	2005	Institut de veille sanitaire (France), now part of the Agence nationale de santé publique	Laval University; US CDC; Netherlands; New Zealand	1. Evaluation of reported cases 2. Validation of cases and environmental exposure 3. In-depth descriptive study 4. Additional epidemiological work	Yes—at every stage

Jurisdiction	Lead investigating agency	Other agencies and actors that may be involved in the investigation	Document type consulted	Year produced	Procedural authoring agency	Other guidelines referenced in procedures	Steps defined as part of the procedure	Risk communication included in procedure
Manitoba	Medical officer of health from the regional health authority	Provincial cancer agency; provincial cancer registry; provincial ministry of health; provincial ministry of labour	Guideline	2015	Regional health authority	US CDC; Alberta guidelines	1. Primary evaluation and information intake 2. Primary evaluation and assessment of information 3. Secondary evaluation and analysis of data 4. Determine feasibility of epidemiological study 5. Conduct epidemiological study	Yes—at some stages
Saskatchewan	Provincial cancer agency	Regional medical health officer; provincial health authority; provincial ministry of health; provincial ministry of labour	Unknown	Early 2000s	Saskatchewan Cancer Agency	US CDC	NA	NA
New Brunswick	Cancer department of provincial ministry of health and/or Office of the Chief Medical Officer of Health	Provincial department of environment; communications branch at the provincial department of health; analytics branch at the provincial department of health; regional medical health officer	No formal protocol or guideline strictly followed	NA	NA	US CDC	NA	NA
Northwest Territories	Territorial Department of Health and Social Services	Academic researchers and/or expert scientists from other provinces; PHAC field epidemiologist; local clinician	No formal protocol or guideline strictly followed	NA	NA	US CDC; Alberta guidelines	NA	NA
Canada	PHAC's Canadian Field Epidemiology Program	Provincial or territorial ministry of health; chief medical health officer from province or territory; provincial, territorial, regional and/or local health authority	No formal protocol or guideline strictly followed	NA	NA	US CDC	NA	NA

Abbreviations: NA, not available; PHAC, Public Health Agency of Canada; US CDC, United States Centers for Disease Control and Prevention.

Interview	Jurisdiction	How suspected cancer clusters were reported	Frequency of reports	Environmental or occupational hazards suspected	Involvement of officials trained in risk communication	Perceived public satisfaction with response to report of cluster	Need for ongoing outreach or monitoring after investigation
1	Ontario	Citizen reported to local public health department	Less than annual	Yes	Yes	Generally positive	No
2	Ontario	Citizen reported to local public health department; employer reported to local medical officer of health	Less than annual	Yes	Yes	Positive and negative	No
3	Ontario	Citizen reported to local public health department; employer reported to local medical officer of health	Less than annual	Yes	Yes—through other government agencies or departments	Positive and negative	No
4	Ontario	Citizen reported to local public health department	Less than annual	Yes	Yes—through other government agencies or departments	Generally negative	Yes
5	Manitoba	Health care professional reported to provincial cancer agency; employer reported to provincial cancer agency; First Nations community reported to regional medical officer of health	Annual	Yes	No or not known	Generally positive	No
6	Manitoba	Citizen reported to regional medical officer of health	Annual	Yes	No or not known	Positive and negative	No
7	Alberta	Citizen reported to provincial authority for health service delivery; citizen reported to regional medical officer of health; health care professional reported to provincial ministry of health; provincial authority for health service delivery reported to provincial ministry of health; employer reported to provincial ministry of health	Annual	Yes	Yes—through other government agencies or departments	Positive and negative	Yes
8	British Columbia	Citizen reported through online form to provincial cancer agency; citizen reported to provincial ministry of health; citizen reported to regional medical officer of health	Annual	Yes	No or not known	Positive and negative	No

Interview	Jurisdiction	How suspected cancer clusters were reported	Frequency of reports	Environmental or occupational hazards suspected	Involvement of officials trained in risk communi-cation	Perceived public satisfaction with response to report of cluster	Need for ongoing outreach or monitor-ing after investigation
9	Saskatchewan	Citizen reported to regional medical officer of health; citizen reported to health care professional	Annual	Yes	Yes—through other government agencies or departments	Generally positive	No
10	Quebec	Health care professional reported to regional public health agency; employer reported to regional public health agency	Less than annual	Yes	Yes	Generally negative	Yes
11	New Brunswick[a]	Citizen requested information; health care professionals requested information; news media requested information	Never; respond to general requests for information on cancer on an annual basis	No	No or not known	N/A	N/A
12	Northwest Territories	Citizen reported to local health authorities; local clinician reported to territorial ministry of health; cluster discovered during routine surveillance of cancer data by territorial health ministry	Less than annual	Yes	Yes—through nongovern-mental organizations	Positive and negative	Yes
13	Canada	Provincial or territorial or regional lead of investigating agency reported to PHAC	Less than annual	Yes	No or not known	Generally positive	Yes

Abbreviations: N/A, not applicable; PHAC, Public Health Agency of Canada.

[a] Investigators noted they had never launched an investigation and had never taken action beyond responding to a citizen's concerns about cancer with public education.

citizens brought forward the majority of inquiries surrounding cancer clusters due to concerns about local cancer cases. However, an official interviewed in one province, Quebec, identified clinicians and employers as the most frequent initiators of cancer cluster reports. All officials had been involved in the large-scale investigation of at least one suspected cancer cluster in their province or territory over the course of their career. In five interviews, officials stated they received requests to investigate reports of cancer clusters on an annual basis, whereas in seven interviews, officials reported that they received requests less frequently. Officials interviewed in one province, New Brunswick, had never received a report of a cancer cluster but had frequently responded to more general inquiries about cancer rates from the public and other stakeholders that were not necessarily tied to a specific geographic location or timeline.

All officials interviewed confirmed that environmental or occupational exposures were suspected and assessed in at least one of the reported cancer clusters they had investigated. In five interviews, officials stated they either did not have staff trained in risk communication or were not aware of any such training. In three interviews, officials stated they had direct access to staff with risk communication training, while in five interviews, officials stated they had occasional access to this expertise through other governmental or nongovernmental agencies. Officials in four interviews perceived an overall positive response from the public after responding to reports of a cancer cluster, while in eight others, officials perceived either a mostly negative response or a mix of positive and negative responses from the public. In five interviews, officials cited the need for ongoing community outreach after they finished investigating a suspected cancer cluster because either the community had requested further monitoring of cancer incidence rates or public health officials were gathering more data to observe trends.

Communication approaches

The primary themes that emerged from our interviews with Canadian public health officials regarding communication approaches and challenges encountered while investigating reports of cancer clusters are summarized in Table 3. Officials

in eight interviews stated that the main messages communicated during and after investigating a suspected cancer cluster consisted of explanations of the difference between observed versus expected cancer incidence rates and explaining various risk factors that are associated with increased rates of cancer (e.g. sun exposure, smoking, etc.). Officials in three interviews also discussed communicating with citizens why their agency was or was not pursuing further action investigating the report of a cancer cluster as a primary theme.

All officials interviewed identified the local community members and other government agencies as key stakeholders to communicate with about the progress of an investigation; however, there was less agreement about the importance of communicating with other stakeholders. In just over half of the interviews, officials identified local elected officials (e.g. city councillors, members of parliament, etc.) as key communication stakeholders, whereas the news media, employers and nongovernmental organizations were identified less frequently (in 23%, 23% and 8% of interviews, respectively).

In most interviews, officials perceived the biggest challenges with communicating risk to citizens to be as a result of the complexity of information related to statistics and cancer rates (77%), due to issues addressing public perceptions of cancer risk (77%) and due to difficulties with crafting effective messages on risk (70%). Another challenge to communicating risk effectively identified in three interviews included language barriers and special cultural considerations when communicating with citizens whose mother tongue was not one of Canada's two official languages (i.e. English and French) or with recent immigrants to Canada. In most interviews, officials saw the main purpose of conducting risk communication while investigating a suspected cancer cluster as a way to educate the public on cancer (85%). Other goals of risk communication identified less frequently in the interviews included promoting changes to health behaviours (38%), addressing public concerns (38%) and improving public perceptions of government transparency (23%).

When discussing specific approaches to disseminating information and communicating results with stakeholders after a

suspected cancer cluster had been investigated, officials discussed the use of printed text documents (e.g. reports, brochures) and face-to-face interactions with community members (e.g. town halls, one-on-one meetings) as the most common formats of information sharing (85% and 77%, respectively). In cases where the suspected cancer cluster was addressed with a response at an early stage of the process without necessarily requiring the launch of a large-scale investigation, officials in most interviews stated that telephone or email correspondence with the individual(s) raising the concern was carried out (70%). In six interviews, officials also discussed presenting results from the investigation of a reported cancer cluster using visual tools (e.g. PowerPoint) to stakeholders.

The officials interviewed had mixed experiences when it came to leveraging the news media as information disseminators while investigating reports of a cancer cluster. The media's role in assisting with information sharing during the investigation was perceived as positive by officials in six interviews, some of whom discussed collaborating with local news media to report on the results of their investigations. However, in seven interviews, officials said the media played either a negative or neutral role in sharing information about investigating suspected cancer clusters.

Discussion

Despite past concerns raised about their overall value in other jurisdictions,[6] we found that cancer cluster investigations are regularly undertaken by Canadian public health officials for the purposes of educating the public about cancer and exploring whether observed incidences of cancer in a community occur at levels that are higher than expected. While these goals were found to be consistent across Canada, the investigation procedures varied considerably across the provinces and territory included in this study. In the absence of national cancer cluster guidelines, each Canadian jurisdiction has taken a different approach to investigating clusters, whereby some have produced their own guidelines and others have opted mostly to follow the US CDC's procedures.

This patchwork of approaches has resulted in little procedural consistency for carrying

Topic	Themes	Number of interviews with theme present (%)
Main messages communicated to community during/after investigation	Observed vs. expected incidence rates	8 (62%)
	Cancer risk factors	8 (62%)
	Why pursuing investigation or why not	3 (23%)
Key stakeholders for communication	Citizens/community	13 (100%)
	Other government agencies or ministries	13 (100%)
	Local elected officials	7 (54%)
	Employers	3 (23%)
	News media	3 (23%)
	Nongovernmental organizations	1 (8%)
Challenges communicating risk	Complexity of information	10 (77%)
	Addressing public perceptions of risk	10 (77%)
	Crafting messages on risk	9 (70%)
	Language and/or cultural considerations	3 (23%)
Purpose of risk communication	Public education	11 (85%)
	Health behaviour change	5 (38%)
	Address public concerns	5 (38%)
	Improve transparency	3 (23%)
Communication formats used to share results or investigation conclusions	Printed texts (e.g. reports, brochures)	11 (85%)
	Face-to-face	10 (77%)
	Telephone or email	9 (70%)
	Presentations	6 (46%)
Role of the media in information sharing	Positive role	6 (46%)
	Negative role	5 (38%)
	Neutral	2 (15%)

out investigations into reports of cancer clusters in Canadian communities, which can generate confusion among investigators regarding which guidelines to follow and how to effectively respond. Indeed, one participant we spoke to described having to pose questions through an email listserv to find out what guidelines were commonly used in their own jurisdiction and to informally gather advice from other epidemiologists regarding cluster investigation best practices.

The establishment of pan-Canadian guidelines in cooperation with all Canadian provinces and territories could therefore make the process of responding to reports of cancer clusters more consistent across and within Canadian jurisdictions, and would especially benefit jurisdictions without clear procedures or guidelines in

place. Pan-Canadian guidelines could also delineate the specific duties of investigators and what skills and expertise they are likely to require, which would benefit jurisdictions where lead investigators have not been identified by eliminating some of the current guesswork around which agencies and individuals should be tasked with investigating suspected cancer clusters in each Canadian jurisdiction.

In addition, the approaches used by Canadian officials to investigate suspected cancer clusters (wherever guidelines were used) did not always appear to make use of evidence-based procedural best practices. For example, although it is widely known that the public's interest in cancer clusters is highly influenced by perceived environmental hazards and harmful exposures,[9] only one jurisdiction included

environmental exposure validation as a defined action in their investigation protocol. Further, only three jurisdictions explicitly specified a step for examining the feasibility of an epidemiological study of the reported cancer cluster as a part of their procedural guidelines. This is surprising, given the increasing reluctance of officials to pursue large-scale epidemiological studies of most suspected cancer clusters—except for those that meet specific criteria to warrant an investigation—due to limited time and resources.[24]

Interestingly, despite most officials having identified information on cancer risk factors as a primary message communicated during the course of investigations, only a third of the Canadian jurisdictions we studied included risk communication at every step of their investigation protocols.

Therefore, establishing pan-Canadian cancer cluster guidelines could benefit public health officials, as well as members of the community where the concern originated, by encouraging a more widespread adoption of procedural best practices surrounding risk communication and other initiatives that may improve the public's understanding of cancer.

However, the case for pan-Canadian cancer cluster guidelines goes beyond achieving procedural uniformity and aiding officials in jurisdictions where guidelines are either lacking or do not currently exist; they would also allow investigators to count and compare reported cancer clusters across all Canadian jurisdictions, a practice which is currently hampered by large discrepancies in how cluster concerns are documented and which inquiries are escalated. For example, one participant we spoke to noted that they did not investigate reports of cancer clusters until each individual case (within the suspected cluster) made contact with the investigator to confirm their diagnosis so that the investigator could determine whether the consistent case definition criterion had been met. In other jurisdictions, complaints of clusters were validated through a crude assessment of observed versus expected rates in the area of interest. Establishing pan-Canadian guidelines that outline a consistent approach for validating reports of cancer clusters would help illuminate whether differences in the number of clusters that get investigated in Canadian jurisdictions were due to a true difference in the number of reported clusters requiring investigation, or due to differences in the way officials were responding to the reported clusters.

Finally, there are two significant scenarios in which pan-Canadian guidelines for cancer clusters would be beneficial due to federal jurisdiction over health matters. The first involves clusters arising in Indigenous communities, where provincial and federal jurisdictional ambiguities remain and the need for national policy frameworks on health matters has previously been raised beyond cancer clusters.[25] The second involves clusters for which a cross-boundary environmental exposure is suspected either across two provinces or across the Canada–US border,[26] whereby the federal government would also have jurisdiction over such matters.

Our study also brought to light some experiences of cancer cluster investigators that were shared across Canadian jurisdictions. There was considerable agreement among the public health officials interviewed regarding the challenges they faced in communicating risk to stakeholders, which included communicating complex statistical information and addressing the public's perceptions of high risks to health from environmental hazards. These challenges suggest that public health officials would benefit greatly from more support from specialized communications staff with this type of training. Indeed, these findings are consistent with those from a survey of US state health departments conducting cancer cluster investigations, in which 75% of states indicated they would benefit from more resources in risk communication.[27] However, most of the officials we interviewed said they had no direct access to staff trained in risk communication in their department. Fortunately, best practices for risk communication have been widely published;[28-30] however, in the absence of a cross-Canadian, cluster-reporting database with investigation resources that are easily accessible to public health officials alongside procedural guidelines, investigators may be missing out on a useful tool for conducting risk communication more effectively and cohesively.

A type of national cancer cluster–reporting database called the Cancer Cluster Public Inquiry Triage System, as well as an electronic listserver, were established by the US CDC's National Center for Environmental Health (NCEH) in 2002. The database was developed to track the public's cancer cluster concerns and improve information sharing between federal, state and local public health agencies by providing a mechanism to share expertise and scientific methods.[31] A similar Canadian cluster-reporting database could be used to establish a platform for federal, provincial and local investigators to share knowledge and best practices about responding to initial reports of clusters. The database could be especially beneficial to more junior investigators by providing them with a network of senior experts to consult on cancer cluster investigative methodologies, should a full-scale cluster investigation be warranted once initial concerns are validated and other criteria established by the investigators are met.

Additionally, this kind of database would offer Canadian public health officials an opportunity to study patterns of citizen expressions of concerns about cancer and particular hazards. Analyzing these complaints could help officials identify which communities would benefit the most from education campaigns about cancer and cancer risk factors and could supply citizens with valuable information on specific cancers or local hazards. For example, the US NCEH used their database to study which types of cancers were most frequently cited by cluster inquirers, to inform their development of additional educational tools.[31] In a recent survey, approximately half of US states were found to regularly report cancer inquiries as a part of the tracking program.[32] In other jurisdictions, regulators have leveraged databases containing data on complaints about hazardous exposures to direct efforts towards targeted exposure assessment studies and improve the management of exposure risks.[33]

Another interesting finding from this work was the agreement found among public health officials interviewed regarding the primary purpose of risk communication as a means to conduct public education on cancer risk. While this is an important objective of any public health agency during routine activities, this goal may fall short in addressing the expectations of a citizen reporting a cancer cluster, whose primary objective is to seek answers for an unexplained pattern of cancer diagnoses. Other research has found that when a cluster investigation does not confirm the presence of a statistically significant excess in cancer, concerned citizens often persist in believing that the cluster of cancer cases cannot be random, largely due to a lack of trust in public health experts.[34]

Therefore, addressing public concerns about the perceived threat and maintaining trust and credibility ought to be a primary goal of risk communication during an investigation and may require a different communications approach compared to one that centres on education alone. In fact, one official interviewed observed that being transparent with citizens about what steps were taken to come to the decision on whether to investigate their concerns or not contributed to the overall positive response they received from local community members, despite the investigation not progressing to a full epidemiological study to identify the causes of cancer.

Thus, rather than trying to identify a cancer cluster based on a small number of cases that are typically too limited for an informative statistical analysis, public health experts would do better to divert resources towards addressing public concerns about cancer. Indeed, Rothman commented that "responding to reports of perceived clusters is to assuage community anxiety about environmental problems. The investigation of cluster reports can thus serve both social and scientific ends, and might be seen more constructively as a social service than as a scientific activity."[35,p.14]

Using face-to-face, two-way communication approaches to deliver the findings of an investigation into a suspected cancer cluster has also been found to be an effective way to reduce tensions and address concerns,[36] a view that was echoed by most of the officials interviewed in this work. Therefore, this method for communicating with public stakeholders should be considered over other communication formats, though it may require some extra training or resources targeted towards community engagement.

Investigators should assess the desire for face-to-face communication among the inquirer(s) and the feasibility of incorporating these approaches.[37] Feasibility will depend on the time required to tailor messaging to a community's needs and the costs of facilitating discussions that may occur in person (e.g. townhall) or those that occur increasingly on virtual platforms (e.g. Zoom meetings). Interestingly, one interviewee discussed seeing noticeable improvements in public trust after hiring an external, nongovernmental organization to coordinate in-person meetings to share information and lead discussions with community members during a suspected cancer cluster investigation, such that public health officials were participants in the discussion with local community members rather than leading the conversation. This kind of approach is rooted in participatory communication theory surrounding horizontal models of communication[38] and should continue to be explored by public health officials conducting work with community stakeholders as a way to foster trust with local community members.

Strengths and limitations

This is the first study to explore cluster investigation practices for noncommunicable diseases by public health agencies and officials across Canada. The broad regional coverage of procedural practices that was captured using both a thematic analysis of expert interviews and a content analysis of text documents should be viewed as a major strength of a study of this kind.

Still, this study has some important limitations. Firstly, although we attempted to obtain a diverse sample of participants with various experiences conducting cancer cluster investigations across Canada, we did not interview an exhaustive list of public health officials who have investigated every cluster. Our participant recruitment approach instead centred on collecting detailed perspectives from a smaller sample of key experts. Another limitation of this study includes the challenges associated with comparing jurisdictions within and outside of Canada where public health agencies and departments vary widely with respect to their organization, administration of duties and resources. Future research examining the strengths and weaknesses of investigation approaches in various jurisdictions globally could provide more context for comparisons. In addition, it is possible that responses from other investigators in each province/territory could have differed depending on the scope of knowledge and experience of the public health official interviewed. However, the experiences of officials interviewed in this study still provide a snapshot of the common challenges likely encountered by officials investigating cancer clusters in many other jurisdictions.

Conclusion

In summary, although this work has demonstrated the usability and accessibility of the CDC's cancer cluster guidelines as a great resource internationally, it has also highlighted some benefits of establishing pan-Canadian guidelines for investigating reports of cancer clusters. Pan-Canadian guidelines would not only improve procedural consistency across local and provincial/territorial agencies and address important discrepancies in public health practices when responding to inquiries around suspected cancer clusters in Canada, but they are also warranted in situations in which the federal government already has jurisdiction over environmental health matters. Furthermore, achieving greater consistency in approaches across Canadian jurisdictions through the establishment of pan-Canadian guidelines would allow investigators to draw comparisons across cancer cluster responses from different provinces and territories and facilitate evaluations of the procedures adopted.

This study also identified the benefits of developing a Canadian database for clusters to serve as a reporting system to track citizen concerns and as a resource sharing platform for health officials responding to reports of clusters. Such a database would also help local, provincial and federal agencies carry out public health education to supply valuable information in response to citizen inquiries about cancer clusters, and might also address some citizen concerns around cancer without necessitating the launch of cluster investigations that are unlikely to reveal any definitive answers around the suspected causes of cancers. However, public education is carried out most effectively when health officials responding to community concerns have the necessary skills and training in risk communication, which appears to be a key challenge area among the officials we interviewed.

Furthermore, for the rare instances in which cluster investigators proceed beyond the initial stages of a cluster response and towards a more formal investigation, we have proposed, based on the views expressed by the public health officials we spoke to, that investigators consider face-to-face, participatory communication approaches when feasible. Leveraging participatory communication practices during this investigative phase may improve engagement with the public when delivering findings from the investigation and, importantly, may help officials manage the community's expectations around the results of investigations with an open and transparent dialogue. Since many citizens report suspected cancer clusters in the hope of uncovering answers about the cause of their diagnosis or that of a loved one, the inability of most cluster investigations to meet these expectations ought to be a key fact communicated honestly with concerned citizens from the moment that investigators respond to a cluster inquiry.

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Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

All authors contributed to the study's conception and design. CS led the data collection, analysis and manuscript preparation for this work. NY provided analytical assistance and comments on all drafts of the manuscript. Both authors approved of the final manuscript for submission.

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References

1. Bassil KL, Yang J, Arbour L, et al. Spatial variability of gastroschisis in Canada, 2006–2011: an exploratory analysis. Can J Public Health. 2016; 107(1):e62-e67. https://doi.org/10.17269/cjph.107.5084

2. Torabi M, Green C, Yu N, Marrie RA. Application of three focused cluster detection methods to study geographic variation in the incidence of multiple sclerosis in Manitoba, Canada. Neuroepidemiol. 2014;43:38-48. https://doi.org/10.1159/000365761

3. Windsor-Essex County Health Unit (WECHU). Remington Park cancer cluster investigation [Internet]. Windsor (ON): WECHU; 2016 [cited 2021 Jun 4]. Available from: https://www.wechu.org/sites/default/files/reports-and-statistics/Remington_Park_Cancer_Cluster_Report_Sept_2016_WECHU_Final.pdf

4. Centers for Disease Control and Prevention (CDC). About cancer clusters [Internet]. Atlanta (GA): CDC; 2019 [cited 2021 May 22]. Available from: https://www.cdc.gov/nceh/clusters/default.htm

5. Goodie J. Toxic tort and the articulation of environmental risk. Law Text Culture. 2008;12:6. https://ro.uow.edu.au/ltc/vol12/iss1/6

6. Goodman M, LaKind JS, Fagliano JA, et al. Cancer cluster investigations: review of the past and proposals for the future. Int J Environ Res Public Health. 2014;11(2):1479-99. https://doi.org/10.3390/ijerph110201479

7. McComas KA, Besley JC, Trumbo CW. Why citizens do and do not attend public meetings about local cancer cluster investigations. Policy Stud J. 2006;34(4):671-98. https://doi.org/10.1111/j.1541-0072.2006.00197.x

8. Coory MD, Jordan S. Assessment of chance should be removed from protocols for investigating cancer clusters. Int J Epidemiol. 2013;42(2):440-7. https://doi.org/10.1093/ije/dys205

9. Goodman M, Naiman JS, Goodman D, LaKind JS. Cancer clusters in the USA: what do the last twenty years of state and federal investigations tell us? Crit Rev Toxicol. 2012;42(6):474-90. https://doi.org/10.3109/10408444.2012.675315

10. Department of Health. Cancer rates on the Bellarine Peninsula [Internet]. Melbourne (Australia): State of Victoria; 2019 [cited 2021 May 22]. Available from: https://www2.health.vic.gov.au/public-health/chief-health-officer/cho-publications/cancer-rates-bellarine-peninsula

11. Black RJ, Sharp L, Finlayson AR, Harkness EF. Cancer incidence in a population potentially exposed to radium-226 at Dalgety Bay, Scotland. Br J Cancer. 1994;69(1):140-3. https://doi.org/10.1038/bjc.1994.23

12. Trumbo CW. Public requests for cancer cluster investigations: a survey of state health departments. Am J Public Health. 2000;90(8):1300-2. https://doi.org/10.2105/ajph.90.8.1300

13. Trumbo CW, McComas KA, Besley JC. Individual- and community-level effects on risk perception in cancer cluster investigations. Risk Anal. 2008; 28(1):161-78. https://doi.org/10.1111/j.1539-6924.2008.01007.x

14. Besley JC, McComas KA, Trumbo CW. Local newspaper coverage of health authority fairness during cancer cluster investigations. Sci Commun. 2008;29(4):498-521. https://doi.org/10.1177/1075547008316216

15. McComas KA, Lundell HC, Trumbo CW, Besley JC. Public meetings about local cancer clusters: exploring the relative influence of official versus symbolic risk messages on attendees' post-meeting concern. J Risk Res. 2010;13(6):753-70. https://doi.org/10.1080/13669870903551688

16. Abrams B, Anderson H, Blackmore C, et al. Investigating suspected cancer clusters and responding to community concerns: guidelines from CDC and the Council of State and Territorial Epidemiologists. MMWR. 2013;62(8): 1-14.

17. Fletcher T, Crabbe H, Close R, et al. Guidance for investigating non-infectious disease clusters from potential environmental causes. London (UK): Public Health England; 2019. 45 p. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/781573/INIDC_guidance_v1.0.pdf

18. New Zealand Ministry of Health. Investigating clusters of non-communicable disease: guidelines for public health units. Wellington (NZ): Ministry of Health; 2015. 50 p. Available from: https://www.health.govt.nz/system/files/documents/publications/investigating-clusters-non-communicable-disease-guidelines-may15-v3.pdf

19. Caldwell GG. Twenty-two years of cancer cluster investigations at the Centers for Disease Control. Am J Epidemiol. 1990;132(supp1):S43-S47. https://doi.org/10.1093/oxfordjournals.aje.a115787

20. National Collaborating Centre for Health Public Policy. Structural profile of public health in Canada [Internet]. Québec (QC): NCCHPP; 2018 [cited 2021 May 22]. Available from: https://ccnpps-ncchpp.ca/structural-profile-of-public-health-in-canada/

21. Neimeyer RA. Constructivist approaches to the measurement of meaning. In: Neimeyer GJ, editor. Constructivist assessment: a casebook. Newbury Park (CA): Sage Publications; 1993: 58-103.

22. Terry G, Hayfield N, Clarke V, Braun V. Chapter 2: Thematic analysis. In: Willig C, Stainton-Rogers W, editors. The SAGE handbook of qualitative research in psychology. 2nd ed. London (UK): SAGE Publications; 2017: 17-37.

23. Thomas DR. A general inductive approach for qualitative data analysis [Internet]. Auckland (NZ): University of Auckland; 2003 [cited 2021 Jun 4]. Available from: https://citeseerx.ist .psu.edu/viewdoc/download?doi = 10 .1.1.462.5445&rep = rep1&type = pdf

24. Aldrich T, Sinks T. Things to know and do about cancer clusters. Cancer Invest. 2002;20(5-6):810-6. https:// doi.org/10.1081/cnv-120003546

25. Lavoie JG. Policy silences: why Canada needs a national First Nations, Inuit and Métis health policy. Int J Circumpolar Health. 2013;72:22690. https://doi.org/10.3402/ijch.v72i0 .22690

26. Beaumont H. 'Them plants are killing us': inside a cross-border battle against cancer and pollution. Environmental Health News [Internet]. 2020 Apr 7. Available from: https://www.ehn .org/air-pollution-cancer-michigan -ontario-2645647668.html

27. Anderson H, Blackmore C, Stanbury M, Simms E. A synopsis of the 2010 National Assessment of State Cancer Cluster Investigations and Protocols. Atlanta (GA): Council of State and Territorial Epidemiologists; 2012 [cited 2021 May 22]. 63 p. Available from: http://www.cste2.org/webpdfs /ASynopsisofthe2010National AssessmentofStateCancerCluster InvestigationsandProtocols.pdf

28. Lundgren RE, McMakin AH. Risk communication: a handbook for communicating environmental, safety, and health risks. Hoboken (NJ): John Wiley & Sons; 2018. 544 p.

29. Heath RL, O'Hair HD, editors. Handbook of risk and crisis communication. New York (NY): Routledge; 2010. 696 p.

30. Covello VT, McCallum DB, Pavlova MT, editors. Effective risk communication: the role and responsibility of government and nongovernment organizations. New York (NY): Plenum Press; 1989. 369 p.

31. Kingsley BS, Schmeichel KL, Rubin CH. An update on cancer cluster activities at the Centers for Disease Control and Prevention. Environ Health Perspect. 2007;115(1):165-71. https://doi.org/10.1289/ehp.9021

32. US Centers for Disease Control and Prevention (CDC). Results from a state and territorial survey about updating the 2013 CDC guidelines for investigating cancer clusters [Internet]. Atlanta (GA): CDC; 2022 Feb 22 [cited 2022 May 10]. Available from: https://www.cdc.gov/nceh/clusters /survey-report.html

33. Hansen A, Pisaniello D, Varghese B, et al. What can we learn about workplace heat stress management from a safety regulator complaints database? Int J Environ Res Public Health. 2018;15(3):459. https://doi.org/10 .3390/ijerph15030459

34. Siegrist M, Cvetkovich GT, Gutscher H. Shared values, social trust, and the perception of geographic cancer clusters. Risk Anal. 2001;21(6):1047-54. https://doi.org/10.1111/0272-4332 .216173

35. Rothman KJ. Clustering of disease. Am J Public Health. 1987;77(1):13-5. https://doi.org/10.2105/AJPH.77.1.13

36. Simpson BW, Truant P, Resnick BA. Stop and listen to the people: an enhanced approach to cancer cluster investigations. Am J Public Health. 2014;104(7):1204-8. https://doi.org/10 .2105/ajph.2013.301836

37. Wanyonyi KL, Themessl-Huber M, Humphris G, Freeman R. A systematic review and meta-analysis of face-to-face communication of tailored health messages: implications for practice. Patient Educ Couns. 2011;85(3): 348-55. https://doi.org/10.1016/j.pec .2011.02.006

38. Thomas M, Narayan P. The role of participatory communication in tracking unreported reproductive tract issues in marginalized communities. Inf Tech Dev. 2016;22(1):117-33. https://doi.org/10.1080/02681102 .2014.886549

Release notice

Impact of COVID-19 in adults with chronic conditions: Emergency department visits

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The Public Health Agency of Canada is pleased to announce the release of the fact sheet *Impact of COVID-19 in adults with chronic conditions: Emergency department visits*.

Based on data from the National Ambulatory Care Reporting System and the Discharge Abstract Database, this fact sheet describes the demographics, health characteristics and outcomes of adults (aged 20 years and over) on their first documented emergency department visit (EDV) in Canada with a confirmed or suspected COVID-19 diagnosis, between January 1, 2020, and March 31, 2021. Relationships between severe EDV outcomes (i.e. admission, transfer to an acute care facility or death) and sex, age and selected chronic conditions are also examined.

Key highlights

- Approximately 1 in 4 adults (aged 20 + years) visiting emergency departments with COVID-19 experienced a severe outcome.

- Adults experiencing a severe outcome were more likely to be male (55.6% vs. 47.7%) and older (average age 67 years vs. 47 years) compared to adults with other outcomes.

- The percentage of adults experiencing a severe outcome increased with age from 5.7% for those aged 20 to 34 years to 69.1% for those aged 80 + years.

- Adults experiencing a severe outcome were more likely to have one or more of 18 chronic conditions compared to adults with other outcomes (49.1% vs. 13.9%).

- Having more chronic conditions was associated with an increased risk of severe outcome: from 15.7% for adults with none of the 18 identified chronic conditions to 71.1% for adults with 4 or more chronic conditions.

For more information, visit the Canada.ca website at: www.canada.ca/en/public-health/services/diseases/coronavirus-disease-covid-19/epidemiological-economic-research-data/impact-covid-19-adults-chronic-conditions-emergency-department-visits.html.

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 2022:

Biswas A, Chen C, **Prince SA**, et al. Workers' activity profiles associated with predicted 10-year cardiovascular disease risk. J Am Heart Assoc. 2022;11(14):e025148. https://doi.org/10.1161/JAHA.121.025148

Eisenhauer M, Crupi L, Ray R, et al. Tapping into the minds and hearts of the local public health workforce during the COVID-19 pandemic. Can J Public Health. 2022;113(5):678-85. https://doi.org/10.17269/s41997-022-00664-2

Lang E, Colquhoun H, LeBlanc JC, […] **Traversy G**, et al. Recommendation on instrument-based screening for depression during pregnancy and the postpartum period. CMAJ. 2022;194(28):E981-E989. https://doi.org/10.1503/cmaj.220290

Liang G, Zhu F, Mirza AI, […] **Bonner C**, […] **Graham M**, […] **Knox NC**, […] **Van Domselaar G**, et al. Stability of the gut microbiota in persons with paediatric-onset multiple sclerosis and related demyelinating diseases. Mult Scler J. 2022;28(11):1819-24. https://doi.org/10.1177/13524585221079533

Lukoševičiūtė J, **Gariepy G**, Mabelis J, et al. Single-item happiness measure features adequate validity among adolescents. Front Psychol. 2022;13:884520. https://doi.org/10.3389/fpsyg.2022.884520

Ravensbergen L, **Wasfi R**, Van Liefferinge M, […] **Prince SA**, **Butler G**, et al. Associations between Light Rail Transit and physical activity: a systematic review. Transp Rev. 2022. https://doi.org/10.1080/01441647.2022.2099999