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Masking in reports of "most serious" events: bias in estimators of sports injury incidence in Canadian children

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Abstract

Introduction: Surveys that collect information on injuries often focus on the single "most serious" event to help limit recall error and reduce survey length. However, this can mask less serious injuries and result in biased incidence estimates for specific injury subcategories.

Methods: Data from the 2002 Health Behaviour in School-aged Children (HBSC) survey and from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) were used to compare estimates of sports injury incidence in Canadian children.

Results: HBSC data indicate that 6.7% of children report sustaining a sports injury that required an emergency department (ED) visit. However, details were only collected on a child's "most serious" injury, so children who had multiple injuries requiring an ED visit may have had sports injuries that went unreported. The rate of 6.7% can be seen to be an underestimate by as much as 4.3%. Corresponding CHIRPP surveillance data indicate an incidence of 9.9%. Potential masking bias is also highlighted in our analysis of injuries attended by other health care providers.

Conclusion: The "one most serious injury" line of questioning induces potentially substantial masking bias in the estimation of sports injury incidence, which limits researchers' ability to quantify the burden of sports injury. Longer survey recall periods naturally lead to greater masking. The design of future surveys should take these issues into account. In order to accurately inform policy decisions and the direction of future research, researchers must be aware of these limitations.

Keywords: *adolescent, athletic injury, biostatistics, epidemiology, most serious injury, sports injury, surveillance, survey*

Highlights

- Surveys often collect information on only the most serious injury event within a recall period, which can reduce recall bias and shorten the survey length. However, this line of questioning can also mask less serious injuries, leading to an underestimation of the incidence of specific injury subtypes, such as those that occur during physical activity or sports.
- In this study, data from the 2002 Health Behaviour in School-aged Children (HBSC) survey and from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) were used to compare estimates of sports injury incidence in Canadian children, and evidence of masking bias was found.
- Without an accurate estimation of the incidence of injury subtypes, our ability to quantify injury burden and the impact of interventions is limited.
- Potential masking must be taken into consideration during the design of a survey as well as during the analysis and interpretation of survey data.

Introduction

Unintentional injuries cause acute health problems and are considered a leading cause of youth mortality worldwide.[1,2] A significant portion of pediatric injuries occur while playing or training for a sport or physical activity ("sports injuries").[3,4,5] Unbiased information about sports injuries may help direct public health resources and evaluate the effectiveness of injury prevention efforts. Inaccurate estimates of the prevalence of specific injury subtypes make it impossible to weigh, for example, the health benefits of physical activity promotion programs against the increased risk of sports injuries.

Health measurement surveys such as the Health Behaviour in School-aged Children (HBSC) study,[2] the Global School-Based Student Health Survey (GSHS),[6] the Canadian Community Health Survey (CCHS),[5] the National Longitudinal Survey of Children and Youth (NLSCY)[7] and the National Population Health Survey

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(NPHS) have utilized a line of questioning that investigates the circumstances surrounding respondents' "one most serious injury."[8] In general, injuries are defined as those that limit daily activities[5,8,9] or require treatment from a doctor or nurse.[2,6,8] However, of the surveys we considered, only the HBSC explicitly defines what is meant by the one "most serious" injury: the injury that "took the most time to get better."[2] The GSHS asks respondents, "During the past 12 months, what was the most serious injury that happened to you?" (with responses such as "I had a broken bone or a dislocated joint," etc.).[8] The CCHS asks respondents who sustained multiple injuries to think "about the most serious injury" and answer contextual questions, including the month, year, nature of and location where the most serious injury was sustained.[9] Similarly, the NLSCY asks, "For the most serious injury, what type of injury did he have?" (in this case, proxy reports from parents were used) prior to asking questions about the nature, context and location of the most serious injury.[10]

Recall bias poses a significant threat to validity in injury survey data. Recall error can result when a respondent's response is incomplete due to memory decay (forgetting as a result of time passing). The accuracy of estimators from surveys that use longer recall periods are more affected by limitations of memory and recall.[11] Since memory decay decreases with increasing severity of injuries,[12-13] the "one most serious injury" line of questioning should help reduce recall bias; in addition, the respondent only has to remember and report the contextual variables to do with a single injury event, which could greatly reduce the time needed to complete the questionnaire and increase the accuracy and completeness of response.

However, gathering in-depth data on only the single most serious injury does present an important shortcoming: if someone reports a fighting-related injury as their "most serious" in the past 12 months, any "less serious" sports injuries sustained during that period would go unreported. This line of questioning results in underestimating the incidence of specific injury categories whenever a respondent sustains more than one injury during the same recall period. This issue is often overlooked, and the magnitude of this bias in sports injury incidence estimators has not been explored. Published estimates, such as the one stating that 66% of pediatric injuries are sports-related,[5] are biased because they are based on only "most serious" injuries. Billette and Janz[5] state in their introduction that their data do not reflect all injuries, but do not acknowledge this masking bias in their summary ("Highlights") section.[5] Tozija et al.[14] relied on GSHS data to claim that 29.3% of injuries sustained by adolescents occurred at school, and Jildeh et al.[15] used HBSC data to justify their claim that 78.5% of injuries occur at home; neither of these studies acknowledged the potential masking bias arising from collecting data on only the "most serious" injury.

Methods

In order to explore the potential extent of the masking and bias arising from a "one most serious injury" line of survey questioning, we estimated sports injury incidence rates in Canadian children using the 2002 cycle of the HBSC survey data and the 2001/2002 Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) surveillance data. We chose this period for the analysis because current HBSC and CHIRPP data are not as directly comparable. Like Pickett et al.,[16] we used rates from two CHIRPP hospitals in Frontenac County, Ontario to calculate rates. These sites have been relatively good indicators of national surveillance trends in the past; together they represent the only CHIRPP sites with full community coverage.[16]

CHIRPP captures injury data for all people who present with an injury to an emergency department (ED) of a participating hospital; the HBSC survey captures the "most serious" injury to be treated by a doctor or nurse in a family doctor's office, a health clinic, a hospital, a school health service, etc. and, since 2002, data on whether the reported injury was treated in an ED (see Table 1 for an overview of the demographics of those with reported sports injuries in the two data sets). This means that HBSC data can be used to estimate the incidence of *all* treated sports injuries in Canadian children through the percentage of HBSC respondents who reported sustaining any sports injury; the data can also be used to estimate incidence of *ED-treated* sports injuries. The rate of ED-treated sports injuries should be more directly comparable with the surveillance-based incidence estimate, which is calculated as the number of pediatric sports injuries presenting to the ED per 100 children in the at-risk population. In the CHIRPP data, a sports injury was defined as any injury sustained during sports (organized, practice, lessons and coaching), recreational activities (including tobogganing, trampoline, brownies, scouts, etc.), dancing in the home, playing or climbing.

The HBSC data include the "one most serious injury" line of questioning, which (as pointed out earlier) can lead to incomplete reporting of sports injuries, so a "naive" survey-based estimate is really a lower limit on the range of plausible estimates of sports injury incidence. By using additional HBSC data to determine whether respondents sustained multiple injuries within the recall period, we can determine the potential extent of the masking of less serious injuries including less serious sports injuries. This information can be used to identify a possible upper limit for the sports injury incidence estimate. This upper limit is calculated as the percentage of HBSC respondents who (1) reported a sports injury as their one most serious injury, or (2) reported multiple injuries and thus may have sustained a "less serious" sports injury that went unreported.

The CHIRPP data set was restricted to those aged 11 to 15 years at the time of the ED visit in order to match the target age group of the HBSC. Table 2 shows a comparison of the injury data reported in these data sources.

TABLE 1
Demographic information for those with reported sports injuries in each data source

	HBSC (n = 1766)		HBSC ED[a] (n = 445)		CHIRPP (n = 884)	
	Count, n	Percentage, %	Count, n	Percentage, %[b]	Count, n	Percentage, %
Sex						
Male	861	48.8	223	50.1	562	63.6
Age, years						
11	237	13.4	48	10.8	152	17.2
12	409	23.2	112	25.2	172	19.5
13	384	21.7	105	23.6	203	23.0
14	379	21.5	83	18.7	186	21.0
15	357	20.2	97	21.8	171	19.3

Abbreviations: CHIRPP, Canadian Hospitals Injury Reporting and Prevention Program; ED, emergency department; HBSC, Health Behaviour in School-Aged Children.

[a] HBSC ED refers to the set of injuries for which the respondent sought ED treatment.

[b] The percentage of individuals who sought ED treatment.

Results

Of the 6688 individuals who responded to the HBSC survey in 2001–2002, 1766 (26.4%) reported that their most serious injury was sustained while playing or training for sports / during a recreational activity (Table 2). However, 1994 children reported multiple injuries and only 1047 of those reported a sports injury as their most serious. Since it is possible that the other 947 children had less serious sports injuries, 14.2% of children may have had sports injuries that went unreported (i.e. they were masked) due to this "one most serious injury" line of questioning. Valid sports injury incidence rate estimates from the HBSC survey, therefore, lie between 26.4 and 40.6 injured children per 100 per year, depending on the extent of masking (Table 3).

If we restrict data to injuries that required ED treatment, we can estimate incidence separately using survey and surveillance data and get a better sense of the true extent of masking. In the 12-month recall period, 896 children (13.4% of the HBSC sample) sustained injuries that required ED treatment; 445 of these children reported a sports injury as their most serious injury (6.7% overall). Of the 451 who described their most serious injury as from another subcategory, 287 (4.3% overall) indicated they had had multiple injuries. This means that 4.3% of children could have had masked sports injury incidents (the rate of masking could theoretically be even greater if a child thought an injury that did not require an ED visit was "more serious" than one that did). Valid estimates of the incidence of sports

TABLE 2
Comparison of injury data as reported in the three data sources

Injury report	HBSC (n = 6688)		HBSC ED[a] (n = 6688)		CHIRPP (n = 8896)	
	Count	%	Count	%[b]	Count	%
Injured in the 12-month recall period	3652	54.6	896	13.4	1453	16.3
Sports injury[c]	1766	26.4	445	6.7	884	9.9
Multiple injuries[d]	1994	29.8	559	8.4	—	—
Multiple injuries where the most serious injury was not a sports injury[d]	947	14.2	287	4.3	—	—

Abbreviations: CHIRPP, Canadian Hospitals Injury Reporting and Prevention Program; ED, emergency department; HBSC, Health Behaviour in School-Aged Children.

[a] HBSC ED refers to the set with injuries for which the respondent sought ED treatment only.

[b] Here this is the percentage within all HBSC respondents (not just those who sought ED treatment).

[c] Most serious in the HBSC study and the reason for visit for CHIRPP surveillance.

[d] There is no equivalent reporting of "most serious" injuries among the surveillance data.

injuries requiring ED visits, therefore, lie anywhere between 6.7 and 11.0 (or more) children per 100 per year (Table 3).

There were 884 visits to the ED as a result of pediatric sports injury from among the 8896 children living in the restricted CHIRPP catchment area—approximately 60.8% (n = 884/1453) of all injuries reported (Table 2). Therefore, our surveillance-based sports injury incidence estimate is 9.9 children per 100 per year, which is larger than the naive survey-based estimate of 6.8, but within the range produced when we recognize the potential masking arising from the "one most serious injury" line of questioning (Table 3). In fact, this larger surveillance-based estimate may still be an underestimation of the true incidence rate, since sports injuries can only be identified in those children whose guardians consent to the collection of detailed information about the injury event.

TABLE 3
Sports injury incidence estimates

	Sports injury incidence rate (children per 100 per year)
All injuries requiring medical treatment	
HBSC	26.4–40.6
Serious injuries requiring ED treatment	
HBSC	6.7–11.0
CHIRPP	9.9

Abbreviations: CHIRPP, Canadian Hospitals Injury Reporting and Prevention Program; HBSC, Health Behaviour in School-Aged Children.

Discussion

The purpose of this paper is to highlight the existence of masking bias in surveys that gather data on only the "most serious" injury event. The potential impact of masking arising from the "one most serious injury" line of questioning is evident in our estimates of sports injury incidence. In particular, the estimate produced by CHIRPP (9.9 sports injuries per 100 children per year) falls near the top of the range produced by the HBSC ED survey data (6.7–11.0 sports injuries per 100 children per year). This suggests that masking is a potentially serious concern. Using this line of questioning in surveys may reduce recall bias, but incidence rate estimates of injury subcategories will be underestimated due to the masking of less serious injuries; regression estimators and estimators of the percent of injuries falling in a particular subcategory could be biased in either direction as a result of this masking. The extent of the masking and bias will depend on the incidence, relative severity and likelihood of the co-occurrence of specific injury subtypes, as well as on the likelihood of multiple injury occurrences within the recall period.

These factors indicate that data from the "one most serious injury" line of questioning is not appropriate when comparing incidence estimates between subgroups (for example, males versus females) that may have varying degrees of masking. Researchers should consider the potential impact of this masking bias when designing or analyzing injury surveys. Questions about whether other "less serious" injuries were experienced during the recall period could be used to produce a range of injury incidence estimates. Shorter recall periods would capture fewer individuals with multiple injuries, which would lead to fewer events being masked and to less bias. Collecting information on all injury events would eliminate masking entirely. However, this benefit needs to be weighed against the potential drawbacks of such changes to the study design including loss of power and increased recall bias.

In this article, we focus on the circumstances surrounding injury events and demonstrate a clear, but often overlooked, bias associated with estimating incidences when using data from the "one most serious injury" line of questioning. A similar bias occurs when estimating incidence of injury effects (e.g. concussion, broken bone, etc.), however, comparing survey and surveillance data would be more challenging because HBSC respondents can report up to five injury effects while CHIRPP surveillance captures at most three. Note that the direction of bias of incidence estimates is known: the masking bias results in an underestimation of the incidence of injury subgroups. However, studies of association or of relative rates could be biased in either direction if the amount of masking differs in the different exposure groups.

Limitations

The data used for our analyses are from 2001/2002, when comparable survey and surveillance data were readily available. As a result, the sports injury incidence estimates are not current.

The CHIRPP surveillance captures *all* people presenting to the ED with an injury; *detailed* information, including the context of the injury, is recorded only for children whose parents consent to be part of the study (overall consent rates at the two sites were 85% at site 1 and 60% for site 2).

The target demographic of the HBSC was students aged 11 to 15 years based on grade, but in actuality children aged 9 years and 19 years are included. To improve comparability, we limited both our CHIRPP and HBSC datasets to just 11- to 15-year-olds.

As CHIRPP surveillance only provides community coverage for Frontenac County, comparing the CHIRPP results to the HBSC national survey is problematic. The demographics captured in our CHIRPP Frontenac County and HBSC national datasets differ in some regards. Specifically, the CHIRPP data had a higher percentage of males (63.6% versus 48.8% in HBSC) and a slightly different age breakdown than the HBSC data (e.g. 17.2% of 11 year olds versus 13.4% in HBSC). Because we know that injury varies by age and sex, this may have some

implications for the results. However, the differences are not so significant as to influence our overall finding that sports injury incidence estimates are likely biased and underestimate true incidence if they are underpinned by data derived from survey questions asking about the "one most serious" injury.

Conclusion

In order to design intervention programs and public policy that address key risk behaviours and outcomes in youth, researchers and policy makers must be able to rely on accurate estimates of injury incidence. As the results suggest, the difference between the HBSC study and the CHIRPP surveillance estimates of incidence rates is substantial if we do not account for potential masking in the survey data. The "one most serious injury" line of questioning may overcome some of the traditional biases associated with survey data, but estimates of sports injuries (or any specific subcategory of injuries) should only be used if the inherent masking and potential biases are recognized. Incidences of specific sports injuries will be underestimated by naive analyses of surveys that collect information on only the "one most serious event." Such analyses should instead report ranges of plausible incidence estimates that account for the potential levels of masking. Masking from the "one most serious" line of questioning should be considered alongside issues such as recall bias when designing future surveys. We also strongly encourage collecting data on whether survey participants experienced other "less serious" events to allow for an exploration of the potential extent of masking.

Conflict of interest

None declared by any author.

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Health behaviours associated with indoor tanning based on the 2012/13 Manitoba Youth Health Survey

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Abstract

Introduction: Although indoor tanning causes cancer, it remains relatively common among adolescents. Little is known about indoor tanning prevalence and habits in Canada, and even less about associated behaviours. This study explores the prevalence of adolescent indoor tanning in Manitoba and its association with other demographic characteristics and health behaviours.

Methods: We conducted secondary analyses of the 2012/13 Manitoba Youth Health Survey data collected from Grade 7 to 12 students (n = 64 174) and examined associations between indoor tanning (whether participants had ever used artificial tanning equipment) and 25 variables. Variables with statistically significant associations to indoor tanning were tested for collinearity and grouped based on strong associations. For each group of highly associated variables, the variable with the greatest effect upon indoor tanning was placed into the final logistic regression model. Separate analyses were conducted for males and females to better understand sex-based differences, and analyses were adjusted for age.

Results: Overall, 4% of male and 9% of female students reported indoor tanning, and prevalence increased with age. Relationships between indoor tanning and other variables were similar for male and female students. Binary logistic regression models indicated that several variables significantly predicted indoor tanning, including having part-time work, being physically active, engaging in various risk behaviours such as driving after drinking for males and unplanned sex after alcohol/drugs for females, experiencing someone say something bad about one's body shape/size/appearance, identifying as trans or with another gender, consuming creatine/other supplements and, for females only, never/rarely using sun protection.

Conclusion: Indoor tanning among adolescents was associated with age, part-time work, physical activity and many consumption behaviours and lifestyle risk factors. Though legislation prohibiting adolescent indoor tanning is critical, health promotion to discourage indoor tanning may be most beneficial if it also addresses these associated factors.

Highlights

- This study explores the prevalence of adolescent indoor tanning in Manitoba and its association with various demographic characteristics and health behaviours, for male and female students separately.
- A greater proportion of older and female students have used indoor tanning equipment.
- Most variables demonstrated significant associations through binary logistic regression.
- Several variables significantly predict indoor tanning: part-time work, being physically active, risk behaviours such as drinking and driving (males) and unplanned sex after using alcohol/drugs (females), body-related bullying, gender identity, consuming creatine or other supplements and never/rarely using sun protection (females).
- Though legislation prohibiting adolescent indoor tanning is critical, health promotion to discourage indoor tanning may be most beneficial if it also addresses these associated factors.

Keywords: *indoor tanning, UV exposure, risk factors, skin cancer, youth, adolescents, students, Canada*

Introduction

Skin cancer is the most common type of cancer in Canada.[1] In 2015, an estimated 6800 Canadians were diagnosed with melanoma, which accounts for about 80% of skin cancer deaths.[2-3] While mortality is rare, the treatment-related costs of this disease are substantial and are projected to increase from about $466 million in 2004 to $922 million in 2031.[3-4]

Many skin cancers and the associated treatment costs are avoidable as up to 90% of skin cancers are due to ultraviolet (UV) exposure.[5]

Indoor tanning involves exposure to a concentrated source of UV light. On average, the radiation from indoor tanning equipment corresponds to a UV index

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of 13, which is considerably higher than the UV index of 8.5 associated with the noon summer sun at intermediate latitudes.[6] Tanning beds' UV emissions vary depending upon the design and power of the equipment, operator knowledge and compliance with federal guidelines.[7] Furthermore, because the UV radiation emitted by indoor tanning equipment can vary across the effective area, and radiation in some areas can be 30% greater than the average, overexposure inevitably occurs.[6] "Ever use" of tanning beds before the age of 25 was found to significantly increase melanoma risk,[8-9] and correlations have also been found between indoor tanning and basal and squamous cell carcinoma.[9-11]

The National Sun Survey II[1] (NSS2) estimated that 10.5% of the Canadians surveyed in 2006 tanned indoors in the past year, an increase from 7.7% in 1996, which suggests a growth in popularity. The NSS2 also found that indoor tanning is more common among females, particularly young women, a finding echoed by research conducted elsewhere.[12-22] Fewer studies, however, have explored the sex differences in behaviours to do with indoor tanning.[16-18,21,24] Robust cross-sectional and longitudinal surveys about indoor tanning behaviours are rare, no less so than in Canada.

Research and public health promotion efforts should target adolescents as they are at a critical age to prevent risk behaviours from developing. In fact, adolescents are *less* likely to try indoor tanning if they have not done so by a certain age.[20] Exploring sex-based differences in behaviours to do with indoor tanning can help focus preventative strategies.[24] Furthermore, the impacts of gender identity and sexual orientation on indoor tanning have not been investigated.

Poor self-image and low self-esteem are associated with indoor tanning among adolescents.[12,22,25] Among male adolescents in the United States, a correlation between indoor tanning and a perception of being very overweight or very underweight and being a victim of bullying suggests that bullying and peer relationships also play a role.[25]

Indoor tanning is also correlated with smoking and susceptibility to smoking, binge drinking and drug use.[12,13,16,18,20-22,24,26] It may be that adolescents who tan indoors are more susceptible to engage in risk behaviours despite the risks being well documented. The association between indoor tanning and risk behaviours that are unrelated to appearance enhancement suggests that some engage in these behaviours for other purposes, such as to cope with anxiety. For instance, a significant proportion of indoor tanners report that tanning lifts their spirits and is relaxing.[20]

While the literature examining the relationship between indoor tanning and the use of sunscreen outdoors is inconsistent,[14,15,17,18] the relationship between indoor tanning and physical activity is also unclear. Several studies have found that adolescents who play on a sports team are more likely to tan indoors.[18,27] Conversely, Demko et al.[16] found that physical activity among female adolescents is associated with a lower likelihood of indoor tanning. Controlling for size of peer group and sun exposure through outdoor physical activity may shed some light on these conflicting findings.

Adolescents' proximity to indoor tanning facilities also impacts their use. In the United States, shorter distances to indoor tanning facilities were correlated with greater use.[23]

The purpose of this secondary analysis of the 2012/13 Manitoba Youth Health Survey (YHS) is to

- determine the prevalence of indoor tanning among Manitoba adolescents,
- explore relationships between indoor tanning and an extensive set of variables to confirm or challenge findings in a Canadian setting and
- generate new hypotheses around reasons for indoor tanning.

We hypothesize that indoor tanning will be positively associated with various risk behaviours (such as substance use), consumption behaviours related to bolstering appearance (i.e. indicative of weight control efforts), poorer mental well-being and being bullied.

Applying a social ecological model[28] to this research helps us examine associated behaviours and risk factors and consider individual characteristics, social influences, communities, institutions, structures, policies and systems. In terms of institutional factors, legislation on indoor tanning came into force in June 2012 in Manitoba (before the Youth Health Survey was conducted). The legislation that was in effect at the time of this study required youth younger than 18 years to have written permission to tan indoors and those under 16 years to be accompanied by their parent or guardian. As this research is limited to individuals' survey responses about varied health behaviours, and as all participants are residents of Manitoba (and are exposed to similar institutions, structures, policies and systems), we focus upon individual characteristics and social influence, where possible.

Methods

The Youth Health Survey and sampling procedures

The Manitoba YHS, a self-reported paper survey completed in school that includes questions about physical activity, eating behaviours, sun safety, mental well-being, bullying, school connectedness, tobacco use, drug and alcohol use, healthy sexuality and injury prevention, was designed and implemented by Partners in Planning for Healthy Living, a network of health and research partners from across Manitoba.[29]

All Manitoba schools, including independent, Francophone, Hutterite and First Nations schools, were invited to participate in the survey in the 2012/13 school year. Overall, 476 schools (73% of all eligible schools) conducted the 2012/13 survey, and 64 174 Grade 7 to 12 students (67% of all the students enrolled in the eligible grades in Manitoba) completed it.

Measures

The dependent variable used in this secondary analysis study is history of indoor tanning. Indoor tanning use was measured using responses to the question "Have you ever used any artificial tanning

equipment such as a tanning bed, sunlamp or tanning light?" (possible responses were "Yes" or "No"). Only students with a valid answer to this question and who reported their sex ("male" or "female") were included in analyses (n = 60 648; 95% of the entire Manitoba dataset). Each independent variable was analyzed independently, and missing answers were removed from each analysis if the student did not have a valid answer for the dependent and independent variables; as a result, the denominator is different for each independent variable.

For the urban/rural variable, schools were categorized as urban (schools in Winnipeg and Brandon) or rural (all other schools).

The descriptive characteristics and binary logistic regression included 25 independent variables (most with collapsed response categories for simplicity). These independent variables were selected based on previous research; some, such as smoking, were found to be significant in other research, whereas others, such as consumption behaviours and self-esteem, were related to a cluster of variables examined in other research. Descriptions of the independent variables and how they were derived are available on request from the authors.

Statistical analysis

We analyzed male and female students separately as a number of studies have found sex differences in the prevalence of indoor tanning, but few have explored whether the behaviours associated with indoor tanning differ.

We calculated the prevalence of indoor tanning and the frequencies of all variables. All variables were included in binary logistic regression models to determine the direction, significance and size of effect of all associations with indoor tanning. The binary logistic regression models also enabled investigating unique associations between similar variables and indoor tanning (e.g. if perceiving oneself as overweight was associated with indoor tanning whereas experiencing someone say something bad about one's body shape/size/appearance was not). Binary logistic regression models were adjusted for age to observe the impacts of health behaviours independently of their relationship with age. Since the independent and dependent variables are categorical measures, we used chi-square analysis to examine the associated behaviours of students who have tanned indoors and those who have not, with an alpha level set at 0.05. Confidence intervals (CI) were set to 95%.

The binary logistic regression models explored the relationship between independent variables and indoor tanning, and demonstrated significant positive or negative associations for most variables. In other words, there were too many significant variables to include in the final logistic regression models. To reduce the number of variables for the final logistic regression models, we tested for collinearity between significant variables for each sex. This involved analyzing two-by-two tables of all combinations of independent variables and examining relationships between the two independent variables. Independent variables that had skewed distributions were indicative of correlations. Testing for collinearity revealed several groups of highly correlated variables that differed slightly for male and female adolescents. We used the variable with the greatest effect in the final logistic regression model as a proxy for the group of highly correlated variables. Significant variables from the initial binary logistic regression that were not highly correlated to any other variables were also placed in the final logistic regression models. The final logistic regression model explored the significance of variables' relationship to indoor tanning once all variables were included in the model.

We used forward selection to determine the significance of independent variables within the final logistic regression models. These models were adjusted for age. Analyses were completed using statistical package SAS version 9.2 (SAS Institute Inc., Cary, NC, USA) in the Department of Epidemiology and Cancer Registry at CancerCare Manitoba.

Ethical approval for this research was obtained from the Health Research Ethics Board of the University of Manitoba.

Results

Overall, 4% (1223/30 642) of male and 9% (2671/30 006) of female students had used indoor tanning equipment in their lifetime. Table 1 shows that students who use indoor tanning equipment, and particularly girls, tend to be older than those who do not (56% of girls who tanned indoors were 15 years and older compared to 30% of girls who had not tanned indoors).

The unadjusted odds ratios (ORs) of having used indoor tanning equipment are shown in Table 2. We examined separate datasets for male and female students and adjusted the results for age. Response categories were collapsed so that each independent variable had two categories.

The binary logistic regression of students' behaviours (Table 2) found that indoor tanning was significantly associated with having part-time work; being physically active; smoking; binge drinking; marijuana and other drug use; drinking or drug use and driving; experiencing someone say something bad about one's body shape/size/appearance; having poorer mental well-being; identifying as trans or with a different gender; having had sex; having unplanned sex after alcohol/drugs; drinking soft drinks and diet soft drinks; taking creatine/other supplements; consuming meal replacement bars or shakes; and eating fast food.

In addition, female students' indoor tanning was also associated with perceiving oneself as overweight, never/rarely using sun protection and attending a rural school, while male students' indoor tanning was also associated with being attracted to the same sex or both sexes and eating vegetables/fruit four or more times in a day.

We found a strong correlation between several groupings of variables among male students: physical activity level and fruit and vegetable consumption (of these, physical activity had the greater effect related to indoor tanning); smoking, binge drinking, marijuana use, other drug use, drinking and driving, drug use and

TABLE 1
Descriptive characteristics of Grades 7 to 12 students by indoor tanning status and by sex, Manitoba, 2012

Description	Male		Female		Total	
	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)
All	1223 (100)	29 409 (100)	2671 (100)	27 335 (100)	3904 (100)	56 744 (100)
Age, years						
≤ 12	169 (14)	4698 (16)	163 (6)	4717 (17)	332 (9)	9415 (17)
13–15	533 (43)	15 381 (52)	1022 (38)	14 307 (52)	1555 (40)	29 688 (52)
16–17	458 (37)	8173 (28)	1306 (49)	7434 (27)	1764 (45)	15 607 (28)
18+	69 (6)	1117 (4)	174 (7)	852 (3)	243 (6)	1969 (3)
Part-time work, hours per week						
None	710 (59)	20 674 (71)	1198 (45)	17 646 (65)	1908 (49)	38 320 (68)
< 15	274 (23)	5611 (19)	879 (33)	7494 (28)	1153 (30)	13 105 (23)
≥ 15	225 (19)	2780 (10)	573 (22)	1942 (7)	798 (21)	4722 (8)
Body mass index[a]						
Underweight	55 (6)	974 (4)	63 (3)	665 (3)	118 (4)	1639 (4)
Healthy weight	577 (65)	15 226 (67)	1609 (78)	15 441 (76)	2186 (74)	30 667 (71)
Overweight	143 (16)	3636 (16)	282 (14)	2628 (13)	425 (14)	6264 (15)
Obese	113 (13)	2860 (13)	112 (5)	1544 (8)	225 (8)	4404 (10)
Perception of body weight						
Underweight	137 (12)	2766 (10)	147 (6)	1549 (6)	284 (7)	4315 (8)
About the right weight	898 (76)	22 428 (78)	1881 (72)	19 755 (74)	2779 (73)	42 183 (76)
Overweight	153 (13)	3396 (12)	580 (22)	5254 (20)	733 (19)	8650 (16)
Physical activity level[b]						
Inactive	152 (13)	4215 (15)	425 (17)	5396 (21)	577 (16)	9611 (18)
Moderately active	287 (24)	9217 (33)	977 (39)	10 192 (39)	1264 (34)	19 409 (36)
Active	739 (63)	14 744 (52)	1134 (45)	10 234 (40)	1873 (50)	24 978 (46)
Smoking status[c]						
Non-smoker	880 (71)	26 189 (89)	1907 (71)	24 784 (91)	2787 (71)	50 973 (90)
Occasional	167 (14)	1896 (6)	434 (16)	1496 (5)	601 (15)	3392 (6)
Daily	186 (15)	1324 (5)	330 (12)	1055 (4)	516 (13)	2379 (4)
Past month binge drinking, number of days[d]						
0	737 (63)	23 423 (83)	1312 (51)	22 500 (85)	2049 (55)	45 923 (84)
1–5	300 (26)	3934 (14)	1033 (40)	3453 (13)	1333 (36)	7387 (14)
≥ 6	133 (11)	779 (3)	212 (8)	404 (2)	345 (9)	1183 (2)
Past month marijuana use, number of times						
0	821 (70)	24 619 (87)	1797 (69)	23 796 (89)	2618 (70)	48 415 (88)
≥ 1	346 (30)	3712 (13)	794 (31)	2850 (11)	1140 (30)	6562 (12)
Past month other drug use, number of times[e]						
0	964 (82)	26 917 (95)	2264 (87)	25 419 (95)	3228 (86)	52 336 (95)
≥ 1	205 (18)	1333 (5)	336 (13)	1232 (5)	541 (14)	2565 (5)

Continued on the following page

TABLE 1 (continued)
Descriptive characteristics of Grades 7 to 12 students by indoor tanning status and by sex, Manitoba, 2012

Description	Male		Female		Total	
	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)
Past month drinking and driving						
Never	939 (80)	26 496 (94)	2226 (85)	25 821 (97)	3165 (84)	52 317 (95)
Not in this past month	66 (6)	880 (3)	188 (7)	514 (2)	254 (7)	1394 (3)
≥ 1 times	163 (14)	937 (3)	198 (8)	370 (1)	361 (10)	1307 (2)
Past month drug use and driving						
Never	845 (80)	24 426 (94)	2053 (83)	24 356 (96)	2898 (82)	48 782 (95)
Not in this past month	45 (4)	564 (2)	159 (6)	394 (2)	204 (6)	958 (2)
≥ 1 times	167 (16)	1008 (4)	247 (10)	554 (2)	414 (12)	1562 (3)
Someone said something bad about your body shape, size or appearance in past year						
Never	754 (67)	19 982 (72)	1106 (43)	14 149 (54)	1860 (50)	34 131 (63)
≥ 1 times	287 (25)	7114 (26)	1319 (52)	11 035 (42)	1606 (44)	18 149 (34)
Every day	92 (8)	635 (2)	126 (5)	990 (4)	218 (6)	1625 (3)
Mental health continuum[f]						
Languishing	108 (9)	1285 (4)	226 (8)	1746 (6)	334 (9)	3031 (5)
Moderate	438 (36)	9719 (33)	1138 (43)	10 448 (38)	1576 (41)	20 167 (36)
Flourishing	670 (55)	18 117 (62)	1296 (49)	14 946 (55)	1966 (51)	33 063 (59)
Using sun protection outdoors[g]						
Never	416 (34)	7701 (27)	731 (28)	3870 (14)	1147 (30)	11 571 (21)
Rarely	468 (39)	12 536 (43)	1212 (46)	11 076 (41)	1680 (44)	23 612 (42)
Often	219 (18)	7216 (25)	550 (21)	9128 (34)	769 (20)	16 344 (29)
Always	112 (9)	1522 (5)	152 (6)	2930 (11)	264 (7)	4452 (8)
Gender identity[h]						
Identify with the same sex	730 (89)	18 627 (97)	1877 (97)	18 230 (98)	2607 (95)	36 857 (97)
Identify with a different sex	39 (5)	364 (2)	41 (2)	327 (2)	80 (3)	691 (2)
Trans	54 (7)	265 (1)	16 (1)	67 (0)	70 (3)	332 (1)
Sexual orientation[i]						
Attracted to different sex	695 (88)	17 986 (95)	1682 (89)	16156 (90)	2377 (88)	34 142 (93)
Attracted to same sex	32 (4)	356 (2)	47 (2)	405 (2)	79 (3)	761 (2)
Attracted to both sexes	62 (8)	497 (3)	171 (9)	1339 (7)	233 (9)	1836 (5)
Has had sex						
No	455 (53)	15 125 (77)	889 (46)	15 524 (82)	1344 (48)	30 649 (80)
Yes	356 (41)	3998 (20)	1032 (53)	3161 (17)	1388 (50)	7159 (19)
I don't know	47 (5)	443 (2)	23 (1)	149 (1)	70 (2)	592 (2)
Unplanned sex after alcohol/drugs						
Did not have sex	485 (59)	15 217 (79)	908 (47)	15 517 (83)	1393 (51)	30 734 (81)
Did not do this in past year	35 (4)	463 (2)	40 (2)	265 (1)	75 (3)	728 (2)
Yes	166 (20)	1387 (7)	504 (26)	1003 (5)	670 (24)	2390 (6)
No	140 (17)	2108 (11)	466 (24)	1810 (10)	606 (22)	3918 (10)

Continued on the following page

TABLE 1 (continued)
Descriptive characteristics of Grades 7 to 12 students by indoor tanning status and by sex, Manitoba, 2012

Description	Male		Female		Total	
	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)
Vegetables and fruit consumption (yesterday), number of times						
0	76 (6)	1519 (5)	146 (6)	1310 (5)	222 (6)	2829 (5)
1–3	220 (19)	7005 (25)	747 (28)	7465 (28)	967 (25)	14 470 (26)
4–7	373 (32)	10 484 (37)	995 (38)	10 483 (39)	1368 (36)	20 967 (38)
≥ 8	513 (43)	9546 (33)	743 (28)	7710 (29)	1256 (33)	17 256 (31)
Soft drink consumption (yesterday), number of times						
0	430 (38)	12 967 (47)	1509 (60)	16 623 (63)	1939 (53)	29 590 (55)
1–3	473 (42)	12 179 (44)	869 (34)	8456 (32)	1342 (37)	20 635 (38)
4–7	126 (11)	1774 (6)	101 (4)	881 (3)	227 (6)	2655 (5)
≥ 8	93 (8)	597 (2)	51 (2)	229 (1)	144 (4)	826 (2)
Diet soft drink consumption (yesterday), number of times						
0	739 (66)	22 514 (83)	2 098 (83)	22 685 (87)	2 837 (78)	45 199 (85)
1–3	231 (21)	3 766 (14)	348 (14)	2 969 (11)	579 (16)	6 735 (13)
4–7	84 (8)	702 (3)	55 (2)	344 (1)	139 (4)	1 046 (2)
≥ 8	61 (5)	265 (1)	25 (1)	81 (0)	86 (2)	346 (1)
Creatine/other supplements consumption (yesterday), number of times						
0	758 (69)	23 939 (89)	2270 (91)	24 223 (95)	3028 (85)	48 162 (92)
1–3	199 (18)	2274 (8)	164 (7)	997 (4)	363 (10)	3271 (6)
4–7	70 (6)	402 (1)	33 (1)	116 (0)	103 (3)	518 (1)
≥ 8	70 (6)	197 (1)	16 (1)	37 (0)	86 (2)	234 (0)
Meal replacement bars or shakes consumption (yesterday), number of times						
0	692 (61)	21 883 (80)	2069 (82)	22 939 (88)	2761 (75)	44 822 (84)
1–3	292 (26)	4766 (17)	397 (16)	2897 (11)	689 (19)	7663 (14)
4–7	77 (7)	545 (2)	42 (2)	230 (1)	119 (3)	775 (1)
≥ 8	67 (6)	233 (1)	21 (1)	69 (0)	88 (2)	302 (1)
Fast food consumption (yesterday), number of times						
0	501 (44)	16 231 (59)	1629 (64)	17 480 (66)	2130 (57)	33 711 (62)
1–3	428 (37)	9834 (35)	811 (32)	8010 (30)	1239 (33)	17 844 (33)
4–7	131 (11)	1263 (5)	74 (3)	712 (3)	205 (6)	1975 (4)
≥ 8	90 (8)	414 (1)	44 (2)	160 (1)	134 (4)	574 (1)

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TABLE 1 (continued)
Descriptive characteristics of Grades 7 to 12 students by indoor tanning status and by sex, Manitoba, 2012

Description	Male		Female		Total	
	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)	Have tanned indoors, n (%)	Have not tanned indoors, n (%)
Rural or urban location of school						
Rural	548 (44)	12 536 (43)	1208 (45)	11 376 (42)	1756 (45)	23 912 (42)
Urban	685 (56)	16 873 (57)	1463 (55)	15 959 (58)	2148 (55)	32 832 (58)

Abbreviations: BMI, body mass index; SPF, sun protection factor.

Note: % values are based on number of valid answers for each variable. Due to rounding, some response options may not add up to 100%.

[a] Body mass index calculated from students' self-reported age, height and weight and classified according to the 2000 Centers for Disease Control BMI-for-age growth charts for boys and girls.

[b] Students' physical activity levels were categorized as active, moderately active or inactive based upon their reported previous week's minutes of vigorous and moderate activity.

[c] Daily smokers reported smoking cigarettes every day or almost every day; occasional smokers reported smoking at least 100 cigarettes in their lifetime or smoking on some days in the past month.

[d] Binge drinking was defined as having ≥ 5 alcoholic drinks within a couple of hours.

[e] Past month other drug use is a summary variable that includes any reported use of cocaine or crack, methamphetamines, ecstasy, LSD or other hallucinogens, or a prescription or over-the-counter drug to get high.

[f] Mental health continuum is calculated based upon students' responses to 14 questions about feelings.[30]

[g] Using sun/UV protection outdoors is defined as the frequency (never, rarely, often or always) that students seek shade, cover up or wear sunscreen with an SPF of 15 or higher outdoors for more than 30 minutes on a sunny day.

[h] Students were asked to self-identify as male or female at the outset of the survey, then asked for their gender identity (male, female or trans) in the healthy sexuality section. Students were placed into categories "same" (they identified as the same gender for both questions), "different" (they identified as a different gender for each question), or "trans" (they identified as trans in the healthy sexuality section).

[i] Students were asked to whom they were attracted (males, females, both males and females, or no one), and their responses compared to their self-identified sex (male or female) at the outset of the survey. Students were attracted to the "same" sex, a "different" sex or "both." Students attracted to no one were not included in these analyses.

driving, having had sex and having had unplanned sex after using alcohol/drugs (of these, drinking and driving had the greatest effect related to indoor tanning); experiencing someone say something bad about one's body shape/size/appearance and having poorer mental well-being (of these, the former had the greater effect related to indoor tanning); identifying as trans or with a different gender and being attracted to the same sex or both sexes (of these, identifying as trans or with a different gender had the greater effect related to indoor tanning); and consuming soft drinks, diet soft drinks, creatine/other supplements, meal replacement bars/shakes and fast food (of these, creatine/other supplements consumption had the greatest effect related to indoor tanning). For male students, having part-time work was not strongly associated with any other variables, but we nevertheless added it to the final logistic regression model.

The results for the final logistic regression model for male students are shown in Table 3. Having part-time work; being physically active; drinking and driving; experiencing someone say something bad about one's body shape/size/appearance; identifying as trans or with a different gender; and consuming creatine/other supplements all maintained their significant associations with indoor tanning.

When testing for collinearity among significant variables of female students, we found a strong correlation between several groupings of variables: smoking, binge drinking, marijuana use, other drug use, drinking and driving, drug use and driving, having had sex, and having had unplanned sex after alcohol/drugs (of these, unplanned sex after alcohol/drugs had the greatest effect related to indoor tanning); experiencing someone say something bad about one's body shape/size/appearance, perceiving oneself as overweight and having poorer mental well-being (of these, experiencing someone say something bad about one's body shape/size/appearance had the greater effect related to indoor tanning); and consuming soft drinks, diet soft drinks, creatine/other supplements, meal replacement bars/shakes and fast food (of these, creatine/other supplements consumption had the greatest effect related to indoor tanning). For female students, having part-time work, being physically active, using sun protection, gender identity and rural location of school were not strongly associated with any other variables. These were added to the final logistic regression model as well.

The results for the final logistic regression model for female students are shown in Table 4. Having part-time work, being physically active, experiencing someone say something bad about one's body shape/size/appearance, never/rarely using sun protection, identifying as trans or with a different gender, having had

TABLE 2
Indoor tanning among male and female Grade 7–12 students, by demographic characteristics and health behaviours, adjusted for age, Manitoba, 2012

	Male			Female		
	OR	95% confidence limits	*p* value[a]	OR	95% confidence limits	*p* value[a]
Part-time work						
No (Ref)	1.00			1.00		
Yes	**1.57	1.39–1.78	< .001	**1.87	1.72–2.03	< .001
Body mass index						
Healthy weight/Underweight (Ref)	1.00			1.00		
Overweight/Obese	1.01	0.87–1.17	.880	0.93	0.83–1.05	.251
Perception of body weight						
About the right weight/Underweight (Ref)	1.00			1.00		
Overweight	1.08	0.91–1.29	.380	*1.11	1.01–1.23	.034
Physical activity level						
Active (Ref)	1.00			1.00		
Moderately active / Inactive	**0.63	0.55–0.71	< .001	**0.73	0.67–0.79	< .001
Smoking status						
Non-smoker (Ref)	1.00			1.00		
Daily/Occasional smoker	**3.02	2.63–3.46	< .001	**3.15	2.86–3.48	< .001
Past month binge drinking, days						
0 (Ref)	1.00			1.00		
≥ 1	**2.77	2.42–3.17	< .001	**4.42	4.04–4.84	< .001
Past month marijuana use, times						
0 (Ref)	1.00			1.00		
≥ 1	**2.55	2.22–2.92	< .001	**3.10	2.82–3.41	< .001
Past month other drug use, times						
0 (Ref)	1.00			1.00		
≥ 1	**3.92	3.33–4.62	< .001	**2.78	2.44–3.17	< .001
Past month drinking and driving, times						
0 (Ref)	1.00			1.00		
≥ 1	**4.27	3.56–5.12	< .001	**4.55	3.79–5.46	< .001
Past month drug use and driving, times						
0 (Ref)	1.00			1.00		
≥ 1	**4.09	3.40–4.92	< .001	**3.75	3.19–4.40	< .001
Someone said something bad about your body shape, size or appearance in past year, times						
0 (Ref)	1.00			1.00		
≥ 1	**1.29	1.13–1.46	< .001	**1.52	1.40–1.65	< .001
Mental health continuum						
Flourishing (Ref)	1.00			1.00		
Languishing/Moderate	**1.28	1.14–1.44	< .001	**1.21	1.11–1.31	< .001
Using sun protection outdoors						
Always/Often (Ref)	1.00			1.00		
Never/Rarely	1.10	0.97–1.25	.147	**2.12	1.94–2.32	< .001

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TABLE 2 (continued)
Indoor tanning among male and female Grade 7–12 students, by demographic characteristics and health behaviours, adjusted for age, Manitoba, 2012

	Male			Female		
	OR	95% confidence limits	*p* value[a]	OR	95% confidence limits	*p* value[a]
Gender identity						
Identify with same gender (Ref)	1.00			1.00		
Trans/Identify with different gender	**3.74	2.97–4.71	< .001	*1.42	1.07–1.90	.017
Sexual orientation						
Attracted to a different sex (Ref)	1.00			1.00		
Attracted to the same sex / both sexes	**2.73	2.17–3.42	< .001	1.10	0.95–1.29	.201
Have had sex						
No / Don't know (Ref)	1.00		< .001	1.00		
Yes	**2.59	2.22–3.02		**4.69	4.22–5.22	< .001
Unplanned sex after alcohol/drugs						
No/Not in past year (Ref)	1.00		< .001	1.00		
Yes	**2.80	2.31–3.38		**4.78	4.21–5.41	< .001
Vegetables and fruit consumption (yesterday), times						
≥ 4 (Ref)	1.00			1.00		
< 4	**0.76	0.67–0.87	< .001	1.01	0.93–1.10	.784
Soft drink consumption (yesterday)						
0 (Ref)	1.00			1.00		
≥ 1	**1.44	1.27–1.63	< .001	**1.22	1.12–1.33	< .001
Diet soft drink consumption (yesterday)						
0 (Ref)	1.00			1.00		
≥ 1	**2.50	2.19–2.84	< .001	**1.47	1.31–1.65	< .001
Creatine/other supplements consumption (yesterday)						
0 (Ref)	1.00			1.00		
≥ 1	**3.55	3.10–4.06	< .001	**2.08	1.78–2.44	< .001
Meal replacement bars or shakes consumption (yesterday), times						
0 (Ref)	1.00			1.00		
≥ 1	**2.53	2.23–2.86	< .001	**1.79	1.60–1.99	< .001
Fast food consumption (yesterday), times						
0 (Ref)	1.00			1.00		
≥ 1	**1.82	1.61–2.05	< .001	*1.14	1.05–1.24	.002
Rural or urban location of school						
Rural (Ref)	1.00			1.00		
Urban	0.93	0.83–1.04	.190	**0.83	0.77–0.90	< .001

Abbreviation: OR, odds ratio.

[a] Differences between students engaging in indoor tanning and those not engaging in indoor tanning for each variable were assessed with the χ^2 test.

* *p* value ≤ .05.

** *p* value ≤ .001.

TABLE 3
Indoor tanning behaviours among male Grade 7–12 students by demographic characteristics and health behaviours, adjusted for age, Manitoba, 2012

	OR	95% confidence limits	*p* value[a]
Part-time work			
No (Ref)	1.00		
Yes	**1.33	1.13–1.57	< .001
Physical activity level			
Active (Ref)	1.00		
Moderately active / Inactive	**0.72	0.61–0.84	< .001
Past month drinking and driving, times			
0 (Ref)	1.00		
≥ 1	**2.84	2.21–3.65	< .001
Someone said something bad about your body shape, size or appearance in past year, times			
0 (Ref)	1.00		
≥ 1	*1.19	1.01–1.40	.043
Gender identity			
Identify with same gender (Ref)	1.00		
Trans / Identify with different gender	**2.75	2.09–3.61	< .001
Creatine/other supplements consumption (yesterday), times			
0 (Ref)	1.00		
≥ 1	**2.62	2.19–3.13	< .001

Abbreviation: OR, odds ratio.

[a] Differences between students engaging in indoor tanning and those not engaging in indoor tanning for each variable were assessed with the χ^2 test.

* $p \leq .05$.

** $p \leq .001$.

unplanned sex after alcohol/drugs and consuming creatine/other supplements all maintained their significant associations with indoor tanning. Going to a rural school lost its significant association with indoor tanning in the final logistic regression model.

Discussion

Our research expands upon worldwide examinations of indoor tanning and associated behaviours among adolescents. This is also the first large-scale study of indoor tanning and associated behaviours exclusively among Canadian adolescents.

Our results suggest that several groupings of factors are associated with adolescents' indoor tanning. A combination of individual characteristics, social influences and community factors are likely at the root of these relationships. Many associations were similar for male and female students.

For both male and female students, part-time work played a significant role in indoor tanning behaviour. This association with part-time work may indicate that people who use indoor tanning equipment are more likely to have spending money than non-users. This is consistent with a study by Mayer et al.[23] that found that having a larger allowance was predictive of indoor tanning. It is possible that some associated behaviours are partly explained by adolescents' spending patterns.

The association between indoor tanning and fast food and soft drink consumption was unexpected as most other consumption behaviours associated with indoor tanning relate more closely to appearance and weight control (creatine/other supplements and meal replacement bars).

Positive attitudes towards indoor tanning and a tanned appearance more often lead to adolescents' indoor tanning.[14,20,26] For female students, indoor tanning was associated with perceiving oneself as overweight and someone saying something bad about their body shape, size or appearance, but not with body mass index itself. This suggests that indoor tanning is used as a tool to improve one's appearance and is linked to greater self-consciousness about one's body. Alternately, as other studies suggest, being bullied may be related to indoor tanning independently of body image.[20,26]

TABLE 4
Indoor tanning behaviours among female Grade 7–12 students by demographic characteristics and health behaviours, adjusted for age, Manitoba, 2012

	OR	95% confidence limits	*p* value[a]
Part-time work			
No (Ref)	1.00		
Yes	**1.68	1.51–1.88	< .001
Physical activity level			
Active (Ref)	1.00		
Moderately active / Inactive	**0.80	0.72–0.89	< .001
Someone said something bad about your body shape, size or appearance in past year			
Never (Ref)	1.00		
1 or more times	**1.31	1.18–1.46	< .001
Using sun protection outdoors			
Always/Often (Ref)	1.00		
Never/Rarely	**2.10	1.87–2.37	< .001
Gender identity			
Identify with same gender (Ref)	1.00		
Trans / Identify with different gender	*1.41	1.01–1.98	.044
Unplanned sex after alcohol/drugs			
No / Not in past year / Did not have sex (Ref)	1.00		
Yes	**3.88	3.38–4.45	< .001
Creatine/other supplements consumption (yesterday)			
0 times (Ref)	1.00		
1 or more times	**1.84	1.49–2.26	< .001

Abbreviation: OR, odds ratio.

Note: Rural or urban location of school variable was removed from the table as it was not significant in this model.

[a] Differences between students engaging in indoor tanning and those not engaging in indoor tanning for each variable were assessed with the χ^2 test.

* $p \leq .05$.

** $p \leq .001$.

For both male and female students, experiencing someone say something bad about their body shape, size or appearance had a stronger association (greater significance and size of effect) with indoor tanning than their perceiving themselves overweight. This suggests that indoor tanning may function as a coping mechanism, at least in part. This is confirmed by the associations between indoor tanning and poorer mental well-being, suggesting that indoor tanning is the product of the interaction between body-related insecurity *and* efforts to cope.

Furthermore, the consistent association between indoor tanning and behaviours not related to appearance—smoking, binge drinking, marijuana use, other drug use, drinking and driving, drug use and driving, having had sex and having had unplanned sex after alcohol/drugs—may indicate that indoor tanning is one of a number of risk behaviours used for coping. This association may also indicate that these individuals do not prioritize health behaviours despite knowing their benefits. Mayer et al.[23] found that adolescents who tan indoors have greater knowledge of the risks surrounding indoor tanning, likely due to greater exposure to health warnings while at indoor tanning facilities. Further education on the dangers of UV exposure and benefits of protective behaviours alone is therefore unlikely to reduce their use of indoor tanning; interventions targeting attitudes in relation to appearance have been found to be more effective.[30] Other cultural factors that could be determined through a focus group or in interview setting may be at play. Open-ended questions about the reasons for and attitudes towards indoor tanning could better address this gap in the research.

We should also consider the implications of social influence upon indoor tanning. Adolescents who tan indoors may be more likely to justify risk behaviours due to the risk behaviours of their peer group. The attitudes and behaviours of peers and parents, and adolescents' perception of these, have been found to significantly impact adolescents' indoor tanning.[17,19,20,22]

As many adolescents are accompanied by their parents when they initiate indoor tanning, legislation requiring that adolescents have signed parental consent (legislation in effect at the time of the survey) may do little to curb this behaviour. An indoor tanning ban for people younger than 18 years came into effect in Manitoba on January 1, 2016. This then limits indoor tanning to youth with a prescription from a health professional, youth with access to home indoor tanning equipment and youth who use indoor tanning facilities that do not adhere to legislation.

While social influence may be at root of the relationships between indoor tanning and various risk behaviours, the association between indoor tanning and physical activity (a healthy behaviour) for both male and female students may also be attributed to social influence. Guy et al.[18] and Miyamoto et al.[27] found that sports team membership is associated with indoor tanning. Unfortunately these studies did not control for size and variety of peer group (which may bolster an adolescent's exposure to more diverse attitudes and behaviours) or unprotected outdoor UV exposure (which may contribute to skin darkening). However, these analyses also find that female students who never or rarely use sun protection are almost twice as likely to tan indoors, suggesting a relationship between purposefully seeking UV exposure via indoor tanning and neglecting to protect against outdoor UV exposure.

Another sex-based difference was the relationships between indoor tanning and gender identity for male students, and between indoor tanning and sexual activity for female students. While all of these associations were significant for both male and female students, the size of the effect varied between the sexes. The final logistic regression model found that male students who identify as trans or with a different gender are nearly three times as likely to have used indoor tanning equipment, compared to 1.41 times as likely for female students. Similarly, binary logistic regression found that sexual orientation is significantly associated with indoor tanning for male students, but not for female students. The association between indoor tanning and identifying as trans or with a different gender among male students may be indicative of a lesser adherence to traditionally perceived gender norms. Alternately, the size of effect of sexual activities (having had sex, having had unplanned sex after alcohol/drugs) upon indoor tanning for female students was greater than that for male. There may be a greater sense of body consciousness and concern about appearance among sexually active female adolescents. A more in-depth investigation into adolescents' attitudes and reasons for indoor tanning could investigate these relationships.

Finally, the association between indoor tanning and a student's school being in a rural area was significant only for female students. This may suggest that the culture of risk behaviours or appearance enhancement differs subtly between rural and urban settings for female adolescents only. However, this association lost significance in the final logistic regression model when adjusting for other variables.

Given the complex interaction of individual characteristics and social influences contributing to adolescents' indoor tanning, identifying opportune areas for preventive strategies is challenging. However, a consistent theme through much of this study is that indoor tanning is indicative of body self-consciousness and/or efforts to enhance one's appearance. This underlying reason may contribute to the association of indoor tanning with consumption of creatine or other supplements and meal replacement bars or shakes (particularly for male students); physical activity; sexual activity (particularly for female students); identifying as trans or with another gender (particularly for male students); experiencing someone say something bad about one's body shape/size/appearance; and even using sun protection (for female students). Interventions or campaigns that address healthy body image and highlight indoor tanning's detrimental effects upon appearance, especially at this critical age, could have a significant impact.

The association between indoor tanning and a number of risk behaviours that are unrelated to appearance enhancement were more challenging to address. These risk behaviours may be indicative of poorer mental well-being, coping efforts, peer pressure or feelings of invincibility despite knowledge of the negative outcomes. Continued efforts targeting mental health and encouraging healthy behaviours may have positive effects regarding indoor tanning as well.

Strengths and limitations

A strength of this research is that the extensive list of variables included in analyses allowed us to explore the associations between many behaviours and indoor tanning that have not been previously explored simultaneously. The test for collinearity enabled grouping of variables related to indoor tanning and each other, and highlighted variables that are *not* associated with each other but are independently associated with indoor tanning. The final logistic regression model allowed for the examination of the strength of the association between variables (or groups of variables) and indoor tanning when interacting.

A limitation of this study is that the YHS was not completed by 27% of eligible schools and 33% of Grade 7 to 12 Manitoba students. Most of the schools not represented were independent schools (not within a school division), Hutterite schools and First Nations schools. Many of these are within very small communities likely without access to indoor tanning equipment. However, many of these schools did participate. We examined the extent of similarity between schools by applying the logistic generalized estimating equation GEE model to the student data. The intra-class correlation within schools was very low (< 0.01 for male students and 0.03 for female students), suggesting that multilevel modelling was not necessary.

An additional limitation was that the YHS was not completed by adolescents who were not enrolled in school or in attendance when the questionnaire was implemented. It is likely that adolescents who were absent are more likely to be older and more likely to engage in risk

behaviours. As older age and risk behaviours are associated with indoor tanning, the non-participation of these students would actually suppress indoor tanning prevalence. It is impossible to know the exact effect of this limitation upon the results.

As the YHS relies on self-reporting, the findings may be subject to recall bias and response bias.

Finally, the YHS's time and space constraints led to the omission of questions that contribute to a greater understanding of who and why adolescents are tanning indoors, such as skin tone, attitudes or beliefs. Only one question determined the prevalence of indoor tanning (ever use of indoor tanning equipment) and there were no measures of the frequency of indoor tanning. Similarly, all questions about food and drink consumption were based on "yesterday's" consumption, substance use was based on behaviours from the "past month (30 days)" and physical activity was based on the "past week." These time spans are used as a proxy for regular habits. There is a risk that participants' behaviours reported are not representative of their regular habits.

Conclusion

This research highlights the significance of appearance enhancement and risk behaviours, and suggests that both individual characteristics and social influence contribute to indoor tanning.

Since these indoor tanning data were collected, most provinces, including Manitoba, have put into force legislation prohibiting the sale of indoor tanning to adolescents younger than 18 years. This legislation should limit access during a critical time, reducing the likelihood of initiating indoor tanning later in life. However, this research can be applied to design interventions targeting adults who choose to use indoor tanning equipment.

With a greater knowledge of adolescents' behaviours, policy makers, health practitioners, health promotion staff, parents and educators are better equipped to identify and discuss opportunities to improve adolescent and overall health. Although the landscape of indoor tanning is changing with current shifts in policy and awareness, continued work is needed to address positive attitudes towards a tanned appearance and the underlying reasons for adolescents' risk behaviours.

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Patterns of multiple health risk–behaviours in university students and their association with mental health: application of latent class analysis

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Abstract

Introduction: University and college campuses may be the last setting where it is possible to comprehensively address the health of a large proportion of the young adult population. It is important that health promoters understand the collective challenges students are facing, and to better understand the broader lifestyle behavioural patterning evident during this life stage. The purpose of this study was to examine the clustering of modifiable health-risk behaviours and to explore the relationship between these identified clusters and mental health outcomes among a large Canadian university sample.

Methods: Undergraduate students (n = 837; mean age = 21 years) from the University of Toronto completed the National College Health Assessment survey. The survey consists of approximately 300 items, including assessments of student health status, mental health and health-risk behaviours. Latent class analysis was used to identify patterning based on eight salient health-risk behaviours (marijuana use, other illicit drug use, risky sex, smoking, binge drinking, poor diet, physical inactivity, and insufficient sleep).

Results: A three-class model based on student behavioural patterns emerged: "typical," "high-risk" and "moderately healthy." Results also found high-risk students reporting significantly higher levels of stress than typical students ($\chi^2(1671) = 7.26$, $p < .01$).

Conclusion: Students with the highest likelihood of engaging in multiple health-risk behaviours reported poorer mental health, particularly as it relates to stress. Although these findings should be interpreted with caution due to the 28% response rate, they do suggest that interventions targeting specific student groups with similar patterning of multiple health-risk behaviours may be needed.

Keywords: *university students, mental health, health-risk behaviours, latent class analysis*

Highlights

- This study examined modifiable health-risk behaviours and mental health outcomes among Canadian undergraduate students.
- There are three discernable patterns of health-risk behaviours among these students.
- Our findings support the notion that engaging in multiple health-risk behaviours is associated with poorer mental health among the university student population.
- Interventions targeting specific student groups with similar patterning of multiple health-risk behaviours may be needed, and a greater emphasis should be placed on supporting health-protecting behaviours of diet, physical activity, and sleep.

Introduction

Behaviours that students acquire or reinforce while in college and university may shape their future health and the health of future generations through the students' eventual roles as parents and leaders. With approximately 20 million enrolled in over 6000 postsecondary institutions across the United States and Canada,[1] their influence on health could be significant.

The 2015 Okanagan Charter for Health Promoting Universities and Colleges is an international charter developed to promote health in university and college students. The Charter recognizes that postsecondary institutions must focus on health promotion and that the campus is an ideal setting for health-promoting initiatives.[2] Because campuses often have subsidized facilities, programs and staff who support interventions or health-promoting work, postsecondary students can benefit from sustained health messaging.

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High school graduation is largely considered to be the first major life transition, as it is accompanied by substantial adjustments across several life domains.[3] Health promotion during this period is particularly salient because a substantial proportion of the population starts to engage in health-risk behaviours.[4] Emerging adulthood is a time of significant increases in tobacco, marijuana and alcohol use and decreases in health-protective behaviours such as physical activity and healthy eating.[4,5] Given younger adults' greater autonomy, we can expect changes in behaviour: Previous inhibitions about health-risk behaviours may weaken with reduced adult supervision and an increased perception that many health-risk behaviours are normative adult behaviours.[6] Postsecondary institutions, with large numbers of young adults converged into this shared space, may be the last setting to comprehensively address the health of a relatively self-contained population.

While it is likely that many health-risk behaviours are interrelated, most epidemiological research into health behaviours in the postsecondary student population have failed to consider the potential of such interrelationships;[7] studies typically examine multiple health-risk behaviours as separate dependent measures.[8] It is important that health promoters understand the collective challenges students face. In addition, researchers should understand the broader lifestyle behavioural patterning evident during this life stage.

Emerging statistical techniques such as latent class analysis (LCA) allow multiple health-risk behaviours or multiple dependent variables to be investigated together. Specifically, LCA identifies a parsimonious number of classes of individuals who display similar responses.[9] Segmenting populations into specific groups based on behavioural profiles may improve the scope, utilization and efficacy of interventions that target multiple modifiable health-risk behaviours simultaneously.[10]

Laska et al[11] published the first study to use LCA to examine lifestyle patterning of modifiable health-risk behaviours among postsecondary students. They found four distinct behavioural patterns, information that may be useful for tailoring on-campus health promotion activities to target these specific student segments. However, little is known how such behavioural typologies (i.e. shared patterning of health-risk behaviours) may be related to mental health outcomes such as stress, anxiety and depression.

Postsecondary students' psychological well-being is increasingly recognized as important.[2,7] Young adults appear to experience greater stress and depressive symptoms than in the past,[12] and have higher levels of psychological distress than the general population.[13] Examining the relationship between multiple health-risk behaviours and mental health outcomes may help determine the behavioural profiles of postsecondary students and how these relate to their mental health.

The primary purpose of this study was to use LCA to examine the distinct health-risk behavioural patterns in a sample of Canadian university students. Advancing the work of Laska and colleagues,[11] we also examined the relationship between the identified latent classes and several mental health outcomes including fatigue, stress, depression, anxiety and psychological distress.

Methods

Database and sample

We collected data during the spring of 2009 using the National College Health Assessment (NCHA).[14] (For further information, see the American College Health Association [ACHA] website[15].) The NCHA survey, which has been evaluated extensively for reliability and validity among college and university students in the United States,[15] consists of approximately 300 questions, including assessments of student health status, mental health and health behaviours.

To obtain our study sample, 5000 students from the approximately 50 000 on the St. George campus at the University of Toronto were randomly chosen to participate in the survey. Each student was emailed an invitation to complete the web-based survey on a secure website maintained by the ACHA. Three reminders to complete the online survey were sent to the students over one month.

Our sample comprised 837 full-time undergraduate students (survey response rate = 27.9%). The mean age (standard deviation) of the sample was 20.92 (3.73) years, and participants were predominantly female (64%) and Caucasian (65%). The characteristics of our sample are shown in Table 1.

Study procedures were approved by the University of Toronto Research Ethics Board.

Measures

Participants provided demographic information consisting of age, sex, height and weight, living situation (e.g. on/off campus/parental home) and information on student status (e.g. full-time/part-time, year of study).

The eight health-risk behaviours measured were insufficient physical activity, fruit and vegetable intake, and sleep and smoking, marijuana use, illicit drug use, binge drinking and risky sexual behaviours. The five mental health outcomes measured were fatigue, stress, diagnosed depression, diagnosed anxiety and psychological distress.

Smoking (cigarettes), marijuana, illicit drugs

As with Canadian surveillance,[16] participants were asked about their cigarette smoking and marijuana and illicit drug use: "Within the last 30 days, on how many days did you use the following..." Response options ranged from "never used" to "have used but not in the last 30 days" to "used all 30 days." Responses were dichotomized to represent users (in the past 30 days) or non-users (have not used in the past 30 days).

Binge drinking

Participants were asked, "Within the last 15 days, how many times did you have 5 or more drinks in one sitting?" As in previous research,[17] respondents who answered that they engaged in one or more sessions of binge drinking during

TABLE 1
Participant and mental health outcome characteristics

	Overall (*N* = 837)	Male (n = 299)	Female (n = 538)
Mean age (SD)	21.00 (4.25)	21.43 (5.76)	20.75 (3.10)
Place of residence, n (%)			
On-campus	183 (21.9)	71 (23.7)	112 (20.8)
Off-campus	654 (78.0)	228 (76.3)	426 (79.2)
Study year, n (%)			
First	199 (23.8)	69 (23.1)	130 (24.2)
Second	228 (27.2)	85 (28.4)	143 (26.6)
Third	196 (23.4)	72 (24.1)	124 (23.0)
Fourth	162 (19.4)	54 (18.1)	108 (20.1)
Fifth or higher	52 (6.2)	19 (6.4)	33 (6.1)
Stress, n (%)			
Not stressed	362 (43.2)	139 (46.5)	223 (41.4)
Stressed	473 (56.5)	158 (52.8)	315 (58.6)
No response	2 (0.2)	2 (0.7)	
Fatigue, n (%)			
Not fatigued	453 (54.1)	160 (53.5)	293 (54.5)
Fatigued	380 (45.4)	138 (46.2)	242 (45.0)
No response	4 (0.5)	1 (0.3)	3 (0.6)
Diagnosed anxiety, n (%)			
No	766 (91.5)	281 (94.0)	485 (90.1)
Yes	71 (8.5)	18 (6.0)	53 (9.9)
Diagnosed or treated for depression, n (%)			
No	775 (92.6)	283 (94.6)	492 (91.4)
Yes	62 (7.4)	16 (5.4)	46 (8.6)
Mean psychological distress (SD)	3.55 (2.64)	3.04 (2.60)	3.90 (0.24)

Abbreviation: SD, standard deviation.

Note: Place of residence, study year, stress, fatigue, diagnosed anxiety and diagnosed depression are represented by the number of participants (percentages); age and psychological distress reflect mean scores (standard deviations).

the past 15 days were considered binge drinkers, while those who did not engage in binge drinking within the past 15 days were classified as non-binge drinkers.

Risky sexual behaviour

Participants were asked, "Within the last 12 months, have you experienced the following as a consequences of your drinking … had unprotected sex?" Responses were either yes or no (because they do not drink or they did not engage in this health-risk behaviour). Consistent with previous research in this area,[11] a positive response was considered as risky sexual behaviour.

Insufficient physical activity

Moderate-to-vigorous physical activity (MVPA) behaviours were assessed using two questions: "On how many of the past 7 days did you: Do moderate-intensity cardio or aerobic exercises (caused a noticeable increase in heart rate, such as brisk walk) for at least 30 minutes?" and whether they "[did] vigorous-intensity cardio or aerobic exercises ([that] caused large increase in breathing or heart rate such as jogging) for at least 20 minutes?" Participants chose answers from a scale of 0 to 7 days. Consistent with the previous Canadian physical activity guidelines,[18] the scores of the two items were added and classified as "insufficiently active" (students who engaged in < 3 days of MVPA per week) or "sufficiently active" (students who engaged in MVPA for ≥ 4 days per week).

Insufficient fruit and vegetable intake

Participants were asked "How many servings of fruits and vegetables do you usually have per day? (1 serving = 1 medium piece of fruit; ½ cup fresh, frozen, or canned fruits/vegetables; ¾ cup fruit/vegetable juice; 1 cup salad greens; ¼ cup dried fruits)." The response options were 0 servings per day, 1 to 2 servings per day, 3 to 4 servings per day and 5 or more servings per day. Responses were dichotomized to reflect sufficient versus insufficient fruit and vegetable intake (≥ 5 servings of fruit and vegetables each day versus < 5 servings of fruits and vegetables). Although the consumption of 5 or more servings per day is below the Canadian recommendations,[19] this measure was consistent with earlier US recommendations.[20]

Insufficient sleep

Participants were asked, "On how many of the past 7 days did you get enough sleep so you felt rested when you woke up in the morning?" Consistent with earlier research,[11] responses were dichotomized to reflect either sufficient (restful on ≥ 4 nights per week) or insufficient (< 4 nights) sleep on most nights of the week.

Fatigue

Participants were asked, "In the past 7 days, how often have you felt tired, dragged out, or sleepy during the day?" Participants were considered to have greater than normal fatigue if they reported 4 or more days, while those who reported less than 4 days were considered to have normal fatigue.

Stress

A single question asked, "Within the last 12 months, how would you rate the overall level of stress that you have experienced?" Participants who chose "no stress," "less than average stress" or "average stress" from the list were considered to have had normal stress, while those who chose "more than average stress" or "tremendous stress" were categorized as having greater than normal stress.

Diagnosed depression and anxiety

Participants were asked, "Within the last 12 months, have you been diagnosed or

treated by a professional for any of the following?" Responses for depression and anxiety were each dichotomized as "yes" (yes, diagnosed but not treated; yes, treated with medication; yes, treated with psychotherapy; yes, treated with medication and psychotherapy; yes, other treatment) or "no" (have not been diagnosed or treated).

Psychological distress

Six questions were used to measure psychological distress. These questions asked participants, "Have you ever felt things were hopeless; felt overwhelmed by all you had to do; felt exhausted (not from physical activity); felt very lonely; felt very sad; felt overwhelming anxiety). Affirmative responses (i.e. yes, in the last 12 months) were summed and reported as a composite score of psychological distress.

Statistical analysis

We conducted LCA to identify the underlying patterns (or classes) of health-risk behaviours based on student responses to the questions on binge drinking, smoking, marijuana and illicit drug use, risky sexual behaviour, and insufficient physical activity, fruit and vegetable intake and sleep. To ensure that the maximum likelihood solution was correctly identified within these models, we conducted 200 iterations of each model (i.e. from two to four). We also randomly generated start values to ensure we achieved true maximum likelihood. Using Mplus version 6.1,[21] decisions about the optimal number of latent classes were based on model fit statistics including Akaike Information Criterion (AIC); Bayesian Information Criterion (BIC); sample-size adjusted Bayesian Information Criterion (ABIC); entropy; and the Lo–Mendell–Rubin's likelihood ratio (LMR) and bootstrapped Lo–Mendell–Rubin's likelihood ratio tests (BLMR).[22]

To select the appropriate number of latent classes, we analyzed a two-class model and compared this analysis with successive models, which specified an increasing number of latent classes (up to four). We examined specific model estimates for both three- and four-class models to select a final specification based on the interpretability of the results.[11] A test of measurement invariance revealed no significant sex differences between constrained and non-constrained models. Sex, year of study and place of residence (living on or off campus) were included as covariates in the final models. We used the auxiliary function in Mplus to examine the relationship between class membership and mental health outcomes of stress, fatigue, anxiety, depression and psychological distress in a multinomial logistic regression. Each mental health outcome was examined as a separate dependent variable, and test of equality of means across classes using posterior probability-based multiple imputations are reported.

Results

Latent class findings

Based on the eight health-risk behaviours of insufficient physical activity, insufficient fruit and vegetable intake, insufficient sleep, smoking, binge drinking, marijuana use, illicit drug use and risky sexual behaviours, all of which were adjusted for sex, year of study and place of residence (on or off campus), a three-class model of undergraduate students demonstrated the best model fit (see Table 2). Response probabilities for each class—the likelihood of engaging in each of the health-risk behaviours—are shown in Figure 1, and can be described as follows:

Class 1: Typical students

This group is characterized as the most common clustering of the modifiable health-risk behaviours, representing approximately two-thirds (65.7%) of the sample. These students were unlikely to smoke or engage in sexual risk-taking and marijuana or illicit drug use (probabilities between 1.6% to 6.4%), although they are also unlikely to engage in health-protecting behaviours. Probabilities of typical students eating enough fruits and vegetables (6.2%), being physically active (12.2%) and getting sufficient sleep (27.6%) were low (see Figure 1). Of note, among the three classes identified, the typical students reported the lowest probabilities of binge drinking (35.7%).

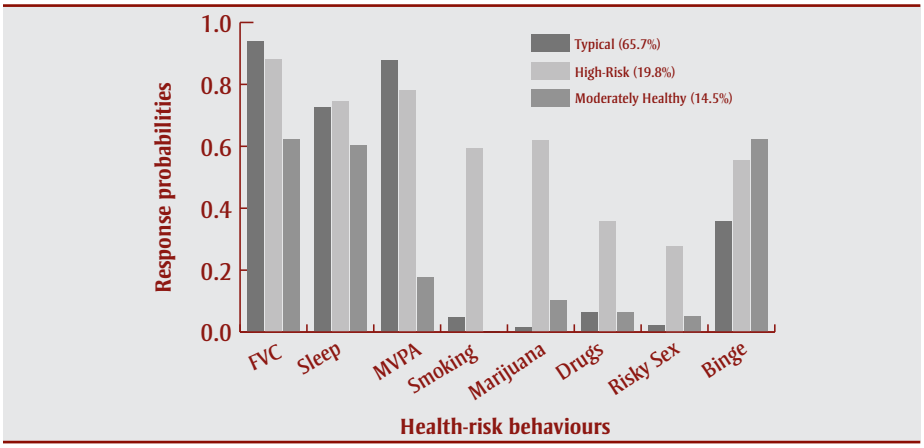
TABLE 2
Criteria to assess model fit

	Model fit without covariates			Model fit with covariates		
	2 Class	3 Class	4 Class	2 Class	3 Class	4 Class
Log likelihood	−2940.43	−2913.89	−2903.32	−2924.82	−2897.72	−2880.59
AIC	5914.87	5879.78	5876.36	5889.63	5859.44	5849.17
BIC	5995.27	6002.75	6042.17	5984.18	6010.71	6057.18
ABIC	5941.29	5920.18	5931.36	5920.66	5909.09	5917.49
Entropy	0.725	0.635	0.753	0.714	0.658	0.635
LMR	227.80*	52.23*	20.80	234.22	53.53*	33.85
BLMR	−3056.22*	−2940.43*	−2913.89	−3043.37	−2924.82*	−2897.72
Estimated parameters	17	26	35	20	32	44

Abbreviations: ABIC, Adjusted Bayesian Information Criterion; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; BLMR, Bootstrap Lo–Mendell–Rubin Test; LMR, Lo–Mendell–Rubin test.

* $p < .05$.

FIGURE 1
Item-response probabilities for health-risk behaviours across the three classes (typical, high-risk and moderately healthy) that result from latent class analysis of student behaviour



Abbreviations: FVC, fruit and vegetable consumption; MVPA, moderate-to-vigorous physical activity.

Notes: FVC, sleep and MVPA were reversed coded so that lower probabilities of engaging in these behaviours reflect higher risk. Typical students represent 65.7%, high-risk students 19.8%, and moderately healthy students 14.5% of the sample.

Class 2: High-risk students

This group can be characterized as exhibiting poor health behaviours across all of the eight behavioural domains. Like the typical student group, these students were unlikely to engage in health-protecting behaviours (i.e. probabilities of eating enough fruit and vegetable, being physically active and getting enough sleep were all less than 25%). However, they demonstrated the highest likelihood of health-risk behaviours. The probability of high-risk students smoking cigarettes, using marijuana and binge drinking ranged between 55.4% and 61.8%, and their probability for using illicit drugs (35.7%) and engaging in unprotected sex (27.8%) was also the highest. This class represented approximately 20% of the student sample (see Figure 1).

Class 3: Moderately healthy students

This group, 14.5% of the sample, represents those students with the healthiest lifestyles. Similar to the typical student group, moderately healthy students were unlikely to smoke, engage in unprotected sex and marijuana or illicit drug use (probabilities from 0% for smoking to 6.3% for illicit drug use). Despite having the highest likelihood of consuming at least 5 servings of fruits or vegetables (37.7%) and getting sufficient sleep (39.8%), probabilities of engaging in these health-promoting behaviours were modest at best. Moderately healthy students, however, were highly likely to be physically active (with 82.4% of students meeting recommendations for MVPA), but also highly likely to binge drink (62.3%) (see Figure 1).

Class membership and mental health outcomes

Overall, the differences in reported stress on the basis of class membership were significant (χ^2 (2833) = 8.55, p < .05). Specifically, students in the high-risk group reported significantly higher levels of stress than the typical class (χ^2 (1671) = 7.26, p < .01), but not compared to the moderately healthy (χ^2 (1285) = 3.12, p = .07) class of students. While non-significant, descriptive statistics show high-risk students reporting the highest prevalence of other mental health issues, including greater levels of self-reported fatigue, diagnosed anxiety, diagnosed depression and reported psychological distress. Conversely, moderately healthy students reported the lowest prevalence on most of the mental health issues examined. (See Table 3 for a complete description of the mental health outcomes based on class membership.)

Discussion

Our findings revealed several important and distinct patterns of health-risk behaviours in a sample of Canadian undergraduate students. Specifically, we found three discernable groups based on a shared health-risk behaviour profile. These ranged from students likely to engage in multiple health-risk behaviours such as smoking, binge drinking, drug use (marijuana and other illicit drugs) and risky sexual behaviours, to "typical" and "moderately healthy" students who generally did not engage in these risky behaviours. A troubling finding, however, is that the vast majority of students, regardless of class membership, had low probabilities of engaging in health-promoting behaviours. In particular, each of the groups shared similar high probabilities of inadequate sleep and fruit and vegetable consumption.

Traditionally, public health has focussed on reducing health-risk behaviours, particularly those associated with non-communicable diseases such as smoking or alcohol use.[23] Current findings, however, highlight that the most prevalent health-risk behaviours on campus are those that students are not engaging in (i.e. physical activity, fruit and vegetable consumption and sufficient sleep). Even moderately healthy students were likely to be not getting enough sleep and consuming less than half of the nationally recommended 8 to 10 daily servings of fruits and vegetables.[19] These behavioural patterns may reflect the difficulties (e.g. time needed to engage in physical activity; cost of and access to fruit and vegetables) for students in self-regulating complex behaviours such as physical activity, dietary intake and sleep during this major life transition.

These behavioural patterns are also of concern given that evidence shows that smoking, binge drinking and insufficient physical activity increase throughout adolescence and into early adulthood.[4,24] While young adults tend to stop binge drinking and smoking once they reach their mid-twenties, patterns of physical inactivity only continue to worsen.[4] This

TABLE 3
Comparison of mental health outcomes by class membership based on equality test of means across classes

		Probability of mental health problems % (SE)		
	Overall (N = 837)	Typical (65.7%)	High risk (19.8%)	Moderately healthy (14.5%)
Stress	56.5*	54.1 (2.2)[a]	66.9 (4.0)	54.5 (5.3)**
Fatigue	45.4	45.9 (2.3)	49.9 (4.4)	39.0 (5.5)**
Diagnosed anxiety	8.5	7.3 (1.2)	11.2 (2.7)	9.5 (3.2)
Diagnosed depression	7.4	6.7 (1.1)	9.9 (2.5)	6.5 (2.7)
Psychological distress	3.55 (+2.64)	3.52 (0.12)	3.90 (0.24)	3.26 (0.28)**

Abbreviation: SE, standard error.

Note: With the exception of psychological distress, prevalence statistics are represented as percentages; scores for psychological distress range from 0–6; sample sizes are estimated based on probability of latent class membership within classes.

[a] Significantly different from high-risk class.

* $p < .05$.

** $p < .09$.

body of evidence highlights the need to reorient health services to ensure health promotion efforts address the lack of health-promoting behaviours as well as the more commonly targeted health-risk behaviours such as smoking and drug use. Initiatives such as Healthy Campus 2020 framework[25] have been strong proponents for increasing targeting of diet and physical activity among young adults but, to achieve these goals, more campus initiatives aimed at promoting healthy active living are required.

Interestingly, with the exception of binge drinking, there were distinctions between classes in how they engaged in common health-risk behaviours. The overall prevalence of these health-risk behaviours was fairly low, although a clustering of students appeared to be engaging in many of these risky behaviours. These findings suggest that current health promotion strategies are generally effective for a majority of the undergraduate student population but that an at-risk group may require tailored intervention. This intervention may take the form of health promotion materials targeting these health-risk behaviours together rather than in isolation. By targeting multiple health-risk behaviours simultaneously, individuals may be able to transfer their knowledge and experiences from one behaviour to another if the domains share similarities.[26] The idea is to be able to prompt change in one of these behaviours, which may result in a cascading effect, similar to previous research showing a corresponding decrease in marijuana and alcohol use when quitting smoking.[26]

Multiple health-risk behaviours and mental health outcomes

Our study also examined how these patterns of multiple health-risk behaviours were associated with mental health. Broadly, our findings support the notion that engaging in multiple health-risk behaviours is associated with poorer mental health. Although the results were not statistically significant, moderately healthy students reported less fatigue, stress and psychological distress than high-risk students. These are important findings, as psychological distress is often considered a robust indicator of health,[27] while management of stress and fatigue is crucial for academic success.[28] Future research must examine these associations over time, as our cross-sectional study cannot determine the direction of the associations. However, given that student stress is an important focus for the Healthy Campus 2020 framework,[25] interventions do need to be developed to jointly target health-risk behaviours and stress. Promoting physical activity as a way to cope with stress is an example of an intervention approach that targets mental and physical health. Future research that focusses on the at-risk student population will also be important, as their health-risk behaviour profile may reflect maladaptive coping strategies. Potential interventions may be aimed at replacing harmful coping strategies such as smoking and drinking with healthy coping strategies such as regular sleep and physical activity.

Strengths and limitations

While our study uses a fairly novel statistical technique to examine the clustering of multiple health-risk behaviours in a

cohort of university students, we need to acknowledge several limitations. First, there is an obvious response bias, given that only 28% of the undergraduate students invited to participate in the survey responded. Although the low response rate is comparable to other studies that used NCHA data in the United States[30] and Canada,[5,6] our findings nevertheless need to be interpreted with caution.

Second, these data included students from a single university located in a large urban setting. Although the sample was broadly representative of the undergraduate student body at the University of Toronto (i.e. median age = 21.1 years, 56% female),[29] we are limited in our abilities to generalize these findings to students in other postsecondary institutions.

Third, while self-report tools such as the NCHA are critical for gathering health data, analyzing secondary data has its limitations. For example, we were limited by the measures included in the survey and did not have validated measures of mental health outcomes such as anxiety and depression. Moreover, we examined health-risk behaviours assessed on different time scales (i.e. past 7 days, 15 days or 30 days). Although the measures with longer time scales were intended to capture the less common health-risk behaviours (i.e. illicit drug use), it would be ideal to have consistency across each of the behaviours.

Finally, while our analyses included sex, student status and place of residence as covariates, other sociodemographic factors may be important in differentiating class membership. Future research could develop more descriptive profiles of each class in order to assist in tailoring interventions. Future work that uses longitudinal designs to assess the same students over time is also required to determine the direction in the relationship between health-risk behaviours and outcomes such as mental health.

Conclusion

The transition into early adulthood is an important target for health promotion efforts, and the postsecondary campus is an ideal setting for comprehensively addressing the health of many young adults. Responding to the call for action of the Okanagan Charter,[2] our findings reinforce the need to consider what health behaviours campus health services are targeting, acknowledging that a greater emphasis should be placed on supporting health-protecting behaviours of diet, physical activity and sleep. The caveat is that health promoters will need to be mindful of the collective challenges students face and the complexities of behaviour change, and recognize that changes in lifestyle behaviours will likely need to be accompanied by the development of self-regulation skills to manage their competing interests while at college or university. Overall, our findings suggest that patterns of these multiple health behaviours are related to mental health in the postsecondary student population, but more research examining the impact of multiple health behaviours over time is needed.

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CHRONIC DISEASE AND INJURY INDICATOR FRAMEWORK
QUICK STATS, 2016 EDITION

INDICATOR GROUP	INDICATOR MEASURE(S)	LATEST DATA[a]	DATA SOURCE (YEAR)
SOCIAL AND ENVIRONMENTAL DETERMINANTS			
Education	% of population with less than a high school education, population aged 20+ years	12.8%	CCHS (2014)
Income	% of population living below low-income cut-offs, after tax, total population	9.7%	CIS (2013)
Employment	Average annual unemployment rate (% of labour force that was unemployed during reference period), population aged 15+ years	6.8%	LFS (2015)
EARLY LIFE/CHILDHOOD RISK AND PROTECTIVE FACTORS			
Breastfeeding	% of women who reported exclusive breastfeeding of their child for at least the first 6 months of life, women aged 15+ years	26.2%	CCHS (2011–2012)
Birth weight	% of live births with a low birth weight	6.1%	CVS (2011)
Exposure to second-hand smoke	% of households with children aged less than 12 years regularly exposed to environmental tobacco smoke at home	3.1%	CTADS (2013)
Family violence	% of population that experienced any of three types of child abuse [physical abuse, sexual abuse or exposure to intimate partner violence] before the age of 16	32.3%	CCHS-MH (2012)
BEHAVIOURAL RISK AND PROTECTIVE FACTORS			
Physical activity	% of children and youth accumulating at least 60 minutes of moderate-to-vigorous physical activity per day, population aged 5–17 years	9.3%	CHMS (2012–2013)
	% of adults who met physical activity guidelines by accumulating at least 150 minutes of moderate-to-vigorous physical activity each week, in bouts of 10 minutes or more, population aged 18+ years	22.2%	CHMS (2012–2013)
Sedentary behaviour	% children and youth who reported spending more than 2 hours per day watching television or using computers during leisure-time, population aged 5–17 years	48.2%[b]	CHMS (2012–2013)
	Average amount of time per day spent sedentary, excluding sleep time, population aged 5–17 years	8.5 hours	CHMS (2012–2013)
	Average amount of time per day spent sedentary, excluding sleep time, population aged 18+ years	9.8 hours	CHMS (2012–2013)
Healthy eating	% of population that reported consuming fruit and vegetables at least 5 times/day, population aged 12+ years	39.7%	CCHS (2014)
Unhealthy eating	% of children and youth who reported drinking sugar-sweetened beverages daily, population aged 5–17 years	17.2%	CHMS (2012–2013)
Adequate sleep	% of children and youth who reported obtaining adequate daily sleep (10–13 hours for those aged 5 years, 9–11 hours for ages 6–13 years and 8–10 hours for ages 14–17 years), population aged 5–17 years	74.6%	CHMS (2012–2013)
Chronic stress and coping	% of population that reported a high level of coping, population aged 18+ years	56.9%	CCHS-MH (2012)
	% of population that reported life to be "quite a bit" or "extremely" stressful most days in the last 12 months, population aged 12+ years	22.4%	CCHS (2014)
Alcohol use	% of population that exceeds low risk alcohol drinking guidelines for chronic drinking, population aged 15+ years	15.7%	CTADS (2013)
Smoking	% of population that reported being current smokers (daily or occasional), population aged 15+ years	14.6%	CTADS (2013)
	% of population that reported being current smokers (daily), population aged 15+ years	10.9%	CTADS (2013)
RISK CONDITIONS			
Obesity	% of population that is obese (measured), children and youth aged 5–17 years	12.5%	CHMS (2012–2013)
	% of population that is obese (measured), population aged 18+ years	26.4%	CHMS (2012–2013)
Elevated blood glucose	% of population that has elevated[c] blood glucose (measured), population aged 20+ years	4.1%	CHMS (2012–2013)
Elevated blood cholesterol	% of population that has elevated[c] blood cholesterol [TC:HDL-C ratio] (measured), population aged 20+ years	16.8%	CHMS (2012–2013)
Hypertension	Prevalence of hypertension, population aged 20+ years	24.9%	CCDSS (2011/12)[d]
DISEASE PREVENTION PRACTICES			
Contact with health care professional	% of population that reported consulting a family physician or general practitioner at least once in the past 12 months, population aged 12+ years	75.6%	CCHS (2014)
	% of population that reported consulting a dentist, dental hygienist or orthodontist at least once in the past 12 months, population aged 12+ years	66.9%	CCHS (2014)
Disease screening	% of women who reported having a mammogram at least once in the past 5 years, population aged 50–74 years	83.5%	CCHS (2012)
	% of women who reported having at least 1 Pap smear test in the past 3 years, population aged 25–69 years	79.7%	CCHS (2012)
	% of population that reported having at least 1 fecal occult blood test, colonoscopy and/or sigmoidoscopy in the recommended time period, population aged 50–74 years	51.1%	CCHS (2012)
Vaccination (influenza)	% of population living with a chronic health condition that reported having a seasonal flu shot in the past 12 months, population aged 12+ years	50.4%	CCHS (2014)
HEALTH OUTCOMES/STATUS			
General health	% of population that rates their health as "very good" or "excellent", population aged 12+ years	59.1%	CCHS (2014)
	% of population that rates their mental health as "very good" or "excellent", population aged 12+ years	71.2%	CCHS (2014)
	Life expectancy at birth	83.0 years	CCDSS (2009/10–2011/12)
	Life expectancy at 65 years	21.5 years	CCDSS (2009/10–2011/12)
	Health-adjusted life expectancy at birth	72.6 years	CCDSS (2008/09–2010/11)
	Health-adjusted life expectancy at 65 years of age	16.4 years	CCDSS (2008/09–2010/11)

INDICATOR GROUP	INDICATOR MEASURE(S)	LATEST DATA[a]	DATA SOURCE (YEAR)
Morbidity – Prevalence	% of population with at least one of 10 main chronic diseases[e], population aged 20+ years	38.4%	CCHS (2014)
	% of population with at least 1 major[f] chronic disease (cancer, diabetes, cardiovascular diseases, chronic respiratory diseases), population aged 20+ years	21.4%	CCHS (2014)
	Prevalence of diabetes, children and youth aged 1–19 years	0.3%	CCDSS (2011/12)
	Prevalence of diabetes, population aged 20+ years	9.8%	CCDSS (2011/12)
	Prevalence of cardiovascular disease (self-reported), population aged 20+ years	6.2%	CCHS (2014)
	Prevalence of stroke, population aged 20+ years	2.7%	CCDSS (2011/12)
	Prevalence of heart failure, population aged 40+ years	3.6%	CCDSS (2011/12)
	Prevalence of ischemic heart disease, population aged 20+ years	8.4%	CCDSS (2011/12)
	Prevalence of asthma, children and youth aged 1–19 years	15.3%	CCDSS (2011/12)
	Prevalence of asthma, population aged 20+ years	9.5%	CCDSS (2011/12)
	Prevalence of chronic obstructive pulmonary disease, population aged 35+ years	9.6%	CCDSS (2011/12)
	Prevalence of arthritis, population aged 20+ years	17.9%	CCHS (2014)
	Prevalence of lifetime mental illness and substance use disorders, population aged 15+ years	33.3%	CCHS-MH (2012)
	Annual prevalence of the use of health services for mental disorders, children and youth aged 1–19 years	8.7%	CCDSS (2011/12)
	Annual prevalence of the use of health services for mental disorders, population aged 20+ years	16.3%	CCDSS (2011/12)
	Prevalence of mood and/or anxiety disorders, children and youth aged 12–19 years	9.3%	CCHS (2014)
	Prevalence of mood and/or anxiety disorders, population aged 20+ years	12.0%	CCHS (2014)
	Prevalence of diagnosed osteoporosis, population aged 40+ years	11.6%	CCDSS (2011/12)
	% of the population that has been diagnosed with cancer in the previous 10 years	2.4%	CCR (1999–2008)
Morbidity – Incidence	Incidence rate of diabetes, children and youth aged 1–19 years	41.0 per 100 000	CCDSS (2011/12)
	Incidence rate of diabetes, population aged 20+ years	790.5 per 100 000	CCDSS (2011/12)
	Incidence rate of asthma, children and youth aged 1–19 years	1079.7 per 100 000	CCDSS (2011/12)
	Incidence rate of asthma, population aged 20+ years	353.2 per 100 000	CCDSS (2011/12)
	Incidence rate of chronic obstructive pulmonary disease, population aged 35+ years	885.2 per 100 000	CCDSS (2011/12)
	Incidence rate of heart failure, population aged 40+ years	522.6 per 100 000	CCDSS (2011/12)
	Incidence rate of ischemic heart disease, population aged 20+ years	631.0 per 100 000	CCDSS (2011/12)
	Incidence rate of acute myocardial infarction, population aged 20+ years	220.0 per 100 000	CCDSS (2011/12)
	Annual hip fracture rates, population aged 40+ years	149.7 per 100 000	CCDSS (2011/12)
	Incidence rate of all cancers, all male population	438.0 per 100 000[g]	CCR (2010)
	Incidence rate of all cancers, all female population	368.0 per 100 000[g]	CCR (2010)
	Incidence rate of all unintentional injuries, total population	607.3 per 100 000	HMDB (2010–2011)
	Incidence rate of all injuries due to intentional self-harm, total population	47.4 per 100 000	HMDB (2010–2011)
	Incidence rate of all injuries due to assault, total population	24.1 per 100 000	HMDB (2010–2011)
Multimorbidity	% of population with multiple chronic diseases[e] (2+ of 10 chronic diseases), population aged 20+ years	14.8%	CCHS (2014)
Disability	% of population that reported being limited in their activities "sometimes" or "often" due to disease/illness, population aged 12+ years	32.7%	CCHS (2014)
Mortality	Mortality rate due to a major chronic disease (cardiovascular diseases, all cancers, chronic respiratory diseases, diabetes), total population	469.9 per 100 000	CVS (2012)
	Mortality rate due to cardiovascular diseases, total population	191.9 per 100 000	CVS (2012)
	Mortality rate due to cancer, total population	213.2 per 100 000	CVS (2012)
	Mortality rate due to chronic respiratory diseases, total population	44.8 per 100 000	CVS (2012)
	Mortality rate due to all unintentional injuries, total population	32.4 per 100 000	CVS (2012)
	Mortality rate due to homicides, total population	1.4 per 100 000	CVS (2012)
	Mortality rate due to suicide, total population	11.3 per 100 000	CVS (2012)
	Mortality rate due to diabetes, total population	20.0 per 100 000	CVS (2012)
Premature mortality	Probability of dying (%) between ages 30 and 69 years from major chronic diseases (CVD, cancer, chronic respiratory disease, diabetes)	10.7%	CVS (2012)
	Probability of dying (%) between ages 30 and 69 years from cardiovascular disease	3.2%	CVS (2012)
	Probability of dying (%) between ages 30 and 69 years from cancer	6.8%	CVS (2012)
	Probability of dying (%) between ages 30 and 69 years from chronic respiratory diseases	0.7%	CVS (2012)
	Probability of dying (%) between ages 30 and 69 years from diabetes	0.5%	CVS (2012)

Abbreviations: CCDSS, Canadian Chronic Disease Surveillance System; CCHS, Canadian Community Health Survey; CCR, Canadian Cancer Registry; CHMS, Canadian Health Measures Survey; CIS, Canadian Income Survey; CTADS, Canadian Tobacco, Alcohol and Drugs Survey; CVD, cardiovascular disease; CVS, Canadian Vital Statistics; HDL-C, high-density lipoprotein cholesterol; HMDB, Hospital Morbidity Database; LFS, Labour Force Survey; MH, Mental Health; TC, total cholesterol.

[a] All pan-Canadian rates in this table are crude unless otherwise stated.

[b] The estimates for sedentary behaviour differ from those presented in the 2015 CDIIF due to an adjustment made to account for a change in variable formatting during the survey's data collection.

[c] This indicator captures people found to have elevated levels of the condition when assessed at a single clinical visit regardless of diagnosis status (i.e. those previously diagnosed and well controlled are not captured).

[d] CHMS data exist for this indicator presenting pan-Canadian rates according to diagnosis and control status of hypertension.

[e] The ten chronic diseases included are heart disease, stroke, cancer, asthma, chronic obstructive pulmonary disease, diabetes, arthritis, Alzheimer's or other dementia, mood disorder (depression), and anxiety.

[f] The four main groups of chronic diseases include cancer, diabetes, cardiovascular disease (heart disease and/or stroke), chronic respiratory diseases (asthma and/or chronic obstructive pulmonary disease).

[g] Rates are age-standardized to the 1991 Canadian population.

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Call for papers: The food environment in Canada

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Special Issue on: The Food Environment in Canada

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Diet is a fundamental component of health, and dietary habits are closely linked with the development of chronic disease and obesity. The ***food environment*** in which people make their food choices plays a major role in establishing eating habits and overall diet quality. Broadly defined as the physical, economic, policy and socio-cultural surroundings, opportunities and conditions that influence food choices and nutrition status, the food environment can promote or impede healthy diets.

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Pelletier L, **O'Donnell S**, Dykxhoorn J, **McRae L**, Patten SB. Under-diagnosis of mood disorders in Canada. Epidemiol Psychiatr Sci. 2016:1-10. doi: 10.1017/S2045796016000329.

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