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## Inside this issue



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# Original quantitative research

# Strength-training and balance activities in Canada: historical trends and current prevalence

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## Abstract

**Introduction:** Muscle-strengthening and balance activities are associated with the prevention of illness and injury. Age-specific Canadian 24-Hour Movement Guidelines include recommendations for muscle/bone-strengthening and balance activities. From 2000–2014, the Canadian Community Health Survey (CCHS) included a module that assessed frequency in 22 physical activities. In 2020, a healthy living rapid response module (HLV-RR) on the CCHS asked new questions on the frequency of muscle/bone-strengthening and balance activities. The objectives of the study were to (1) estimate and characterize adherence to meeting the muscle/bone-strengthening and balance recommendations; (2) examine associations between muscle/bone-strengthening and balance activities with physical and mental health; and (3) examine trends (2000–2014) in adherence to recommendations.

**Methods:** Using data from the 2020 CCHS HLV-RR, we estimated age-specific prevalence of meeting recommendations. Multivariate logistic regressions examined associations with physical and mental health. Using data from the 2000–2014 CCHS, sex-specific temporal trends in recommendation adherence were explored using logistic regression.

**Results:** Youth aged 12 to 17 years (56.6%, 95% CI: 52.4–60.8) and adults aged 18 to 64 years (54.9%, 95% CI: 53.1–56.8) had significantly greater adherence to the muscle/bone-strengthening recommendation than adults aged 65 years and older (41.7%, 95% CI: 38.9–44.5). Only 16% of older adults met the balance recommendation. Meeting the recommendations was associated with better physical and mental health. The proportion of Canadians who met the recommendations increased between 2000 and 2014.

**Conclusion:** Approximately half of Canadians met their age-specific muscle/bone-strengthening recommendations. Reporting on the muscle/bone-strengthening and balance recommendations elevates their importance alongside the already recognized aerobic recommendation.

***Keywords:*** *muscle, physical activity, recommendations, 24H Guidelines, physical health, mental health, youth, adults, older adults, adherence*

### *Highlights*

- About half (53%) of Canadians 12 years and older meet the age-specific muscle/bone-strengthening recommendations, but only 16% of older adults meet recommendations for activities that challenge balance.
- People who met the muscle/bone-strengthening and balance recommendations reported better mental and physical health than those who did not meet these recommendations.
- Temporal trends suggest an increase in adherence to muscle/bone-strengthening and balance recommendations from 2000 to 2014.

## Introduction

The benefits of regular aerobic physical activity (PA) are well established.[1-3] Aerobic PA is often the centrepiece of health promotion initiatives targeting health behaviours,[4] with adherence to this recommendation the cornerstone of PA surveillance.[5] The recently released Canadian 24-Hour Movement Guidelines ("24H Guidelines") recommend a minimum of 60 min/d of moderate-to-vigorous intensity physical activity (MVPA) for children and youth (5–17 years old) and 150 min/wk for adults (18–64 years) and older adults

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(≥65 years).[6] The guidelines also recommend muscle and bone strengthening for children and youth (≥3 d/wk), muscle strengthening for adults aged 18 to 65 years (≥2 d/wk) and muscle-strengthening and balance activities for adults 65 years and older (strength: ≥2 d/wk; balance: no minimum frequency).[6]

The recommendations for MVPA, muscle/bone and balance activities were also part of the Canadian Physical Activity Guidelines[7] that were released a decade earlier, in 2011. (The 24H Guidelines no longer have the requirement for 10-minute bouts of MVPA.)

Muscle-strengthening exercise refers to resistance training using free or machine weights, elastic bands or one's own body weight.[8] This type of exercise plays a unique and independent role in preventing disease and premature mortality.[8,9] Health benefits include increased skeletal muscle mass and strength and bone mineral density, improved cardiometabolic and physical functioning, reduced musculoskeletal symptoms and reduced symptoms of anxiety and depression.[10-13]

Muscle-strengthening exercise has often been described as the "forgotten" PA guideline.[5,14,15] A 2018 review of international efforts identified only five surveys that included direct/explicit questions about muscle strengthening.[5] There is also evidence to suggest that the combined health benefits of aerobic PA and strength-training activities is greater than those of either activity alone.[16,17]

Bone-strengthening and balance-training activities are also key components of a healthy PA profile. Bone strengthening, which increases resistance to fracture, includes "movements that create impact- and muscle-loading forces on the bone" such as jumping, skipping and hopping.[3] Balance-training activities include movements that challenge postural control; these activities help resist forces that can lead to falls[18] and maintain physical functioning.[19] Some activities provide simultaneous muscle and bone strengthening and balance training, making it difficult to define them separately. The overlap between muscle- and bone-strengthening exercises is particularly challenging to assess independently. For the purpose of this paper, we use the expression "muscle/bone strengthening" to recognize that some activities may have benefits for both.

In Canada, the Physical Activity, Sedentary Behaviour and Sleep (PASS) Indicators provide important surveillance information on the PA levels of children, youth and adults.[20,21] The proportion of Canadians meeting PA recommendations has traditionally been reported as the proportion meeting the aerobic component of the 24H Guidelines (i.e. 60 min/d for children and youth or 150 min/wk for adults),[20] consistent with the PASS surveillance recommendations released alongside the 24H Guidelines.[22,23] Until recently, there has been a lack of national data to assess adherence to the muscle/bone-strengthening and balance components of the 24H Guidelines (and the previous Canadian PA Guidelines). As a result, the PASS Indicators do not report on the proportion of Canadians meeting the age-specific muscle/bone-strengthening or balance recommendations.

In 2020, the Public Health Agency of Canada funded the development of the healthy living rapid response module (HLV-RR) in the Canadian Community Health Survey (CCHS). The HLV-RR module includes two questions to assess muscle/bone-strengthening and balance activities and allows the reporting of current prevalence of meeting the muscle/bone-strengthening and balance components of the 24H Guidelines, as well as meeting the combined PA recommendations (MVPA + muscle/bone strengthening + balance).

The PA module (PAC) in earlier cycles of the annual CCHS (2000–2014) asked participants to self-report frequency of 22 activities over the previous 3 months. Several of the activities could be considered to be muscle/bone-strengthening and/or balance exercises. While using a list of activities to establish adherence to muscle-strengthening exercise is possible,[5] there has been no known attempt to examine the PAC in this way.

Our study objectives were to:

(1) estimate the proportion of Canadian youth (12–17 years), adults (18–64 years) and older adults (≥65 years) currently meeting the age-specific muscle/bone-strengthening and balance-activity recommendations of the 24H Guidelines;

(2) compare the demographic and clinical characteristics of those categorized as meeting the muscle/bone-strengthening and balance recommendations with those meeting the combined recommendations (MVPA + muscle/bone strengthening + balance), the aerobic PA only recommendations (MVPA) and none of the recommendations;

(3) examine the association between meeting combinations of the recommendations and measures of physical and mental health; and

(4) examine age group–specific trends in muscle/bone-strengthening and balance activities among Canadians, using the CCHS (2000–2014).

## Methods

### *Data source*

To meet objectives 1, 2 and 3, we used the HLV-RR data from the 2020 CCHS, and to meet objective 4, we used annual data from older cycles of the CCHS (2000–2014). The CCHS is an ongoing, cross-sectional survey conducted by Statistics Canada. The survey collects self-reported health information from a representative sample of the Canadian household-dwelling population aged 12 years and older living in the provinces and territories. The CCHS excludes individuals living on reserves and Crown Lands, institutionalized residents, full-time members of the Canadian forces, youth aged 12 to 17 years living in foster care and residents in certain remote regions; this is approximately 2% of the Canadian population aged 12 years and older.

The HLV-RR data were collected between January and March 2020, prior to the COVID-19 pandemic. Those who completed the HLV-RR also participated in the 2020 CCHS during the data collection period, except that the HLV-RR excluded respondents living in the three territories and proxy respondents. In total, 11 105 non-proxy respondents completed the HLV-RR. At the national level, the HLV-RR had a household-level response rate of 57.0%.[24]

### *Study population*

The study population included those who completed the strength and balance questions of the 2020 CCHS HLV-RR share file (N = 10 775) or the annual CCHS

(N = 57 070 to N = 124 685, depending on the year) for the years 2000 to 2014. The CCHS provided estimates for 2 years combined from 2000 to 2006, and annual estimates from 2007 onwards.

### Study variables

#### Independent variables

Table 1 shows the variables used to explore current prevalence (2020 CCHS HLV-RR) and trends (2000–2014 CCHS PACs) in age-specific muscle/bone-strengthening and balance recommendations.

#### Dependent variables

##### Population characteristics

Characteristics examined included age (12–17, 18–64, ≥65 years); sex (male, female); immigration status (landed immigrant, non-immigrant); cultural/racial background (White, non-White; the category "White" does not include Indigenous people); household education (secondary or less, postsecondary graduate); distribution of household income quintile (relative measure of household income to household income of all other respondents); and marital status (married/common law, single [widowed/divorced/separated/never married]). Disaggregations for gender were calculated, but too few respondents identified as gender diverse to generate stable results.

##### Health behaviours

Self-reported health behaviours included smoking status; meeting the leisure screen time recommendation (≤2 hours per day for youth; ≤3 hours per day for adults); and meeting the sleep recommendations (youth 12–13 years, 9–11.99 hours/night; youth 14–17 years: 8–10.99 hours/night; adults 18–64 years: 7–9.99 hours/night; adults ≥65 years: 7–8.99 hours/night).

##### Physical and mental health

Measures of health included self-reported general health ("excellent/very good" vs. "good/fair/poor"); self-reported mental health ("excellent/very good" vs. "good/fair/poor"); self-reported body mass index (BMI; under/normal weight vs. overweight/obesity; youth: based on age- and sex-specific BMI cut-points as defined by the World Health Organization; adults: based on Health Canada and World Health Organization body weight classification systems, corrected using the methods of Connor Gorber et al.[29]); and multimorbidity (self-reported diagnoses of ≥2 of asthma, arthritis, cancer, diabetes, heart disease, stroke, chronic respiratory disease [in those ≥35 years] and mood disorders).

### Statistical analyses

Analyses were performed using SAS Enterprise Guide v.7.1 (SAS Institute Inc., Cary, NC, US). For objective 1, we used proportions and 95% confidence intervals (CIs) conducted with proc surveyfreq to describe adherence to the age-specific aerobic PA only (MVPA), muscle/bone strengthening only, balance only and combined (muscle/bone strengthening/balance + aerobic PA) recommendations, overall and by sex and age group (youth, adults and older adults).

For objective 2, we also present characteristics of those meeting the recommendations using proportions or means and 95% CIs. Comparisons between those meeting and those not meeting the various combinations of recommendations were assessed using independent sample *t* tests (proc surveyreg) for continuous outcomes or chi-square (proc surveyfreq) for categorical outcomes.

For objective 3, we assessed the association between meeting the recommendations or combinations of the recommendations and measures of physical and mental health using age-specific multivariate logistic regression models controlling for sex, household income and smoking status conducted using proc surveylogistic.

For objective 4, we present the historical prevalence (2000–2014) of those meeting the age-specific muscle/bone-strengthening/balance recommendations by age and sex using weighted proportions and 95% CIs (proc surveyfreq). The prevalence of meeting each recommendation was graphed against time in years. Age- and sex-specific temporal trends in prevalence were explored using logistic regression with time (CCHS cycle) as a continuous variable to assess if time was a significant predictor of meeting the recommendations conducted using proc surveylogistic.

All analyses were weighted using appropriate cycle survey weights. To account for survey design effects, 95% CIs were estimated using the bootstrap balanced repeated replication technique with 500 replicate weights for the 2000–2014 CCHS, and 1000 replicate weights for the 2020 CCHS. Statistical significance was set at $p < 0.05$.

## Results

### Current adherence to recommendations (Objective 1)

In 2020, youth (56.6%, 95% CI: 52.4–60.8%) and adults aged 18–64 years (54.9%, 95% CI: 53.1–56.8%) had significantly greater adherence to the muscle/bone-strengthening recommendation than older adults aged 65 years and older (41.7%, 95% CI: 38.9–44.5%).

### Characteristics of adherence to recommendations (Objective 2)

Across all age groups, males were significantly more likely than females to meet the muscle-strengthening recommendation (see Table 2). Males aged 12–17 years and 18–64 years were also more likely to meet the combined PA recommendations than their female counterparts.

Because very few older adults met the 7-day balance recommendation compared to the 2-day requirement, for all further analyses we applied the twice-weekly requirement. Older (≥65 years) females were more likely than older males to meet the balance recommendation.

The proportion of Canadians meeting the strength recommendation was lower among landed immigrants, non-White ethnicities, those with a lower household education and those with lower household income (see Table 3). The same differences were observed for the combined PA recommendations except for no difference by cultural/racial background. Among older adults, adherence to the balance recommendation (≥2 times per week) was significantly lower among those with lower household education than those with higher household education.

### Health behaviours and adherence to recommendations (Objective 2)

Among youth and adults, there was no statistically significant difference between smokers and non-smokers for meeting the muscle/bone-strengthening or combined PA recommendations (see Table 3). Those who met the screen time, sleep and aerobic PA recommendations were more likely to meet muscle/bone-strengthening combined recommendations than those who did not.

**TABLE 1**
**Description of methods used to derive the independent variables used to explore current prevalence and trends in PA**

| Derived variable | Questions used | Variable derivation |
|---|---|---|
| Adherence to muscle or muscle/bone-strengthening recommendations | | |
| To classify PA as strength training, we used the following definition: "contracting the muscles against a resistance to 'overload' and bring about a training effect in the muscular system. The resistance is an external force, which can be one's own body placed in an unusual relationship to gravity (e.g. prone back extension) or an external resistance (e.g. free weight)".[25] In addition to strength training, many PAs involve impact that benefits and strengthens muscle and bone. Impact exercise was considered any activity with a GRF ≥1 × body weight on the lower extremities[26,27] including low-impact exercise (GRF 1.1–1.5 × body weight), e.g. rollerblading and skateboarding; moderate impact exercise (GRF 1.51–3.10 × body weight), e.g. jogging, soccer and baseball; and high impact exercise (GRF ≥3.11 × body weight), e.g. jumping rope, ballet, volleyball. | | |
| Current prevalence (HLV-RR 2020) | *In the past 7 days, on how many days did you do activities that increase bone or muscle strength?*<br>Examples of muscle/bone-strengthening activities included with the question: lifting weights; carrying heavy loads; shovelling [snow]; doing sit-ups; or running, jumping or doing sports that involve a quick change in direction. | Youth (12–17 years) muscle/bone strengthening: ≥3 days<br>Adults (18–64 years) muscle strengthening: ≥2 days<br>Older adults (≥65 years): muscle strengthening: ≥3 days |
| Historical trends (CCHS 2000–2014) | *The PAC asked respondents to self-report the frequency of participating in 22 specific activities over the previous 3 months.*<br>It was hypothesized that impact, weight training or both combined are important for muscle/bone strengthening. The strategy was to look at weight training alone and then combined with moderate-to-high impact activities. A sensitivity analysis led to understanding how adding low-impact activities affects the actual proportion of Canadians meeting the muscle/bone-strengthening recommendation.<br>Muscle/bone-strengthening activities were examined as strength training (i.e. weight training); moderate-to-high impact activities (i.e. jogging and running, tennis, volleyball, basketball, soccer) + weight training; and low-impact activities (i.e. walking for exercise, gardening or yard work, popular or social dance, ice hockey, ice skating, in-line skating or rollerblading, golfing, exercise class or aerobics, downhill skiing or snowboarding, baseball or softball) + moderate-to-high impact activities + weight training. | The total 3-month frequency of each activity was divided by 12 to generate an average weekly frequency (assumed 4 weeks/month).<br>Youth (12–17 years) muscle/bone-strengthening adherence: ≥3 days<br>Adults (18–64 years) muscle-strengthening adherence: ≥2 days<br>Older adults (≥65 years) muscle-strengthening adherence: ≥3 days |
| Adherence to balance recommendation | | |
| To classify the balance activities, we applied the following definition from the Prevention of Falls Network Europe (ProFaNE) Taxonomy: "…involv[ing] the efficient transfer of body weight from one part of the body to another or challenges specific aspects of the balance system (e.g. vestibular systems). Balance retraining activities range from re-education of basic functional movement patterns to a wide variety of dynamic activities that target more sophisticated aspects of balance".[25] Examples include tai chi, static balance exercise (e.g. standing on one foot), dynamic balance exercise (e.g. tandem walking) or PAs with a reduced base of support or moving to the limits of stability (e.g. downhill skiing, golfing). | | |
| Current prevalence (HLV-RR 2020) | *In the past 7 days, on how many days did you do any activities that improve balance?*<br>Examples of activities included yoga, tai chi, dance, tennis, volleyball and balance training. | Older adults (≥65 years): balance activities ≥2 days and 7 days.<br>The 24H Guidelines for Adults 65 Years and Older do not explicitly state a minimum weekly frequency for balance activities. We explored adherence to twice-weekly and daily frequencies because clinical trials generally measure twice-weekly balance activities, but documentation supporting the 24H Guidelines suggests that older adults should engage daily in activities that routinely challenge balance.[28] |
| Historical trends (CCHS 2000–2014) | *The PAC module asked respondents to self-report the frequency of 22 specific activities over the previous 3 months.*<br>Balance activities were examined as:<br>(1) sports-related activities that may challenge balance (i.e. popular or social dance, ice hockey, ice skating, in-line skating and rollerblading, jogging or running, golfing, downhill skiing or snowboarding, bowling, baseball or softball, tennis, volleyball, basketball, soccer);<br>(2) sports or exercise or leisure activities that may challenge balance (i.e. sports-related + walking for exercise, gardening or yard work, bicycling, home exercises, exercise class or aerobics, weight training). | The total 3-month frequency of each activity was divided by 12 to generate an average weekly frequency (assumed 4 weeks/month).<br>Older adults (≥65 years): balance activities ≥2 days |

**Abbreviations:** CCHS, Canadian Community Health Survey; GRF, ground reaction force; HLV-RR, healthy living rapid response module in CCHS 2020; PA, physical activity; PAC, physical activity module in the CCHS 2000–2014 cycles.

**TABLE 2**
**Canadians' adherence to individual and combined aerobic, muscle/bone-strengthening and balance PA recommendations, by age and sex, 2020**

| Recommendation met | Youth (12–17 years) | | | | | | Adults (18–64 years) | | | | | | Older adults (≥65 years) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males | | | Females | | | Males | | | Females | | | Males | | | Females | | |
| | % | LCL | UCL | % | LCL | UCL | % | LCL | UCL | % | LCL | UCL | % | LCL | UCL | % | LCL | UCL |
| Aerobic | 65.8 | 59.3 | 72.3 | 49.3* | 43.0 | 55.7 | 62.3 | 59.2 | 65.3 | 53.9* | 51.1 | 56.6 | 46.6 | 42.3 | 50.9 | 35.7* | 32.4 | 38.9 |
| Muscle and bone strength | 61.8 | 56.0 | 67.6 | 51.2* | 44.9 | 57.4 | 61.2 | 53.4 | 64.1 | 48.7* | 46.0 | 51.4 | 49.3 | 44.9 | 53.7 | 35.4* | 32.1 | 38.6 |
| Balance ≥2 d/wk | N/A | – | – | N/A | – | – | N/A | – | – | N/A | – | – | 13.8 | 11.1 | 16.6 | 18.1* | 15.2 | 21.1 |
| Balance 7 d/wk | N/A | – | – | N/A | – | – | N/A | – | – | N/A | – | – | 5.8[E] | 3.8 | 7.9 | 4.5[E] | 3.0 | 6.0 |
| Combined muscle/bone + aerobic (+ balance in older adults) | 50.3 | 43.2 | 57.3 | 32.9* | 26.9 | 39.0 | 46.6 | 43.6 | 49.9 | 34.9* | 32.3 | 37.5 | 8.6 | 6.5 | 10.8 | 9.2 | 6.8 | 11.5 |

**Source:** Canadian Community Health Survey – Healthy Living Rapid Response Module, 2020.

**Abbreviations:** LCL, lower confidence limit; PA, physical activity; UCL, upper confidence limit.

[E] Interpret estimate with caution due to high sampling variability.

* Significantly different from males ($p < 0.05$).

**TABLE 3**
**Characteristics associated with meeting the muscle/bone-strengthening, balance and combined PA recommendations, Canada, 2020**

| Characteristics | Muscle/bone strength recommendation (total sample) | | | Balance recommendation (older adults) | | | Combined muscle/bone + aerobic (+ balance in older adults) (total sample) | | |
|---|---|---|---|---|---|---|---|---|---|
| | %a | LCL | UCL | %a | LCL | UCL | %a | LCL | UCL |
| **Demographics** | | | | | | | | | |
| Age, years | | | | | | | | | |
| 12–17 | 56.6* | 52.4 | 60.8 | – | – | – | 41.7* | 36.9 | 46.4 |
| 18–64 | 54.9* | 53.1 | 56.8 | – | – | – | 40.7* | 38.8 | 42.7 |
| ≥65 | 41.7* | 38.9 | 44.5 | 16.2 | 14.1 | 18.3 | 8.9* | 7.3 | 10.5 |
| Sex | | | | | | | | | |
| Male | 59.1* | 56.8 | 61.5 | 13.8* | 11.1 | 16.6 | 40.0* | 37.7 | 42.4 |
| Female | 46.1* | 44.0 | 48.3 | 18.1* | 15.2 | 21.1 | 29.5* | 27.4 | 31.5 |
| Marital status | | | | | | | | | |
| Married or common law | 52.8 | 50.6 | 55.0 | 16.4 | 13.6 | 19.2 | 33.7 | 31.6 | 35.7 |
| Single[b] | 52.2 | 49.7 | 54.6 | 15.9 | 13.0 | 18.8 | 36.0 | 33.7 | 38.4 |
| Immigration status | | | | | | | | | |
| Landed immigrant | 45.4* | 41.4 | 49.5 | 18.0 | 12.8 | 23.2 | 26.3* | 22.7 | 30.0 |
| Non-immigrant | 54.9* | 53.1 | 56.6 | 15.8 | 13.5 | 18.1 | 37.3* | 35.6 | 38.9 |

**Continued on the following page**

**TABLE 3 (continued)**
**Characteristics associated with meeting the muscle/bone-strengthening, balance and combined PA recommendations, Canada, 2020**

| Characteristics | Muscle/bone strength recommendation (total sample) | | | Balance recommendation (older adults) | | | Combined muscle/bone + aerobic (+ balance in older adults) (total sample) | | |
|---|---|---|---|---|---|---|---|---|---|
| | %a | LCL | UCL | %a | LCL | UCL | %a | LCL | UCL |
| Cultural/racial background | | | | | | | | | |
| Non-White | 47.5* | 43.2 | 51.7 | 18.7[E] | 10.3 | 27.1 | 31.4 | 26.9 | 36.0 |
| White | 53.8* | 52.1 | 55.4 | 15.8 | 13.7 | 17.9 | 35.1 | 33.4 | 36.9 |
| Highest household education level | | | | | | | | | |
| Secondary or less | 42.4* | 38.9 | 45.8 | 12.2* | 8.9 | 15.6 | 20.6* | 17.8 | 23.4 |
| Postsecondary graduate | 54.6* | 52.8 | 56.3 | 18.0* | 15.4 | 20.6 | 37.7* | 35.9 | 39.5 |
| Distribution of household income quintile | | | | | | | | | |
| Q1 (Lowest) | 41.3* | 38.2 | 44.4 | 14.4 | 10.7 | 18.1 | 25.3* | 22.4 | 28.3 |
| Q2 | 51.1* | 47.6 | 54.7 | 14.6 | 10.9 | 18.3 | 30.8* | 27.4 | 34.2 |
| Q3 | 52.0* | 48.0 | 56.1 | 14.3 | 10.1 | 18.5 | 34.0* | 30.1 | 37.9 |
| Q4 | 59.9* | 56.1 | 63.7 | 22.8 | 17.2 | 28.4 | 41.0* | 36.8 | 45.1 |
| Q5 (Highest) | 58.6* | 54.9 | 62.3 | 17.9 | 12.5 | 23.4 | 42.1* | 38.6 | 45.7 |
| **Health behaviours** | | | | | | | | | |
| Smoking status | | | | | | | | | |
| Smoker | 52.4 | 47.8 | 56.9 | 8.0[E*] | 3.3 | 12.7 | 33.0 | 28.6 | 37.3 |
| Non-smoker | 52.6 | 50.8 | 54.3 | 17.1* | 14.8 | 19.5 | 34.9 | 33.3 | 36.6 |
| Leisure screen time recommendation[c] | | | | | | | | | |
| Met recommendation | 56.3* | 54.3 | 58.2 | 18.2* | 15.4 | 21.0 | 37.6* | 35.6 | 39.7 |
| Did not meet recommendation | 46.0* | 43.4 | 48.5 | 13.6* | 10.6 | 16.7 | 29.4* | 26.9 | 31.9 |
| Sleep time recommendation[d] | | | | | | | | | |
| Met recommendation | 55.4* | 53.5 | 57.4 | 18.8* | 15.4 | 22.1 | 38.2* | 36.2 | 40.2 |
| Did not meet recommendation | 46.9* | 43.8 | 50.1 | 12.7* | 10.2 | 15.2 | 27.2* | 24.2 | 30.1 |
| MVPA[e] | | | | | | | | | |
| Met recommendation | 68.2* | 66.3 | 70.2 | 28.6* | 26.4 | 30.9 | 100* | – | – |
| Did not meet recommendation | 33.2* | 30.9 | 35.4 | 9.6* | 8.3 | 10.9 | 0* | – | – |

**Source:** Canadian Community Health Survey – Healthy Living Rapid Response Module, 2020.

**Abbreviations:** LCL, lower confidence limit; MVPA, moderate-to-vigorous intensity physical activity; PA, physical activity; UCL, upper confidence limit.

[a] Per cent meeting recommendation.

[b] Widowed, divorced, separated or never married.

[c] ≤ 2 hours per day for youth; ≤3 hours per day for adults.

[d] Youth 12–13 years, 9–11.99 hours/night; youth 14–17 years, 8–10.99 hours/night; adults 18–64 years, 7–9.99 hours/night; adults ≥65 years, 7–8.99 hours/night.

[e] Children and youth (5–17 years), ≥60 min/d of MVPA; adults (18–64 years) and older adults (≥65 years), ≥150 min/wk.

[E] Interpret estimate with caution due to high sampling variability.

* Significantly different between groups ($p < 0.05$).

Among older adults, statistically significant differences were observed across all recommendations with non-smokers and those who met the screen, sleep and aerobic PA recommendations more likely to meet the balance recommendation.

### *Association between recommendation adherence and health (Objective 3)*

Meeting the age-specific muscle/bone-strengthening, balance and combined PA recommendations was associated with a significantly reduced likelihood of multimorbidity and increased likelihood of excellent and very good perceived mental and general health (see Table 4). In addition, among older adults, meeting the balance recommendations was associated with a reduced likelihood of overweight and obesity.

### *Trends in adherence to recommendations (Objective 4)*

Figures 1 and 2 show age- and sex-specific trends in meeting the muscle/bone-strengthening and balance recommendations, respectively. The difference between Figures 2a and 2b are largely due to the addition of leisure activities; these can—but do not always—challenge balance. Walking, gardening/yard work and cycling are three of the most popular leisure activities, with 71% of older adults reporting walking, 49% reporting gardening/yard work and 24% reporting cycling in 2014. Removal of these activities to assess balance resulted in a decline in adherence to the balance recommendation from 76.1% to 46.9% (data not shown).

At all ages, the odds of adhering to the muscle/bone-strengthening recommendations, regardless of the activities (i.e. weight lifting, moderate-to-high or low-to-high impact), increased over time, with the greatest increase observed among older adults. Among older adults, the odds of adhering to the balance recommendation using either sports or combined sports/exercise/leisure activities also increased over time. While results indicate a small, but linear association with cycle/year, Figures 1 and 2 show cycle-by-cycle differences are not necessarily linear.

## Discussion

Our findings show that approximately 57% of youth aged 12–17 years, 55% of adults aged 18–64 years, and 42% of older adults aged ≥65 years currently (in 2020) meet the muscle/bone-strengthening PA recommendations from the 24H Guidelines. In addition, 16% of older adults engage in activities that challenge balance at least twice per week. Meeting either the muscle/bone-strengthening or balance recommendations alone or in combination with sufficient MVPA was associated with better physical and mental health. Results of the time trend analysis found that in all age groups, there was a small but significant increase in the proportion of Canadians who met the muscle/bone-strengthening and balance recommendations from 2000 to 2014.

### *Comparisons with the literature*

Very few national surveillance systems include ways to assess participation in muscle- and bone-strengthening activities and almost none assess balance activities.[5] Internationally, the prevalence of meeting the strength-training recommendation ranges from 16% to 57% among youth (≥3 times per week) [14,30-34] and from 3% to 70% among adults (most report between 10–30%; ≥2 times per week).[35] Prevalence of sufficient balance training among older adults ranges from 9% to 34%.[14,36,37] The Canadian prevalence estimates for muscle/bone-strengthening and balance recommendations tend towards the higher end of this range. Comparing prevalence globally should be done with caution, however, given the variation in survey questions and methods.

Other studies have also shown that females,[14,30-32,34,38-42] older adults,[14,30,34,38-43] people living at or in households with lower education,[34,38-40,43] people at lower income,[34,39-42] some non-White ethnicities,[31] those with poorer self-rated health,[38-40,42] current smokers[38,42] and those with overweight or obesity[30,31,38-42] are less likely to meet the strength-training recommendation. In addition, among older adults, sufficient balance exercise is lower with increasing age,[14] among females[8,35,36] and among those with lower education,[36,37] lower income,[36] poor self-rated health[37] or obesity.[36,37]

Evidence gathered in Janssen and LeBlanc's systematic review,[44] which informed the 24H Guidelines recommendations,[3] suggests that youth that engage in high impact activities (e.g. jumping) have better bone mass accrual or bone structure. Muscle-strength training has been consistently associated with a reduction in all-cause mortality and in cardiovascular disease incidence and better physical functioning among adults.[8] Similarly, older adults' (≥65 years) engagement in balance and functional training is associated with better physical functioning.[19]

Findings from the present study confirm associations between meeting the recommendation and multimorbidity and perceived physical and mental health. The findings also suggest that meeting either recommendation alone or in combination with sufficient MVPA is associated with better physical and mental health. This supports the concept that all activity is health promoting and provides people with choice for being active. While the effect of strength or balance training on adults' health-related quality of life is uncertain,[8,19] our results for self-reported physical health suggest a cross-sectional association.

Results of the present study do not show a significant association between meeting the strength-training recommendation and self-reported overweight/obesity. While others have observed an association (with self-reported and objectively measured BMI),[45-48] BMI may not be an ideal health outcome in relation to strength training. Strength training may not result in substantial changes to a person's BMI,[49] and conversely, BMI does not provide a complete picture of body composition.[50,51] Future work would benefit from looking at other measures of adiposity and health status.

A significant time trend (2000–2014) was observed for all age groups, suggesting small increases in adherence to the muscle-strengthening and balance recommendations. Bennie et al.,[31] using data from the COMPASS study, found that the prevalence of meeting the strength-training recommendation among secondary school students declined significantly, from 57.0% to 48.5%, between 2015 and 2019.

Other studies have observed increasing trends in muscle-strengthening exercise among adults. In Canada, using longitudinal data from the National Population Health Survey, which assessed PA using the same module from the 2000–2014 CCHS, Perks[52] found that weight training significantly increased from 1994 to 2011.

**TABLE 4**
**Associations between meeting the muscle/bone-strengthening, balance and combined PA recommendations and health outcomes, Canada, 2020**

| Health outcomes | Muscle/bone strength recommendation (total sample) | | | | | | Balance recommendation (older adults) | | | | | | Combined muscle/bone + aerobic (+ balance in older adults) (total sample) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | %[a] | LCL | UCL | aOR[b] | LCL | UCL | %[a] | LCL | UCL | aOR[c] | LCL | UCL | %[a] | LCL | UCL | aOR[b] | LCL | UCL |
| **BMI category[d]** | | | | | | | | | | | | | | | | | | |
| Overweight and obese | 51.9 | 49.7 | 54.1 | 0.91 | 0.77 | 1.07 | 13.8* | 11.5 | 16.0 | 0.54 | 0.39 | 0.74 | 33.8 | 31.6 | 35.9 | 0.98 | 0.82 | 1.17 |
| Under and normal weight | 54.5 | 51.7 | 57.4 | 1.00 | – | – | 22.0* | 17.9 | 26.2 | 1.00 | – | – | 37.2 | 34.2 | 40.1 | 1.00 | – | – |
| **Multimorbidity status[e]** | | | | | | | | | | | | | | | | | | |
| 2+ chronic conditions | 37.4* | 33.8 | 41.1 | 0.68 | 0.57 | 0.82 | 9.9* | 7.5 | 12.2 | 0.47 | 0.34 | 0.66 | 18.9* | 15.8 | 22.0 | 0.79 | 0.62 | 1.00 |
| <2 chronic conditions | 54.5* | 52.8 | 56.3 | 1.00 | – | – | 18.7* | 16.0 | 21.5 | 1.00 | – | – | 36.8* | 35.0 | 38.5 | 1.00 | – | – |
| **Self-reported mental health** | | | | | | | | | | | | | | | | | | |
| Excellent/very good | 55.5* | 53.6 | 57.4 | 1.36 | 1.18 | 1.56 | 17.5* | 14.9 | 20.2 | 1.43 | 1.01 | 2.02 | 36.7* | 34.9 | 38.6 | 1.32 | 1.12 | 1.57 |
| Good/fair/poor | 46.7* | 43.9 | 49.4 | 1.00 | – | – | 12.6* | 9.7 | 15.6 | 1.00 | – | – | 30.5* | 27.6 | 33.4 | 1.00 | – | – |
| **Self-reported general health** | | | | | | | | | | | | | | | | | | |
| Excellent/very good | 58.3* | 56.2 | 60.4 | 1.65 | 1.44 | 1.90 | 20.5* | 17.1 | 23.9 | 1.80 | 1.33 | 2.44 | 41.2* | 39.1 | 43.2 | 1.84 | 1.55 | 2.18 |
| Good/fair/poor | 43.2* | 40.7 | 45.6 | 1.00 | – | – | 11.9* | 9.7 | 14.1 | 1.00 | – | – | 24.2* | 21.7 | 26.7 | 1.00 | – | – |

**Source:** Canadian Community Health Survey – Healthy Living Rapid Response module, 2020.

**Abbreviations:** aOR, adjusted odds ratio; BMI, body mass index; LCL, lower confidence limit; PA, physical activity; UCL, upper confidence limit.

[a] Per cent of population meeting recommendation.

[b] Odds ratios for muscle/bone strength and combined PA recommendations adjusted for age, sex, income and smoking status.

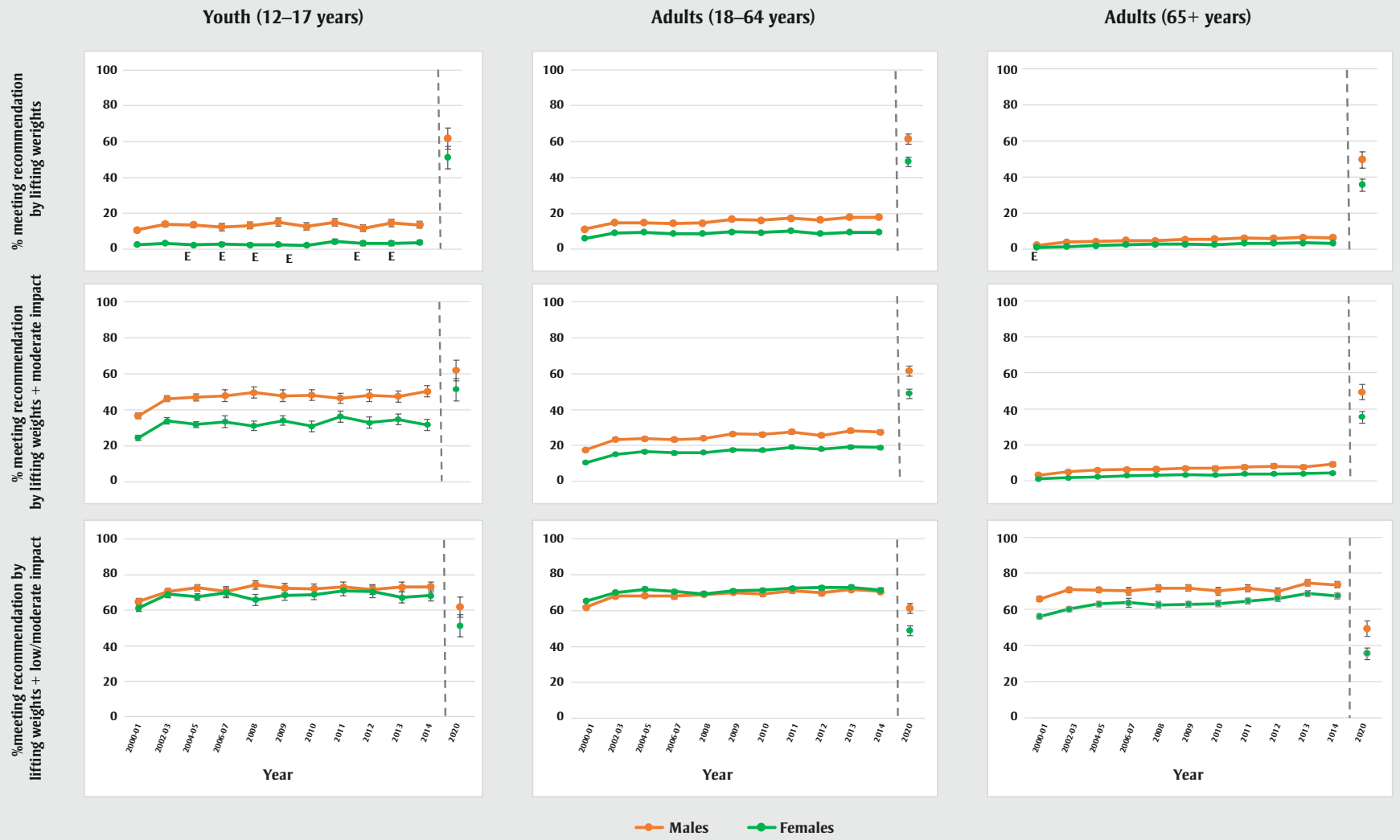
[c] Odds ratios for balance recommendation adjusted for sex, income and smoking status.

[d] For youth, based on age- and sex-specific BMI cut-points as defined by the World Health Organization; for adults, based on Health Canada and World Health Organization body weight classification systems.

[e] Self-reported diagnosis of ≥2 diseases (cancer, diabetes, cardiovascular disease, chronic respiratory disease in those ≥35 years) and mood and/or anxiety disorders.

* Significantly different between groups ($p < 0.05$).

**FIGURE 1**
**Sex-specific temporal trends in adherence to the muscle/bone-strengthening recommendations in youth, adults and older adults[a] based on weight training, moderate-to-high impact activities and low-to-high impact activities, CCHS, 2000–2014**



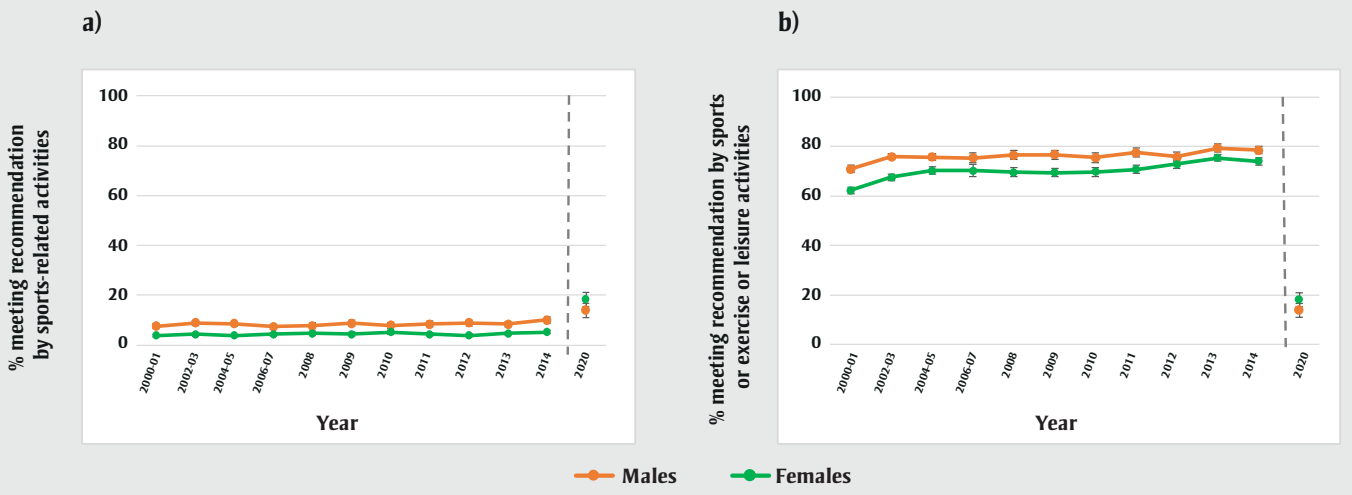

**Source:** Canadian Community Health Surveys, 2000–2014.

**Abbreviations:** CCHS, Canadian Community Health Survey; HLV-RR, healthy living rapid response module.

**Note:** Adherence to the muscle/bone-strengthening recommendation from the 2020 CCHS HLV-RR is shown to the right of the vertical dotted line.

[a] Youth aged 12–17 years, adults aged 18–64 years and older adults aged ≥65 years.

**FIGURE 2**
**Sex-specific temporal trends in adherence to the balance recommendation[a] based on a) sports-related activities and b) sports, exercise or leisure activities, CCHS, 2000–2014**




**Source:** Canadian Community Health Surveys, 2000–2014.

**Abbreviations:** CCHS, Canadian Community Health Survey; HLV-RR, healthy living rapid response module.

**Note:** Adherence to the balance recommendation from the 2020 CCHS HLV-RR is shown to the right of the vertical dotted line.

[a] ≥2 times per week in older adults aged ≥65 years.

Alongside increases in weight training, increases in total leisure PA were observed except among those aged 65 years and older.[52] Among Australian adults, the prevalence of sufficient muscle-strengthening activity increased from 6.4% to 12.0% ($p_{trend}$ < 0.0001) between 2001 and 2010.[43] Using data from Behavioral Risk Factor Surveillance System surveys, Bennie et al.[53] found a small but statistically significant increase (29.1% to 30.3%, $p_{trend}$ < 0.0001) in the prevalence of sufficient muscle-strengthening activity among adults in the United States between 2011 and 2017. There are no known studies that have looked at time trends in balance exercise.

## *Surveillance considerations*

While using the 2000–2014 CCHS PAC provided a way to compare previous data with more recent data from the HLV-RR module, several differences between the modules limit the comparison. These differences include the sampling frame of the surveys; seasons of data collection; recall period (3 months for the older PAC vs. past 7 days for the new HLV-RR module); number of questions (22 activities in the older PAC vs. 2 items with broad examples in the new HLV-RR module); and activities/examples (activities in the older PAC grouped under "weight training," "moderate-to-high impact" and "low-to-high impact," based on assumptions of strength/balance contributions vs. activities in the new HLV-RR module presenting broad examples of muscle/bone-strengthening activities [lifting weights, carrying heavy loads, shovelling, sit-ups, running, jumping sports] and balance activities [yoga, tai chi, dance, tennis, volleyball and balance training]).

The new 2020 module may provide more room for interpretation of balance and muscle strengthening, whereas the old module may misclassify some activities based on the applied assumptions of the movements conducted. The new module question likely also captures activities beyond traditional weight lifting.

It is, however, important to acknowledge that the range of strength-training options/activities has evolved over time, with power yoga, Pilates and weight-based workouts, for example, becoming more popular. Therefore, what is defined as strength training, its promotion or marketing (including through the 24H Guidelines) and the equipment and resources available for this training may have influenced prevalence over time. While the prevalence of strength training in 2020 is provided alongside 2000–2014 trends as an exploratory exercise, it is not appropriate to directly compare the estimates.

Current Canadian estimates of adherence to the muscle/bone-strengthening recommendations using the new 2020 CCHS HLV-RR module exceed those observed internationally. Prevalence estimates are likely influenced by variation in the surveillance question(s) used.[35] Most population surveys ask specific questions about strength training, but several ask about a range of activities that could strengthen muscles or improve balance. International estimates are largely based on questions referencing traditional forms of strength training such as weight lifting or calisthenics. In fact, some surveys ask respondents to not include aerobic activities in their responses.[40,54] Many activities that would improve aerobic fitness could also strengthen muscles and improve balance. It is, however, not clear to what extent different strength-training activities influence health outcomes.

The new module used in the CCHS HLV-RR does not include a measure of intensity or duration. While current recommendations are based on minimum weekly frequencies, future work is needed to understand whether intensity and

duration have important implications for health. In addition, the muscle/bone-strengthening recommendation in the 24H Guidelines was informed by resistance training studies. Therefore, it is recommended that future measures also assess resistance training separately. Future work is also needed to assess the reliability of the HLV-RR module to assess trends and to better understand how including different examples may change estimates, and whether the module requires further adjustment.

### *Strengths and limitations*

Strengths of this study include the use of large, nationally representative samples of Canadian youth and adults to examine historical trends and current prevalence of adherence to muscle/bone-strengthening and balance recommendations. Further, the HLV-RR module allowed for the examination of the sociodemographic and behavioural characteristics of those meeting recommendations. While it was not possible to assess the criterion validity of the new module, assessing associations with indicators of health provided a means to assess construct validity. Historically, the validity of muscle-strength training exercise questions has been rarely assessed,[35] largely due to a lack of comparison measures that require few resources to obtain.

All data used in this study are cross-sectional, making it impossible to examine causal associations with health or to ascertain within-person changes. However, repeated cross-sectional surveys account for the non-stationary nature of the Canadian population. It was also not possible to directly compare the older (2000–2014) and the newer (2020) results due to differences in methodology. Finally, in both modules, activities are self-reported and subject to recall and response biases.

## Conclusions

Results of this study suggest that approximately half of Canadians meet the muscle/bone-strengthening recommendation but only 16% of older adults meet the balance recommendation from the 24H Guidelines. Temporal trends suggest that adherence to both recommendations increased between 2000 and 2014. Meeting either recommendation alone or in combination with sufficient MVPA is associated with better physical and mental health. Surveillance reporting on the muscle/bone-strengthening and balance components of the Canadian 24H Guidelines alongside the already recognized aerobic PA recommendation provides important information on another health behaviour associated with optimal health among Canadians.

## Conflicts of interest

None.

## Authors' contributions and statement

All authors contributed to the conceptualization and design of the study and interpretation of the data. SAP undertook the analysis with verification by JJL. SAP wrote the original draft. All authors critically revised and approved the final paper.

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

## References


1. Warburton DE, Charlesworth S, Ivey A, Nettlefold L, Bredin SS. A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. Int J Behav Nutr Phys Act. 2010;7:39. https://doi.org/10.1186/1479-5868-7-39

2. Warburton DE, Bredin SS. Health benefits of physical activity: a systematic review of current systematic reviews. Curr Opin Cardiol. 2017;32(5):541-56. https://doi.org/10.1097/HCO.0000000000000437

3. 2018 Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. Washington (DC): Department of Health and Human Services; 2018 [cited 2022 Dec 12]. Available from: https://health.gov/sites/default/files/2019-09/PAG_Advisory_Committee_Report.pdf

4. King AC, Whitt-Glover MC, Marquez DX, et al.; 2018 Physical Activity Guidelines Advisory Committee. Physical activity promotion: highlights from the 2018 Physical Activity Guidelines Advisory Committee Systematic Review. Med Sci Sports Exerc. 2019;51(6):1340-53. https://doi.org/10.1249/MSS.0000000000001945

5. Milton K, Varela AR, Strain T, Cavill N, Foster C, Mutrie N. A review of global surveillance on the muscle strengthening and balance elements of physical activity recommendations. J Frailty Sarcopenia Falls. 2018;3(2):114-24. https://doi.org/10.22540/JFSF-03-114

6. Canadian Society for Exercise Physiology. Canadian 24-hour movement guidelines: an integration of physical activity, sedentary behaviour, and sleep [Internet]. Ottawa (ON): CSEP; 2021 [cited 2021 Mar 05]. Available from: https://csepguidelines.ca/

7. Tremblay MS, Warburton DE, Janssen I, et al. New Canadian Physical Activity Guidelines. Appl Physiol Nutr Metab. 2011;36(1):36-46. https://doi.org/10.1139/H11-009

8. El-Kotob R, Ponzano M, Chaput J, et al. Resistance training and health in adults: an overview of systematic reviews. Appl Physiol Nutr Metab. 2020;45(10):S165-79. https://doi.org/10.1139/apnm-2020-0245

9. Momma H, Kawakami R, Honda T, Sawada SS. Muscle-strengthening activities are associated with lower risk and mortality in major non-communicable diseases: a systematic review and meta-analysis of cohort studies. Br J Sports Med. 2022;56:755-63. https://doi.org/10.1136/bjsports-2021-105061

10. Katzmarzyk PT, Craig CL. Musculoskeletal fitness and risk of mortality. Med Sci Sports Exerc. 2002;34(5):740-4. https://doi.org/10.1097/00005768-200205000-00002

11. Warburton DE, Gledhill N, Quinney A. Musculoskeletal fitness and health. Can J Appl Physiol. 2001;26(2):217-37. https://doi.org/10.1139/h01-013

12. O'Connor PJ, Herring MP, Caravalho A. Mental health benefits of strength training in adults. Am J Lifestyle Med. 2010;4(5):377-96. https://doi.org/10.1177/1559827610368771

13. Ströhle A. Physical activity, exercise, depression and anxiety disorders. J Neural Transm (Vienna). 2009;116(6):777-84. https://doi.org/10.1007/s00702-008-0092-x

14. Strain T, Fitzsimons C, Kelly P, Mutrie N. The forgotten guidelines: cross-sectional analysis of participation in muscle strengthening and balance & co-ordination activities by adults and older adults in Scotland. BMC Public Health. 2016;16(1):1108. https://doi.org/10.1186/s12889-016-3774-6

15. Bennie J, Smith J, Marvos Y, Biddle S, Kolbe-Alexander T. The neglected guideline - resistance exercise and public health. J Sci Med Sport. 2019; 22(S2):S9. https://doi.org/10.1016/j.jsams.2019.08.051

16. Mann S, Beedie C, Jimenez A. Differential effects of aerobic exercise, resistance training and combined exercise modalities on cholesterol and the lipid profile: review, synthesis and recommendations. Sports Med. 2014;44(2):211-21. https://doi.org/10.1007/s40279-013-0110-5

17. Sousa N, Mendes R, Abrantes C, Sampaio J, Oliveira J. Long-term effects of aerobic training versus combined aerobic and resistance training in modifying cardiovascular disease risk factors in healthy elderly men. Geriatr Gerontol Int. 2013;13(4): 928-35. https://doi.org/10.1111/ggi.12033

18. Judge JO. Balance training to maintain mobility and prevent disability. Am J Prev Med. 2003;25(3 Suppl 2): 150-6. https://doi.org/10.1016/S0749-3797(03)00178-8

19. McLaughlin EC, El-Kotob R, Chaput J, et al. Balance and functional training and health in adults: an overview of systematic reviews. Appl Physiol Nutr Metab. 2020;45(10 (Suppl. 2)):S180-96. https://doi.org/10.1139/apnm-2020-0279

20. Center for Surveillance and Applied Research, Public Health Agency of Canada. Physical Activity, Sedentary Behaviour and Sleep (PASS) Indicators data tool, 2021 edition [Internet]. Ottawa (ON): PHAC; 2021 [cited 2022 Dec 12]. Available from: https://health-infobase.canada.ca/pass/data-tool

21. Roberts KC, Butler G, Branchard B, et al. The Physical Activity, Sedentary Behaviour and Sleep (PASS) Indicator Framework. Health Promot Chronic Dis Prev Can. 2017;37(8):252-6. https://doi.org/10.24095/hpcdp.37.8.04

22. Ross R, Chaput JP, Giangregorio LM, et al. Canadian 24-Hour Movement Guidelines for Adults aged 18-64 years and Adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2020;45(10 (Suppl. 2)): S57-102. https://doi.org/10.1139/apnm-2020-0467

23. Tremblay MS, Carson V, Chaput JP, et al. Canadian 24-Hour Movement Guidelines for Children and Youth: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2016;41(6 Suppl 3):S311-27. https://doi.org/10.1139/apnm-2016-0151

24. Statistics Canada. Canadian Community Health Survey (CCHS) - Rapid Response - Healthy Living - Complement to the User Guide. Ottawa (ON): Statistics Canada; 2020.

25. Lamb SE, Becker C, Gillespie LD, et al.; Taxonomy Investigators. Reporting of complex interventions in clinical trials: development of a taxonomy to classify and describe fall-prevention interventions. Trials. 2011;12:125. https://doi.org/10.1186/1745-6215-12-125

26. Rodrigues IB, Ponzano M, Hosseini Z, et al. The effect of impact exercise (alone or multicomponent intervention) on health-related outcomes in individuals at risk of fractures: a systematic review and meta-analysis of randomized controlled trials. Sports Med. 2021;51(6):1273-92. https://doi.org/10.1007/s40279-021-01432-x

27. Weeks BK, Beck BR. The BPAQ: a bone-specific physical activity assessment instrument. Osteoporos Int. 2008; 19(11):1567-77. https://doi.org/10.1007/s00198-008-0606-2

28. Clemson L, Fiatarone Singh MA, Bundy A, et al. Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial. BMJ. 2012;345:e4547. https://doi.org/10.1136/bmj.e4547

29. Connor Gorber S, Shields M, Tremblay MS, McDowell I. The feasibility of establishing correction factors to adjust self-reported estimates of obesity. Health Rep. 2008;19(3): 71-82.

30. Bennie JA, Faulkner G, Smith JJ. The epidemiology of muscle-strengthening activity among adolescents from 28 European countries. Scand J Public Health. 2022;50(2):295-302. https://doi.org/10.1177/14034948211031392

31. Bennie JA, Smith JJ, Qian W, Leatherdale ST, Faulkner G. Longitudinal trends and predictors of muscle-strengthening activity guideline adherence among Canadian youths. J Sci Med Sport. 2022;25(3):230-4. https://doi.org/10.1016/j.jsams.2021.10.008

32. Kann L, McManus T, Harris WA, et al. Youth risk behavior surveillance – United States, 2017. Morb Mort Week Rep. 2018;67(8):1-114. https://doi.org/10.15585/mmwr.ss6708a1

33. Australian Bureau of Statistics. National Health Survey: First results, 2017–18 [Internet]. Belconnen (ACT): Australian Bureau of Statistics; 2018 Dec 12 [cited 2022 Dec 12]. Available from: https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey-first-results/latest-release

34. Xin F, Zhu Z, Chen S, et al. Prevalence and correlates of meeting the muscle-strengthening exercise recommendations among Chinese children and adolescents: results from 2019 Physical Activity and Fitness in China—The Youth Study. J Sport Health Sci. 2022; 11(3):358-66. https://doi.org/10.1016/j.jshs.2021.09.010

35. Shakespear-Druery J, De Cocker K, Biddle SJ, Gavilán-Carrera B, Segura-Jiménez V, Bennie J. Assessment of muscle-strengthening exercise in public health surveillance for adults: a systematic review. Prev Med. 2021;148: 106566. https://doi.org/10.1016/j.ypmed.2021.106566

36. Hyde ET, Omura JD, Chen TJ, Brown DR, Fulton JE, Carlson SA. U.S. older adults' participation in balance activities. J Aging Phys Act. 2021;29(6): 1003-9. https://doi.org/10.1123/japa.2020-0422

37. Merom D, Pye V, Macniven R, et al. Prevalence and correlates of participation in fall prevention exercise/physical activity by older adults. Prev Med. 2012;55(6):613-7. https://doi.org/10.1016/j.ypmed.2012.10.001

38. Bennie JA, Pedisic Z, van Uffelen, Jannique GZ, et al. The descriptive epidemiology of total physical activity, muscle-strengthening exercises and sedentary behaviour among Australian adults – results from the National Nutrition and Physical Activity Survey. BMC Public Health. 2016;16(1):73. https://doi.org/10.1186/s12889-016-2736-3

39. Bennie JA, Pedisic Z, Suni JH, et al. Self-reported health-enhancing physical activity recommendation adherence among 64,380 Finnish adults. Scand J Med Sci Sports. 2017; 27(12):1842-53. https://doi.org/10.1111/sms.12863

40. Bennie JA, Lee DC, Khan A, et al. Muscle-strengthening exercise among 397,423 U.S. adults: prevalence, correlates, and associations with health conditions. Am J Prev Med. 2018; 55(6):864-74. https://doi.org/10.1016/j.amepre.2018.07.022

41. Harris C, Watson KB, Carlson SA, Fulton JE, Dorn JM. Adult participation in aerobic and muscle-strengthening physical activities – United States, 2011. MMWR Morb Mort Weekly Rep. 2013;62(17):326-30.

42. Bennie JA, De Cocker K, Tittlbach S. The epidemiology of muscle-strengthening and aerobic physical activity guideline adherence among 24,016 German adults. Scand J Med Sci Sports. 2021;31(5):1096-104. https://doi.org/10.1111/sms.13922

43. Bennie JA, Pedisic Z, van Uffelen JG, et al. Pumping iron in Australia: prevalence, trends and sociodemographic correlates of muscle strengthening activity participation from a national sample of 195,926 adults. PLoS One. 2016;11(4):e0153225. https://doi.org/10.1371/journal.pone.0153225

44. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 2010;7(1):40. https://doi.org/10.1186/1479-5868-7-40

45. Bennie JA, De Cocker K, Pavey T, Stamatakis E, Biddle SJ, Ding D. Muscle strengthening, aerobic exercise, and obesity: a pooled analysis of 1.7 million US adults. Obesity (Silver Spring). 2020;28(2):371-78. https://doi.org/10.1002/oby.22673

46. Brellenthin AG, Lee DC, Bennie JA, Sui X, Blair SN. Resistance exercise, alone and in combination with aerobic exercise, and obesity in Dallas, Texas, US: a prospective cohort study. PLoS Med. 2021;18(6):e1003687. https://doi.org/10.1371/journal.pmed.1003687

47. Terada T, Scott K, Way KL, et al. Meeting the Canadian strength training recommendations: implications for the cardiometabolic, psychological and musculoskeletal health of nurses. J Nurs Manag. 2021;29(4):681-9. https://doi.org/10.1111/jonm.13204

48. Bennie JA, Ding D, De Cocker K. Dose-dependent associations of joint aerobic and muscle-strengthening exercise with obesity: a cross-sectional study of 280,605 adults. J Sport Health Sci. 2021:S2095-546(21)00002-8. https://doi.org/10.1016/j.jshs.2021.01.002

49. Kay SJ, Fiatarone Singh MA. The influence of physical activity on abdominal fat: a systematic review of the literature. Obes Rev. 2006;7(2): 183-200. https://doi.org/10.1111/j.1467-789X.2006.00250.x

50. Okorodudu DO, Jumean MF, Montori VM, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systematic review and meta-analysis. Int J Obes. 2010;34(5):791-9. https://doi.org/10.1038/ijo.2010.5

51. Javed A, Jumean M, Murad MH, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. Pediatr Obes. 2015;10(3):234-44. https://doi.org/10.1111/ijpo.242

52. Perks TA. Investigating the physical activity behaviors of Canadian adults over time: multilevel sex and age group trajectories across 2 decades. J Phys Act Health. 2017;14(12):933-42. https://doi.org/10.1123/jpah.2017-0130

53. Bennie JA, Kolbe-Alexander T, Seghers J, Biddle SJ, De Cocker K. Trends in muscle-strengthening exercise among nationally representative samples of United States adults between 2011 and 2017. J Phys Act Health. 2020; 17(5):512-8. https://doi.org/10.1123/jpah.2019-0472

54. Bennie JA, De Cocker K, Teychenne MJ, Brown WJ, Biddle SJ. The epidemiology of aerobic physical activity and muscle-strengthening activity guideline adherence among 383,928 U.S. adults. Int J Behav Nutr Phys Act. 2019;16(1):34. https://doi.org/10.1186/s12966-019-0797-2

https://doi.org/10.24095/hpcdp.43.5.02

# Original quantitative research

# Sex differences in children's exposure to food and beverage advertisements on broadcast television in four cities in Canada

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## Abstract

**Introduction:** Sex differences exist in children's obesity rates, dietary patterns and television viewing. Television continues to be a source of unhealthy food advertising exposure to children in Canada. Our objective was to examine sex differences in food advertising exposure in children aged 2 to 17 years across four Canadian English-language markets.

**Methods:** We licensed 24-hour television advertising data from the company Numerator for January through December 2019, in four cities (Vancouver, Calgary, Montréal and Toronto) across Canada. Child food advertising exposure overall, by food category, television station, Health Canada's proposed nutrient profiling model, and marketing techniques were examined on the 10 most popular television stations among children and compared by sex. Advertising exposure was estimated using gross rating points, and sex differences were described using relative and absolute differences.

**Results:** Both male and female children were exposed to an elevated level of unhealthy food advertising and a plethora of marketing techniques across all four cities. Differences between sexes were evident between and within cities. Compared to females, males in Vancouver and Montréal viewed respectively 24.7% and 24.0% more unhealthy food ads/person/year and were exposed to 90.2 and 133.4 more calls to action, 93.3 and 97.8 more health appeals, and 88.4 and 81.0 more products that appeal to children.

**Conclusion:** Television is a significant source of children's exposure to food advertising, with clear sex differences. Policy makers need to consider sex when developing food advertising restrictions and monitoring efforts.

***Keywords:*** *children, adolescents, sex differences, food advertising, marketing techniques, television exposure*

### *Highlights*

- Children continue to be exposed to unhealthy food and beverage advertising on television.
- Targeted advertising based on ethnicity, age and sex is used to influence consumer subpopulations.
- Differences in male and female exposure to food advertising, including unhealthy foods, and marketing techniques were evident between and within cities in Canada.
- Policy makers should consider sex when developing food advertising restrictions and planning monitoring efforts.

## Introduction

In the United States, the prevalence of obesity among children aged 6 to 11 years is 20.3% (21.3% of males and 19.2% of females), while rates for children aged 12 to 19 are 21.2% (22.5% of males and 19.9% of females).[1] In Canada, rates of obesity are lower but remain a public health concern;[2] in 2015, 10.4% of children aged 5 to 11 years had obesity (12.3% of males and 8.5% of females), while rates were higher for those aged 12 to 17 (16.9% of males and 10.6% of females).[3]

A contributing factor to obesity is poor diets. Over time, the diets of Canadian children have shifted; currently 50% of their daily dietary intake is from foods containing added sugar, fat and salt, increasing children's risk of obesity and other chronic illnesses.[4] Compared to females, males consume slightly more ultra-processed foods, that is, foods that go through multiple processes and contain added fats, sugars and sodium.[4]

Unhealthy foods are heavily marketed to children in a variety of media and

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settings.[5] The World Health Organization considers unhealthy food marketing to children a harmful influence on their dietary behaviour as it impacts their food preferences, requests and consumption of energy-dense food.[5-7] Children are vulnerable to marketing due to their limited ability to understand the persuasive purpose of advertising.[8] This is exacerbated when food companies promote products using appealing marketing techniques, like cartoon characters or popular athletes.[9,10] Adolescents are susceptible to food marketing due to their neurocognitive and psychosocial development, which includes their growing independence, susceptibility to peer influence and desire to fit in.[11]

Consumers are influenced by the groups they identify with, and marketers leverage this to appeal to subpopulations. Food companies sometimes use individual characteristics, like ethnicity, to provoke familiarity and a sense of belonging in their advertising.[12,13] Although sex-based targeted marketing has been shown in tobacco and alcohol advertising, we need to investigate if it is used in food advertising given that research has shown that, compared to females, males view more and are more influenced by food marketing.[14,15]

Canadians aged 2 to 17 years watch between 13.9 and 17.3 hours of television weekly, with males watching more than females.[16] This high level of viewership exposes children to a myriad of unhealthy food advertisements (ads).[17] One study in Canada showed that there were 13.4 food ads per hour on children's channels during peak viewing times.[17] This is a concern; a meta-analysis also showed that exposure to food advertisements increased short-term food consumption by an average of 60 kcal more than for children who were not exposed.[18]

Quebec is the only Canadian jurisdiction with legislation restricting advertising to children.[19] Quebec's *Consumer Protection Act* protects children less than 13 years old from all commercial advertising directed at children.[20] Although imperfect, research has shown that, compared to children in Ontario, French-speaking children in Quebec are exposed to fewer child-appealing marketing techniques in food advertising on television.[21] In the rest of Canada, 15 food and beverage companies self-regulate their advertising to children through the *Canadian Children's Food and Beverage Advertising Initiative*. This initiative has been shown to be ineffective.[22,23] Other countries, such as Chile, Ireland, Mexico, Norway and the United Kingdom have statutory television advertising restrictions.[24]

Few studies have examined children's exposure to food advertisements on television in Canada; most have examined ad frequency.[25,26] In addition, most studies investigating television exposure have focussed on one jurisdiction for a period of one month.[27-29] There is also a paucity of research on sex differences in children's exposure to television food advertising that could help inform food advertising regulations.

In this study, we compared children's food advertisement exposures by sex in four cities across Canada over the course of 2019. We hypothesized that, compared to females, males would be exposed to a greater number of unhealthy food ads.

## Methods

### Data collection

Twenty-four-hour television advertising data collected from January 1 to December 31, 2019, for 57 select food and beverage categories and 2475 unique ads, were licensed from Numerator, a company providing audience profiling services in Canada. These data included the broadcast frequency, viewership metrics for audience categories (e.g. general population, children, adolescents and/or adults), the name of the featured company and brand, and the broadcast day, time and station.

Television viewership data were collected from a stratified sampling of households by Numeris, a company that measures media and audiences. Households with a landline are randomly selected from across Canada and asked to complete a telephone survey that collects demographic information. All households that complete this survey are available for recruitment. To ensure that the panel is geographically representative, all phone numbers are assigned a geographical code according to location. Households are then randomly selected from each geographical area. Numeris also uses an iterative marginal weighting technique to maximize the reliability of the sample data and minimize any statistical bias. The recruitment process is conducted regularly throughout the year to replace households that have been removed from the panel. The number of individuals on a Numeris panel can vary as people join or leave the panel; the average sample of children per month was 77 males and 71 females in Vancouver, 99 males and 85 females in Calgary, 66 males and 72 females in the Montréal English market ("Montréal English") and 138 males and 143 females in Toronto. Participants wore portable recording trackers that monitored their television-viewing habits. Numerator then weighted these data by population characteristics such as age, sex, household size, television reception type, region and telephone to approximate market-level viewership of commercial and non-commercial programming.

Television data were examined for four major English-language media markets across Canada (Toronto, Montréal [the English market only], Calgary and Vancouver). The 10 television stations with the highest viewership during peak viewing times for children aged 2 to 17 years were selected for each market. The 57 food and beverage categories, which have been published elsewhere,[30] were selected out of 112 possible options because they are among the most advertised to children, as determined by previous research,[21] and are of public health concern (e.g. they are high in fat, salt and sugar). The other food categories (e.g. tofu, diet products) were not included in this study because they are not heavily advertised on television or particularly consumed by children.

### Frequencies

Food advertisement frequency was drawn from Numerator's AdQuest platform. Frequencies were weighted by the number of products featured in an advertisement and the number of times the advertisement was broadcast. For example, an advertisement featuring two products and broadcast 500 times would have a weighted frequency of 1000. Any advertisement featuring four or more products was limited to a weighting multiplier of 3, so the weighted frequency of an advertisement with five products airing 500 times was 1500. This formula is how Numerator weights the gross ratings point (GRP) based on products being advertised. To maintain consistency, the research team

did the same with the frequency for all advertisements.

### Exposures

Numerator expresses exposure to advertisements as ratings, which reflect the estimated viewing audience for an individual advertisement. This is calculated by dividing the estimated audience for an advertisement by the total population for their media market and then multiplying by 100. Ratings are then summed into a GRP across a specific time frame. Average exposure for a given time frame is calculated by multiplying GRPs for a specific audience segment (in this case those aged 2–17) by 100%. GRP values in this study include 24-hour broadcasting for all of 2019.

### Marketing techniques

We conducted a content analysis for all unique food and beverage advertisements across all markets in 2019. We downloaded all advertisements from the Numerator database as videos and then determined the number of unique advertisements, that is, ones that differed creatively by language or duration from other advertisements. Two trained research assistants (DW and MB) coded all the unique advertisements to identify the presence of each marketing technique; a list of the examined marketing techniques has been published elsewhere.[30] The types of marketing techniques identified were based on previous research,[31] and were coded once for each advertisement, regardless of the number of featured products in the advertisement. Inter-rater reliability of 0.93 was obtained during training when coding practice advertisements. The sample of unique advertisements was divided equally between the two research assistants, and any differences were concluded by consensus.

### Classification

Advertisements were classified as "healthy" or "unhealthy" according to a proposed Health Canada model defining which products can be advertised to children based on nutrient content.[32] Packaged products were considered unhealthy when they contained added fat, sugar or sodium that exceeded one or more established thresholds for saturated fat (2 g), total sugars (5 g) and/or sodium (140 mg) per serving size or reference amount; restaurant items were based on 100 g servings. Multiproduct advertisements with at least one unhealthy product were designated "unhealthy." Advertisements that exclusively featured products with no added fat, sugar or sodium or that did not exceed any of Health Canada's nutrient threshold levels were designated "healthy."

To conduct this classification, the nutrition information for advertised products was first collected from the University of Toronto's 2017 Food Label Information Program (FLIP)[33] and the 2016 Menu-FLIP,[34] which contain food label information for about 17 000 products from Canadian retailers and over 12 000 restaurant and fast-food items. Nutritional data unavailable from FLIP or Menu-FLIP were collected from companies' Canadian websites, product nutrition facts tables from food retailer websites or the companies' American websites. Nutritional data were also estimated based on similar products from the Canadian Nutrient File. Nutritional information was only collected for identifiable products, that is, where the video quality was clear enough to identify the item, and was not collected for advertisements containing only company branding (e.g. logos, characters and/or no food product).

### Data analysis

We performed descriptive analyses for all media markets. Frequency of advertisements were calculated by market, station, food category and healthfulness. Average exposure to advertisements were calculated by multiplying GRPs for children aged 2 to 17 years by 100%. Average exposure to food advertisements per person per year was tabulated for each sex by market, television station, food category and healthfulness. To characterize differences between sexes, we calculated relative and absolute differences in advertisement exposure between females and males, with females used as the comparator group.

## Results

### Overall exposure to advertisements

Exposure to advertisements differed by sex in all examined markets (see Table 1). Females in Vancouver viewed the lowest number of advertisements (1016 ads/person/year), while those in Calgary viewed the highest number (1353.6 ads/person/year). In contrast, males in Calgary viewed the lowest number of advertisements (858.5 ads/person/year), while those in the Montréal English market viewed the highest number (1493.7 ads/person/year). Difference in exposure was highest among males compared to females in the Montréal English market and Vancouver, in relative (27.3% and 24.5%) and absolute (320 and 249.2 ads/person/year) terms. Conversely, exposure among males in Calgary was less compared to females (−36.6%; −495.1 ads/person/year).

### Exposure by food category

Restaurants were the most frequently viewed food category across all markets and by sex (see Table 2). In ads/person/year, females' second and third highest exposures in Calgary, the Montréal English market and Toronto were snacks (Calgary: 102.5; Montréal English: 112.9; Toronto: 108.0) and breakfast food (Calgary: 100.2; Montréal English: 102.9; Toronto: 87.5). Dairy and candy ranked second and third in Vancouver (82.9 and 72.4 ads/person/year). For males, the highest exposures included snacks (Vancouver: 100.1; Calgary: 61.3; Montréal English: 141.7; Toronto: 110.9), breakfast food in Calgary and Toronto (57.6 and 101.1), dairy in Vancouver (109.5) and candy/chocolate in the Montréal English market (117.5).

The largest positive relative differences in exposure among males compared to females were for miscellaneous food (Vancouver: 38.9%) and water (Montréal English: 59.4%), while the largest positive absolute differences, in ads/person/year, were noted for restaurants (Vancouver: 126.5; Montréal English: 187.5), snacks (Montréal English: 28.8) and dairy (Vancouver: 26.6). Conversely, exposures in Calgary were lower among males than among females across all food categories, and most notably for desserts (−44.5%, −15 ads/person/year), breakfast food (−42.5%, −42.6 ads/person/year) and dairy (−42.6%; −39 ads/person/year).

In Toronto, compared to females, males viewed 15.6% or 1.9 fewer advertisements for bread per person/year and 15.5% or 13.6 more advertisements for breakfast foods per person/year.

**TABLE 1**
**Child exposure to food[a] advertisements on the 10 most popular television stations for children 2–17 years, in Vancouver, Calgary, Montréal (English market) and Toronto, by sex, 2019**

| Market | Frequency of ads, n | Exposure, ads/person/year[b] | | Relative difference[c], % | Absolute difference[c] |
|---|---|---|---|---|---|
| | | Females | Males | | |
| Vancouver | 536 542 | 1016.0 | 1265.2 | 24.5 | 249.2 |
| Calgary | 538 094 | 1353.6 | 858.5 | −36.6 | −495.1 |
| Montréal English | 514 696 | 1173.7 | 1493.7 | 27.3 | 320.0 |
| Toronto | 527 265 | 1279.3 | 1264.3 | −1.2 | −15.0 |

**Source:** Numerator, 2019.

**Abbreviations:** ads, advertisements; GRP, gross ratings point.

[a] Analysis based on the 57 selected food classes.

[b] Calculations based on GRPs for children aged 2–17 years.

[c] Males compared to females.

### *Exposure to "unhealthy" advertisements*

Among females, those in Toronto viewed the highest number of unhealthy advertisements (593.7 ads/person/year), whereas those in Vancouver viewed the least (449.0 ads/person/year) (see Table 3). Among males, those in the Montréal English market viewed the highest number of unhealthy advertisements (693.4 ads/person/year), while those in Calgary viewed the least (350.6 ads/person/year). Male exposure to unhealthy food advertisements was higher than that of females' in Vancouver (24.7%, 111 ads/person/year) and Montréal English (24.0%, 134.2 ads/person/year); the opposite was found in Calgary where females' exposure to unhealthy food advertisements was higher than that of males (−38.3%, −217.9 ads/person/year).

### *Exposure by marketing technique*

In Vancouver, more males than females were exposed to all marketing techniques (see Table 4). The most notable relative difference between sexes in Vancouver was to advertisements with licensed characters, where males viewed 32.6% more advertisements compared to females. In absolute terms, the biggest difference was for health appeals (93.3 ads/person/year).

Exposure to marketing techniques was higher for females than for males in Calgary, especially for child language (i.e. language commonly used by children or directed at children, e.g. "hey kids"), with

**TABLE 2**
**Child exposure to food advertisements on the 10 most popular television stations for children 2–17 years, in Vancouver, Calgary, Montréal (English market) and Toronto, by food category and sex, 2019**

| Food category[a] | Vancouver | | | | Calgary | | | | Montréal English | | | | Toronto | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ads/person/year[b] | | Rel diff, % | Abs diff | Ads/person/year[b] | | Rel diff, % | Abs diff | Ads/person/year[b] | | Rel diff, % | Abs diff | Ads/person/year[b] | | Rel diff, % | Abs diff |
| | Female | Male | | | Female | Male | | | Female | Male | | | Female | Male | | |
| Bread | 5.3 | 5.9 | 11.3 | 0.6 | 6.3 | 3.7 | −41.3 | −2.6 | 6.1 | 7.4 | 21.3 | 1.3 | 12.2 | 10.3 | −15.6 | −1.9 |
| Desserts | 29.6 | 38.7 | 30.7 | 9.1 | 33.7 | 18.7 | −44.5 | −15 | 29.4 | 35.5 | 20.7 | 6.1 | 26.4 | 26.1 | −1.1 | −0.3 |
| Candy/chocolate | 72.4 | 87.6 | 21.0 | 15.2 | 78.2 | 46.6 | −40.4 | −31.6 | 90.0 | 117.5 | 30.6 | 27.5 | 80.5 | 77.8 | −3.4 | −2.7 |
| Breakfast food | 65.4 | 79.7 | 21.9 | 14.3 | 100.2 | 57.6 | −42.5 | −42.6 | 102.9 | 103.4 | 0.5 | 0.5 | 87.5 | 101.1 | 15.5 | 13.6 |
| Dairy | 82.9 | 109.5 | 32.1 | 26.6 | 92.5 | 53.1 | −42.6 | −39.4 | 90.8 | 109.2 | 20.3 | 18.4 | 84.4 | 82.8 | −1.9 | −1.6 |
| Condiments | 20.8 | 26.4 | 26.9 | 5.6 | 23.4 | 17.0 | −27.4 | −6.4 | 13.1 | 16.2 | 23.7 | 3.1 | 25.7 | 26.1 | 1.6 | 0.4 |
| Entrees | 26.1 | 30.9 | 18.4 | 4.8 | 32.2 | 21.1 | −34.5 | −11.1 | 35.4 | 45.8 | 29.4 | 10.4 | 34.5 | 31.4 | −9.0 | −3.1 |
| Fruit/vegetables | 10.9 | 12.5 | 14.7 | 1.6 | 16.2 | 11.0 | −32.1 | −5.2 | 16.5 | 22.6 | 37.0 | 6.1 | 23.6 | 21.3 | −9.7 | −2.3 |
| Beverages | 63.5 | 84.6 | 33.2 | 21.1 | 68.1 | 46.7 | −31.4 | −21.4 | 84.3 | 109.5 | 29.9 | 25.2 | 74.9 | 70.5 | −5.9 | −4.4 |
| Miscellaneous | 29.3 | 40.7 | 38.9 | 11.4 | 37.8 | 22.5 | −40.5 | −15.3 | 41.0 | 52.0 | 26.8 | 11.0 | 40.8 | 38.0 | −6.9 | −2.8 |
| Snacks | 78.7 | 100.1 | 27.2 | 21.4 | 102.5 | 61.3 | −40.2 | −41.2 | 112.9 | 141.7 | 25.5 | 28.8 | 108.0 | 110.9 | 2.7 | 2.9 |
| Water | 3.6 | 3.6 | 0 | 0 | 3.5 | 2.5 | −28.6 | −1.0 | 6.4 | 10.2 | 59.4 | 3.8 | 4.9 | 4.7 | −4.1 | −0.2 |
| Restaurants | 553.0 | 679.5 | 22.9 | 126.5 | 792.3 | 517.1 | −41.3 | −2.6 | 581.8 | 769.3 | 32.2 | 187.5 | 710.0 | 699.6 | −1.5 | −10.4 |
| Total | 1041.5 | 1299.7 | 24.8 | 258.2 | 1386.9 | 878.8 | −36.6 | −508.1 | 1210.7 | 1540.5 | 27.2 | 329.8 | 1313.3 | 1300.7 | −1.0 | −12.6 |

**Source:** Numerator, 2019.

**Abbreviations:** abs diff, absolute difference (males compared to females); ads, advertisements; GRP, gross ratings point; rel diff, relative difference (males compared to females).

[a] Analysis based on the 57 selected food classes.

[b] Calculations based on GRPs for children aged 2–17 years.

**TABLE 3**
**Child exposure to food advertisements on the 10 most popular television stations for children 2–17 years, in Vancouver, Calgary, Montréal (English market) and Toronto, by Health Canada Nutrient Profile Model classification and sex, 2019**

| Markets | Ads/person/year[a] | | Relative difference[b], % | Absolute difference[b] |
|---|---|---|---|---|
| | Females | Males | | |
| Vancouver | | | | |
| Healthy | 50.1 | 57.5 | 14.8 | 7.4 |
| Unhealthy | 449.0 | 560.0 | 24.7 | 111.0 |
| Calgary | | | | |
| Healthy | 54.9 | 36.5 | −33.5 | −18.4 |
| Unhealthy | 568.5 | 350.6 | −38.3 | −217.9 |
| Montréal English | | | | |
| Healthy | 53.8 | 68.7 | 27.7 | 14.9 |
| Unhealthy | 559.2 | 693.4 | 24.0 | 134.2 |
| Toronto | | | | |
| Healthy | 49.6 | 44.6 | −10.1 | −5.0 |
| Unhealthy | 593.7 | 601.9 | 1.4 | 8.2 |

**Abbreviations:** ads, advertisements; GRP, gross ratings point.

[a] Calculations based on GRPs for children aged 2–17 years.

[b] Males compared to females.

males viewing 42.8% or 38.5 fewer ads/person/year relative to females. At −190.9 ads/person/year, calls to action, a technique designed to motivate the audience to take a desired action, had the largest negative difference in absolute terms for males compared to females.

The greatest relative difference between males and females in the Montréal English market was for teen incentives, where male exposure was 37.1% higher than females' exposure, while the greatest absolute difference was for calls to action (133.4 ads/person/year). In Toronto, male exposure to advertisements using licensed characters was 44.7% or 2.1 ads/person/year higher than females' exposure. Compared to females, males were less exposed to advertisements for parent–child situations (−6.9%, −15.8 ads/person/year).

## Discussion

Overall, children were exposed to high levels of food advertising on television, and sex differences were apparent. Compared to females, males in Vancouver and Montréal were exposed to a greater number of unhealthy food advertisements, while the opposite was found in Calgary.

### *Frequency and healthfulness of exposures*

Males were exposed to an average of 859 to 1494 and females to an average of 1016 to 1354 food advertisements on the 10 television stations most popular with those aged 2 to 17 years old in 2019. Within each market, both sexes were most exposed to restaurant advertising, including fast-food and sit-down restaurants, where food is typically high in sugar, fat and sodium.[35,36] The ubiquity of restaurant advertising is problematic given that the overconsumption of these foods can lead to the development of chronic diseases, and current consumption by Canadian children is high.[37] Our sample was also exposed to significantly more food advertisements classified as unhealthy, which is consistent with Canadian and international research.[17-28,38,39] Taken together, these findings are of concern given the demonstrated relationship between exposure to food advertising and children's dietary preferences, food intake and food purchase requests.[7,8] The volume of unhealthy food advertising children and adolescents view likely has a negative impact on their eating patterns and dietary choices, demonstrating a need for more stringent policies protecting them from unhealthy food advertising.[5-7]

### *Sex differences in frequency and healthfulness*

Compared to females, males in Vancouver and the Montréal English markets were exposed to between 24.5% and 27.3% more food advertisements and between 24.0% and 24.7% more advertisements for unhealthy foods on television. These results are congruent with those of Castronuovo et al.[15]; this scoping review of food marketing and gender in youth found that, compared to girls, boys were more frequently exposed to food and beverage advertisements.[15] Although the review examined gender, the authors noted that most studies conflate sex and gender.

Experimental research indicates that food advertising influences boys' food preferences and immediate intake of food more than that of girls.[40] Males' greater exposures to food marketing in some Canadian cities may be attributed to their higher television viewership.[16] Another possibility is that food and beverage companies specifically target males via unhealthy food products. Food marketers understand the television-viewing patterns of consumers and may be trying to maintain their grip on existing customers, while broadening their appeal to other consumers based on sex. The sex differences between cities may indicate food and beverage companies utilizing different strategies in different cities or may be attributable to males' and females' different viewership patterns.

### *Sex differences in marketing techniques*

In this study, we found sex differences in marketing techniques, particularly in the Vancouver and Montréal English markets.

**TABLE 4**
**Child exposure to food advertisements on the 10 most popular television stations for children 2–17 years, in Vancouver, Calgary, Montréal (English market) and Toronto, by marketing technique and sex, 2019**

| Marketing technique | Vancouver | | | | Calgary | | | | Montréal English | | | | Toronto | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ads/person/year[a] | | Rel diff, % | Abs diff | Ads/person/year[a] | | Rel diff, % | Abs diff | Ads/person/year[a] | | Rel diff, % | Abs diff | Ads/person/year[a] | | Rel diff, % | Abs diff |
| | Female | Male | | | Female | Male | | | Female | Male | | | Female | Male | | |
| Child actor | 206.2 | 262.9 | 27.5 | 56.7 | 284.4 | 168.9 | −40.6 | −115.5 | 271.8 | 334.2 | 23.0 | 62.4 | 282.5 | 275.3 | −2.5 | −7.2 |
| Child-appealing product | 346.6 | 435.0 | 25.5 | 88.4 | 456.1 | 275.3 | −39.6 | −180.8 | 450.1 | 531.1 | 18.0 | 81.0 | 423.5 | 438.1 | 3.4 | 14.6 |
| Child-appealing characters | 263.3 | 321.9 | 22.3 | 58.6 | 351.0 | 218.6 | −37.7 | −132.4 | 326.6 | 390.9 | 19.7 | 64.3 | 336.5 | 343.9 | 2.2 | 7.4 |
| Child language | 58.2 | 73.2 | 25.8 | 15 | 90.0 | 51.5 | −42.8 | −38.5 | 88.9 | 92.6 | 4.2 | 3.7 | 81.5 | 88.4 | 8.5 | 6.9 |
| Child-appealing special effects | 304.4 | 372.9 | 22.5 | 68.5 | 391.1 | 241.2 | −38.3 | −149.9 | 365.1 | 442.5 | 21.2 | 77.4 | 368.0 | 372.0 | 1.1 | 4.0 |
| Child themes | 136.6 | 167.1 | 22.3 | 30.5 | 167.5 | 101.7 | −39.3 | −65.8 | 179.5 | 196.4 | 9.4 | 16.9 | 173.2 | 189.2 | 9.2 | 16.0 |
| Use of spokes-characters | 197.2 | 250.7 | 27.1 | 53.5 | 266.8 | 160.8 | −39.7 | −106 | 261.1 | 309.0 | 18.3 | 47.9 | 249.3 | 258.6 | 3.7 | 9.3 |
| Use of licensed characters | 4.6 | 6.1 | 32.6 | 1.5 | 4.6 | 3.1 | −32.6 | −1.5 | 6.3 | 6.1 | −3.2 | −0.2 | 4.7 | 6.8 | 44.7 | 2.1 |
| Cross-promo-tions | 19.2 | 22.3 | 16.1 | 3.1 | 27.0 | 20.4 | −24.4 | −6.6 | 20.8 | 26.3 | 26.4 | 5.5 | 32.3 | 31.5 | −2.5 | −0.8 |
| Child incentives | 12.2 | 14.5 | 18.9 | 2.3 | 16.2 | 10.2 | −37.0 | −6.0 | 16.5 | 15.5 | −6.1 | −1.0 | 18.3 | 18.5 | 1.1 | 0.2 |
| Teen actor | 140.9 | 169.7 | 20.4 | 28.8 | 191.9 | 119.7 | −37.6 | −72.2 | 180.0 | 221.6 | 23.1 | 41.6 | 170.3 | 171.2 | 0.5 | 0.9 |
| Teen language | 17.4 | 21.5 | 23.6 | 4.1 | 29.1 | 18.1 | −37.8 | −11 | 30.2 | 29.3 | −3.0 | −0.9 | 30.2 | 37.6 | 24.5 | 7.4 |
| Teen music | 32.9 | 38.5 | 17.0 | 5.6 | 51.3 | 29.7 | −42.1 | −21.6 | 52.3 | 52.7 | 0.8 | 0.4 | 48.9 | 59.0 | 20.7 | 10.1 |
| Teen themes | 195.4 | 233.1 | 19.3 | 37.7 | 271.6 | 176.6 | −35.0 | −95 | 241.1 | 291.5 | 20.9 | 50.4 | 251.4 | 263.7 | 4.9 | 12.3 |
| Teen incentives | 5.2 | 5.7 | 9.6 | 0.5 | 10.6 | 7.5 | −29.2 | −3.1 | 8.9 | 12.2 | 37.1 | 3.3 | 7.9 | 8.8 | 11.4 | 0.9 |
| Teen humour | 28.9 | 34.7 | 20.1 | 5.8 | 45.1 | 27.5 | −39.0 | −17.6 | 42.9 | 49.4 | 15.2 | 6.5 | 38.5 | 42.8 | 11.2 | 4.3 |
| Contest/ sweepstakes | 29.9 | 34.2 | 14.4 | 4.3 | 39.5 | 26.8 | −32.2 | −12.7 | 34.3 | 43.5 | 26.8 | 9.2 | 48.4 | 48.0 | −0.8 | −0.4 |
| Celebrity endorsement | 37.3 | 41.3 | 10.7 | 4 | 46.0 | 32.1 | −30.2 | −13.9 | 50.6 | 67.9 | 34.2 | 17.3 | 66.2 | 68.3 | 3.2 | 2.1 |
| Parent–child situations | 176.4 | 223.6 | 26.8 | 47.2 | 232.1 | 140.4 | −39.5 | −91.7 | 219.9 | 291.0 | 32.3 | 71.1 | 227.8 | 212.0 | −6.9 | −15.8 |
| Health appeal | 347.6 | 440.9 | 26.8 | 93.3 | 459.6 | 287.6 | −37.4 | −172 | 372.4 | 470.2 | 26.3 | 97.8 | 404.3 | 405.9 | 0.4 | 1.6 |
| Price promotion | 280.0 | 334.9 | 19.6 | 54.9 | 364.3 | 242.2 | −33.5 | −122.1 | 285.4 | 364.2 | 27.6 | 78.8 | 357.6 | 356.1 | −0.4 | −1.5 |
| Calls to action | 380.5 | 470.7 | 23.7 | 90.2 | 540.5 | 349.6 | −35.3 | −190.9 | 424.0 | 557.4 | 31.5 | 133.4 | 485.4 | 481.9 | −0.7 | −3.5 |

**Abbreviations:** abs diff, absolute difference (males compared to females); ads, advertisements; GRP, gross ratings point; rel diff, relative difference (males compared to females).

[a] Calculations based on GRPs for children aged 2–17 years.

Although differences between sexes were seen across all food marketing techniques, compared to females, males in these two markets were exposed to between 90.2 and 133.4 more calls to action, between 93.3 and 97.8 more health appeals and between 81.0 and 88.4 more child-appealing products (because of the type/nature of the product, e.g. its shape, colour and/or design). Calls to action may encourage children to access food company websites, buy an item or engage with interactive content, such as advergames, surveys and polls[41]. This technique is of concern given children's and adolescents' attraction to online spaces and the amount of time they spend online.[42] Our results show that males in Vancouver and the Montréal English market were exposed to more health appeals that are attractive to children[43] and may be misleading them into thinking a product is healthy; this is troubling given males' greater intake of ultra-processed foods compared to females' intake.[4]

Marketing techniques create appealing, relatable content that captures a viewer's attention through gender roles and stereotypes or other characteristics.[44] For example, a 2019 Rudd Center for Food Policy and Obesity report stated that food advertising directed at ethnic minorities is on the rise, and that advertising that is created for and directed at specific ethnic groups has negative health impacts, particularly among minority ethnic groups.[45] This form of targeted marketing is a

public health issue, as it propagates health inequalities.[45] The presence of food advertising targeted at ethnic minorities, combined with our research results, underscores the demographically driven nature of corporate marketing strategies that may lead to negative health outcomes.

Obesity is a result of a plethora of factors, including exposure to unhealthy food advertising via different media and settings.[46] While broadcast television remains an important source of exposure to unhealthy food advertising, children are also exposed to food advertising on digital platforms such as streaming television.[23,47] This is worrisome as digital advertising can be targeted to specific viewers using behavioural targeting; it is also cost-effective and more difficult to regulate.[42] Future research should consider examining children's and adolescents' exposure to food advertising on streaming services, by sex, particularly as many such services now offer cheaper subscriptions that include advertising content.[47]

### *Strengths and limitations*

This study has several limitations. First, we were confined to Numerator's method of measuring advertising exposure. For example, Numerator's GRP data record exposure to a maximum of three products per advertisement. Any advertisement featuring four or more products was limited to a weighting multiplier of 3. Second, the unit of analysis we used in this paper was based on the GRP of advertisements, which is a measure used by advertisers to determine the reach of an advertisement. Because GRPs represent the proportion of an audience in the population that viewed advertisements and are not an individual-level measure of exposure, we were unable to perform any statistical tests.

Third, we were unable to examine sex differences in exposure of children aged 2 to 11 years and adolescents aged 12 to 17 separately as sample sizes were too small for reliable viewership estimates. In addition, while the use of gender-based targeting is a known practice, this study could not establish whether the sex differences observed in exposure to marketing techniques stem from targeting by food companies or from differential television-viewing habits, as male children in Canada watch more television compared to female children.[16] Further, we recorded the presence of various characters or endorsers (e.g. child actors, celebrities) in food advertising, but did not record their sex or gender; doing so would have provided greater insight into the targeted audience of advertisements.

Fourth, this study did not include all food categories or television stations monitored by Numerators and/or Numeris. Our findings only apply to the 57 food categories and the 10 stations we examined in this study. Fifth, sex and gender are often conflated. Sex was the variable we used for this study; however, it is likely that food companies target individuals based on gender stereotypes, that is, social constructs rather than biological sex. Additional research exploring gender could provide greater insights into how food companies target children and adolescents.

Lastly, nutritional information was missing for 52% of advertisements. Missing data were largely due to brand advertising and high numbers of restaurant products for which nutritional information was unavailable.

Despite limitations, this is the first Canadian study to explore sex differences in children's and adolescents' exposure to food advertisements on television, using a full year of data, to eliminate seasonal bias, and across four major markets in Canada's most populous provinces.

## Conclusion

Television is a powerful source of exposure to unhealthy food advertising for children and sex differences are evident in some regions. Though research is needed in more media and other settings, public health authorities designing policies that restrict food advertising to children need to consider that some groups may be more vulnerable to unhealthy food marketing and its health impact. Monitoring of television advertising to children and adolescents would benefit from sex- and gender-based analysis so that effective policies can be designed to protect males and females equally.

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## Conflicts of interest

In 2018, EP received a small honorarium from the Stop Marketing to Kids Coalition, a coalition of non-governmental health organizations, for reviewing policy recommendations and supporting evidence. In 2020, EP and JSG were employed by Health Canada, on a casual basis, to support research into food marketing in Canada. EP is supported by the Canada Graduate Scholarship to Honour Nelson Mandela awarded by CIHR.

All other authors have no conflicts of interest.

## Authors' contributions and statement

MPK – Funding acquisition; MPK and JSG – Conceptualization, Methodology; JSG – Project administration; MPK – Supervision; JSG, MW, JSG, MB, DW, EP, LR, MP, LV, CM and ML – Data curation; JSG – Data analyses; MPK – Data interpretation; MPK, AA, JSG, EP, AO and LR – Writing – Original draft; All authors – Review and editing. All authors read and approved the final manuscript.

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

## References

1. Fryar CD, Carroll MD, Afful J. Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2–19 years: United States, 1963–1965 through 2017–2018 [Internet]. Washington (DC): NCHS Health E-Stats; 2020 Dec [revised 2021 Jan 29; cited 2022 Mar 08]. Available from: https://www.cdc.gov/nchs/data/hestat/obesity-child-17-18/overweight-obesity-child-H.pdf

2. Rao DP, Kropac E, Do MT, Roberts KC, Jayaraman GC. Childhood overweight and obesity trends in Canada. Health Promot Chronic Dis Prev Can. 2016;36(9):194-8. https://doi.org/10.24095/hpcdp.36.9.03

3. Statistics Canada. Measured children and youth body mass index (BMI) (World Health Organization classification), by age group and sex, Canada and provinces, Canadian Community Health Survey – Nutrition: Table 13-10-0795-01 [Internet]. Ottawa (ON): Statistics Canada; 2017 [cited 2022 Mar 10]. Available from: https://doi.org/10.25318/1310079501-eng

4. Polsky JY, Moubarac J-C, Garriguet D. Consumption of ultra-processed foods in Canada. Health Rep. 2020;31(11):3-15. https://doi.org/10.25318/82-003-x202001100001-eng

5. Boyland E, McGale L; Safe, Healthy and Sustainable Diet Unit of the Department of Nutrition and Food Safety. Food marketing exposure and power and their associations with food-related attitudes, beliefs, and behaviours: a narrative review. Geneva (CH): World Health Organization; 2022. Licence: CC BY-NC-SA 3.0 IGO.

6. Sadeghirad B, Duhaney T, Motaghipisheh S, Johnston BC. Influence of unhealthy food and beverage marketing on children's dietary intake and preference: a systematic review and meta-analysis of randomized trials. Obes Rev. 2016;17(10):945-59. https://doi.org/10.1111/obr.12445

7. Smith R, Kelly B, Yeatman H, Boyland E. Food marketing influences children's attitudes, preferences and consumption: a systematic critical review. Nutrients. 2019;11(4):875. https://doi.org/10.3390/nu11040875

8. Packer J, Croker H, Goddings AL, et al. Advertising and young people's critical reasoning abilities: systematic review and meta-analysis. Pediatrics. 2022;150(6):e2022057780. https://doi.org/10.1542/peds.2022-057780

9. Ogle AD, Graham DJ, Lucas-Thompson RG, Roberto CA. Influence of cartoon media characters on children's attention to and preference for food and beverage products. J Acad Nutr Diet. 2017;117(2):265-70.e2. https://doi.org/10.1016/j.jand.2016.08.012

10. Bragg MA, Roberto CA, Harris JL, Brownell KD, Elbel B. Marketing food and beverages to youth through sports. J Adolesc Health. 2018;62(1):5-13. https://doi.org/10.1016/j.jadohealth.2017.06.016

11. Harris JL, Yokum S, Fleming-Milici F. Hooked on junk: emerging evidence on how food marketing affects adolescents' diets and long-term health. Curr Addict Rep. 2021;8:19-27. https://doi.org/10.1007/s40429-020-00346-4

12. Harris JL. Targeted food marketing to Black and Hispanic consumers: the tobacco playbook. Am J Public Health. 2022;110(3):271-2. https://doi.org/10.2105/AJPH.2019.305518

13. Fleming-Milici F, Harris JL. Television food advertising viewed by preschoolers, children and adolescents: contributors to differences in exposure for black and white youth in the United States. Pediatr Obes. 2018;13(2):103-10. https://doi.org/10.1111/ijpo.12203

14. Weitzman M, Lee L. Similarities between alcohol and tobacco advertising exposure and adolescent use of each of these substances. J Stud Alcohol Drugs Suppl. 2022;Sup 19 (Suppl 19):97-105. https://doi.org/10.15288/jsads.2020.s19.97

15. Castronuovo L, Guarnieri L, Tiscornia MV, Allemandi L. Food marketing and gender among children and adolescents: a scoping review. Nutr J. 2021;20(1):52. https://doi.org/10.1186/s12937-021-00706-4

16. Canadian Radio-television and Telecommunications Commission. Communications monitoring report: 2019 [Internet]. Ottawa (ON): CRTC; 2020 [modified 2020 Jan 21; cited 2022 Mar 08]. Available from: https://crtc.gc.ca/eng/publications/reports/policymonitoring/2019/cmr6.htm

17. Kelly B, Vandevijvere S, Ng S, et al. Global benchmarking of children's exposure to television advertising of unhealthy foods and beverages across 22 countries. Obes Rev. 2019;20(S2):116-28. https://doi.org/10.1111/obr.12840

18. Russell SJ, Croker H, Viner RM. The effect of screen advertising on children's dietary intake: a systematic review and meta-analysis. Obes Rev. 2019;20(4):554-68. https://doi.org/10.1111/obr.12812

19. Gibeau E. Junk food advertising in Canada: how should it be regulated? Montréal (QC); Union des consommatuers; 2019. https://uniondesconsommateurs.ca/wp-content/uploads/2020/01/811414-Rapport-malbouffe-V2.1-eng.pdf

20. Office de la Protection du Consommateur. Advertising directed at children under 13 years of age: guide to the application of Sections 248 and 249 Consumer Protection Act. Québec City (QC): OPC; 2012. https://cdn.opc.gouv.qc.ca/media/documents/consommateur/sujet/publicite-pratique-illegale/EN_Guide_publicite_moins_de_13_ans_vf.pdf

21. Potvin Kent M, Dubois L, Wanless A. Food marketing on children's television in two different policy environments. Int J Pediatr Obes. 2011;6(2-2):e433-41. https://doi.org/10.3109/17477166.2010.526222

22. Potvin Kent M, Smith JR, Pauzé E, L'Abbé M. The effectiveness of the food and beverage industry's self-established uniform nutrition criteria at improving the healthfulness of food advertising viewed by Canadian children on television. Int J Behav Nutr Phys Act. 2018;15(1):57. https://doi.org/10.1186/s12966-018-0694-0

23. Potvin Kent M, Hatoum F, Wu D, Remedios L. Benchmarking unhealthy food marketing to children and adolescents in Canada: a scoping review. Health Promot Chronic Dis Prev Can. 2022;42(8):307-8. https://doi.org/10.24095/hpcdp.42.8.01

24. Stop Marketing to Kids Coalition. What are other countries doing? [Internet]. Ottawa (ON): Heart and Stroke Foundation of Canada; 2016 [cited 2022 Mar 08]. Available from: https://stopmarketingtokids.ca/what-are-other-countries-doing/

25. Pinto A, Pauzé E, Mutata R, Roy-Gagnon MH, Potvin Kent M. Food and beverage advertising to children and adolescents on television: a baseline study. Int J Environ Res Public Health. 2020;17(6):1999. https://doi.org/10.3390/ijerph17061999

26. Pinto A, Pauzé E, Roy-Gagnon MH, Dubois L, Potvin Kent M. The targeting of preschoolers, children, adolescents and adults by the Canadian food and beverage industry on television: a cross-sectional study. Appl Physiol Nutr Metab. 2021;46(6):651-60. https://doi.org/10.1139/apnm-2020-0621

27. Czoli CD, Pauzé E, Potvin Kent M. Exposure to food and beverage advertising on television among Canadian adolescents, 2011 to 2016. Nutrients. 2020;12(2):428. https://doi.org/10.3390/nu12020428

28. Pauzé E, Potvin Kent M. Children's measured exposure to food and beverage advertising on television in Toronto (Canada), May 2011-May 2019. Can J Public Health. 2021;112(6):1008-19. https://doi.org/10.17269/s41997-021-00528-1

29. Pauzé E, Remedios L, Potvin Kent M. Children's measured exposure to food and beverage advertising on television in a regulated environment, May 2011-2019. Public Health Nutr. 2021;24(17):5914-26. https://doi.org/10.1017/S1368980021001373

30. Potvin Kent M, Soares Guimaraes J, Bagnato M, et al. Broadcast television is not dead: exposure of children to unhealthy food advertising on television in two policy environments (Ontario and Quebec). An observational study. J Nutr. 2023;153(1):268-78. https://doi.org/10.1016/j.tjnut.2022.09.002

31. Mulligan C, Potvin Kent M, Christoforou AK, L'Abbé MR. Inventory of marketing techniques used in child-appealing food and beverage research: a rapid review. Int J Public Health. 2020;65(7):1045-55. https://doi.org/10.1007/s00038-020-01444-w

32. Health Canada. Guide to the application of the Child Health Protection Act (Bill S-228). 2018.

33. Vergeer L, Franco-Arellano B, Tjong GB, Bernstein JT, L'Abbé MR. The level of processing, nutritional composition and prices of Canadian packaged foods and beverages with and without gluten-free claims. Nutrients. 2021;13(4):1183. https://doi.org/10.3390/nu13041183

34. Murphy SA, Weippert MV, Dickinson KM, Scourboutakos MJ, L'Abbé MR. Cross-sectional analysis of calories and nutrients of concern in Canadian chain restaurant menu items in 2016. Am J Prev Med. 2020;59(4):e149-59. https://doi.org/10.1016/j.amepre.2020.05.005

35. Semnani-Azad Z, Scourboutakos MJ, L'Abbé MR. Kids' meals from chain restaurants are exceedingly high in calories, fats, and sodium: a cross-sectional study. BMC Nutr. 2016;2(1):16. https://doi.org/10.1186/s40795-016-0056-8

36. Scourboutakos MJ, Semnani-Azad Z, L'Abbé MR. Added sugars in kids' meals from chain restaurants. Prev Med Rep. 2014;3:391-3. https://doi.org/10.1016/j.pmedr.2014.11.003

37. Moubarac JC. Ultra-processed foods in Canada: consumption, impact on diet quality and policy implications. Montréal (QC): TRANSNUT, University of Montréal; 2017 [cited 2022 Mar 08]. Available from: https://www.heartandstroke.ca/-/media/pdf-files/canada/media-centre/hs-report-upp-moubarac-dec-5-2017.ashx

38. Gallus S, Borroni E, Stival C, et al. Food advertising during children's television programmes in Italy. Public Health Nutr. 2021;24(14):4663-70. https://doi.org/10.1017/S1368980020004693

39. Missbach B, Weber A, Huber EM, König JS. Inverting the pyramid! Extent and quality of food advertised on Austrian television. BMC Public Health. 2015;15(1):910. https://doi.org/10.1186/s12889-015-2275-3

40. Chernin A. The effects of food marketing on children's preferences: testing the moderating roles of age and gender. Ann Am Acad Pol Soc Sci. 2008;615(1):101-18. https://doi.org/10.1177/0002716207308952

41. Oltra I, Camarero C, San Jose Cabezudo R. Inspire me, please! The effect of calls to action and visual executions on customer inspiration in Instagram communications. Int J Advert. 2022;41(7):1209-34. https://doi.org/10.1080/02650487.2021.2014702

42. World Health Organization. Tackling food marketing to children in a digital world: trans-disciplinary perspectives; children's rights, evidence of impact, methodological challenges, regulatory options and policy implications for the WHO European Region. Copenhagen (DK): WHO Regional Office for Europe; 2016. https://apps.who.int/iris/handle/10665/344003

43. Mulligan C, Potvin Kent M, Vergeer L, Christoforou AK, L'Abbé MR. Quantifying child-appeal: the development and validation of a methodology for evaluating child appealing marketing on product packaging. Int J Environ Res Public Health. 2021;18(9):4769. https://doi.org/10.3390/ijerph18094769

44. Ward LM, Grower P. Media and the development of gender role stereotypes. Annu Rev Dev Psychol. 2020;2(1):177-99. https://doi.org/10.1146/annurev-devpsych-051120-010630

45. Harris JL, Frazier W, Kumanyika S, Ramirez AG. Increasing disparities in unhealthy food advertising targeted to Hispanic and Black youth. Storrs (CT): Rudd Center for Food Policy & Obesity, University of Connecticut; 2019. http://uconnruddcenter.org/files/Pdfs/TargetedMarketingReport2019.pdf

46. Huang TT, Drewnosksi A, Kumanyika S, Glass TA. A systems-oriented multilevel framework for addressing obesity in the 21st century. Prev Chronic Dis. 2009;6(3):A82.

47. Hill S. Ads are taking over streaming, and I can't afford to look away [Internet]. Wired. 2022 Aug 19 [cited 2022 Mar 08]; Gear. Available from: https://www.wired.com/story/advertising-services-devices-rant/

https://doi.org/10.24095/hpcdp.43.5.03

# Original quantitative research

# Using classification and regression trees to model missingness in youth BMI, height and body mass data

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This article has been peer reviewed.



## Abstract

**Introduction:** Research suggests that there is often a high degree of missingness in youth body mass index (BMI) data derived from self-reported measures, which may have a large effect on research findings. The first step in handling missing data is to examine the levels and patterns of missingness. However, previous studies examining youth BMI missingness used logistic regression, which is limited in its ability to discern subgroups or identify a hierarchy of importance for variables, aspects that may go a long way in helping understand missing data patterns.

**Methods:** This study used sex-stratified classification and regression tree (CART) models to examine missingness in height, body mass and BMI data among 74 501 youth participating in the 2018/19 COMPASS study (a prospective cohort study examining health behaviours among Canadian youth), where 31% of BMI data were missing. Diet, movement, academic, mental health and substance use variables were examined for associations with missingness in height, body mass and BMI.

**Results:** CART models indicated that the combination of being younger, having a self-perception of being overweight, being less physically active and having poorer mental health yielded female and male subgroups highly likely to be missing BMI values. Survey respondents who did not perceive themselves as overweight and who were older were unlikely to be missing BMI values.

**Conclusion:** The subgroups identified by the CART models indicate that a sample that deletes cases with missing BMI would be biased towards physically, emotionally and mentally healthier youth. Given the ability of CART models to identify these subgroups and a hierarchy of variable importance, they are an invaluable tool for examining missing data patterns and appropriate handling of missing data.

***Keywords:*** *missing data, decision trees, overweight, obesity, adolescents*

### *Highlights*

- Almost one-third (31%) of the 74 501 youth participating in the COMPASS study in 2018/19 were missing body mass index (BMI) values.
- Missing weight values were more prevalent among female youth than among male youth.
- Social desirability likely plays a large role in youth not reporting their height and weight.
- Classification and regression tree models are useful in identifying important subgroups with missing data.

## Introduction

### *Missing data in overweight and obesity literature*

As one of the strongest predictors of chronic diseases,[1] overweight and obesity (OWOB) remains one of the top health concerns globally. Many studies that examine OWOB use body mass index (BMI) derived from self-reported measures of height and body mass to provide a proxy measure of body adiposity. Self-reported measures are usually less accurate than direct anthropomorphic measurements—individuals tend to underreport their body mass and overreport their height[2-5]—but self-reporting is generally more feasible (logistically and financially) than other approaches to population surveillance,[3-5] and these measures are useful in the appropriate context where the limitations of the data are understood.

A less-discussed methodological issue associated with self-reported height and body mass is nonresponse (i.e. missing data). Among youth, who are a primary target in the OWOB prevention literature, large proportions (sometimes over 50%) of self-reported height and body mass data tend to be missing.[6,7] If data are missing completely at random (MCAR), the probability of missingness depends neither on the hypothetical true value of the missing variable (i.e. what the value would be if it *was* reported), nor on any observed covariates. But if data are missing at random (MAR) or not missing at random (NMAR), the probability of missingness depends on observed covariates (for missing at random) and/or the hypothetical true value of the missing variable

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(for not missing at random). Deleting these missing cases (a method called complete case analysis) is a problematic approach, particularly for the last two mechanisms, as it leads to statistical bias.[8] For example, if data are missing at random because younger youth are more likely to neglect reporting their weight, the sample is biased towards older individuals (and then, logically, heavier ones, given child growth patterns).

This introduction of statistical bias as a result of deleting cases has also been proven through numerous simulation studies; it is particularly prominent when there is a large proportion of non-random missingness.[8,9] Despite this, complete case analysis remains the most common approach in epidemiological literature.[10,11] The high degree of missingness in youth self-reported height and body mass data raises concerns about how methods take into account missing data and how mishandling of missing data affects research findings as well as concomitant policy and programming recommendations.

Statistical approaches are often required to deal with missing data; while researchers should follow best practices in survey design, in many cases there may be little they can do to improve reporting patterns.[12,13] Although sophisticated statistical approaches to handling large proportions of non-random missingness are available, they generally require more time and expertise, which may be a barrier to their overall use. That being said, an important initial step towards selecting a reasonable and practical method for handling missing data is understanding the extent and patterns of missingness in a dataset. This is important to understand potential sources of nonreporting bias, but may also be a necessary step to identify inputs for certain missing data approaches (e.g. multiple imputation). Identifying various sources of missingness is especially important in large datasets with many variables, as methods for handling missingness can become exponentially complicated. Moreover, given that missingness is generally unique to studies, there is no clear framework for the process for identifying sources or mechanisms of missingness.

### *Regression approaches*

Research examining BMI or body mass missingness has used regression approaches[6,7,14] where the outcome of a logistic regression is missing versus not missing, and other variables are examined for their potential association with the likelihood of missingness. However, regression approaches may not be ideal in this situation because missingness models may be more complex than a simplistic regression approach allows. Moreover, the process for variable selection in regression models can be ambiguous. When building a regression model, an initial step to selecting variables might be to review the literature for similar analyses, but the literature in the context of examining BMI missingness is scarce.

Bivariate comparisons are also sometimes used to decide on regression inputs; however, for large datasets with substantial missingness, this may not be useful for elimination purposes as many bivariate associations may be statistically significant. Common model selection procedures, such as the Akaike information criterion (AIC) or the Bayesian information criterion (BIC), can be used to select variables, but these procedures can be challenging in practice: we previously examined BMI, height and body mass missingness using model selection procedures for generalized linear mixed models,[15] but this required many additional modelling decisions and a customized algorithm suitable for pseudo-likelihood methods.[16]

Lastly, where variable selection processes yield a large number of relevant variables, the decision process for what to exclude in order to produce a parsimonious model may not be clear. In such cases, identifying a hierarchy of the importance of variables would be beneficial: it may help with parsimony and clearer interpretation, and it may be a necessary step to employ certain missing data approaches like multiple imputation. Although our previous study added to the literature on missingness in youth BMI, we were unable to identify which variables were most important or identify which combinations of factors were most likely to lead to nonreporting.[15] The limitations associated with a regression approach to examining missing data may be addressed by using a different methodological approach.

### *Decision trees*

Decision trees are a type of machine-learning approach that has been leveraged in applied research, including in public health.[17,18] Decision trees are useful for analyzing primary data and for examining missing data; they can be a solution to some of the variable selection problems described above. Decision trees recursively split the data by predictor variables and can handle large datasets with multiple predictors measured on different scales with relative ease. Once pruned, decision trees present a parsed selection of predictor variables in a hierarchical format, allowing some inference on variable importance. Moreover, decision trees allow important and highly specific subgroups to be identified beyond what would be feasible using interaction terms in a regression model.

In addition, unlike regression, the entire decision tree model can be easily visualized, which may help interpretation. In 2015, Tierney et al.[19] published work demonstrating the utility of using decision trees to examine missing data, but to our knowledge no published studies have leveraged this approach.

The purpose of this study is (1) to add to the limited literature on missing data in youth self-reported height and body mass; (2) to identify potential areas of bias stemming from nonreporting in the youth OWOB domain; and (3) to demonstrate the use of decision trees to model missing data, which builds on the work of Tierney et al.,[19] who first identified the utility of this approach.

## Methods

### *Sample*

This study uses a large cross-sectional dataset from the 2018/19 wave of the COMPASS (Cannabis, Obesity, Mental health, Physical activity, Alcohol, Smoking, Sedentary behaviour) study, a prospective cohort study that collects data on a variety of different health behaviours among youth. The 2018/19 COMPASS wave collected data from 74 501 youth, representing an 84.3% participation rate. COMPASS uses an active-information, passive-consent protocol that yields high participation rates, and non-participation is usually due to absence from school on the data collection day or being in a scheduled spare during the data collection time.

### *Variables*

This study focusses on missingness in BMI values as well as missingness in the

height and body mass variables used to derive BMI. Binary indicators of missingness (i.e. missing vs. not missing) were created for each of these variables. Body mass was recorded based on responses to the question asked of students, "How much do you weigh without your shoes on? (Please write your answer in pounds OR in kilograms, and then fill in the appropriate numbers for your weight.)" Height was similarly recorded in response to the question, "How tall are you without your shoes on? (Please write your height in feet and inches OR in centimetres, and then fill in the appropriate numbers for your height)." BMI is derived by dividing body mass (kg) by height squared ($m^2$).

A benefit of decision tree approaches is the feasibility of including many variables. In this study, we included a variety of diet, movement, academic, mental health and substance use variables. Diet-related variables included number of servings of fruits and vegetables, grain products, meat and alternatives, and milk and alternatives as well as number of days per week when breakfast, energy drinks and fast foods were consumed. Movement-related variables included moderate-to-vigorous physical activity, sports participation (inside or outside of school), strength training, physically active peers, screen time sedentary behaviour (STSB) and sleep.

Academic-related variables included English grade (or French grade, for French language schools), Math grade and truancy. Mental health variables included clinically relevant symptoms of depression (CESD-R-10 scale[20]), anxiety (GAD-7 scale[21]), socio-emotional skills (DERS scale[22]), self-reported well-being (Flourishing scale[23]), self-concept (Self Description Questionnaire II short form[24]), self-rated mental health and reported status as a bullying victim or perpetrator. Substance use–related variables included binge drinking, smoking, e-cigarette use, cannabis use and use of alcohol mixed with energy drinks. Although all these variables were input into analyses, only a subset of variables appeared in the final models.

### Outliers

In some cases, missingness was imposed onto the data. We used the 1.5 × interquartile range (IQR) method to identify statistical outliers, and these cut-offs were considered alongside biological plausibility in order to determine how to handle these cases. We marked as missing weights less than 45 lbs (20 kg) or greater than 390 lbs (177 kg) and height less than 4' (1.22 m) or greater than 6'11" (2.11 m). Sleep and STSB were two variables that had a number of unfeasible outliers in the dataset. Youth who reported regularly sleeping less than 4 hours a night or having a collective STSB greater than 16.25 hours per day were marked as missing. Notably, missingness was only imposed for that particular variable; for example, those who reported less than 4 hours of sleep had their sleep value marked as missing, but all other reported variables remained the same.

### Analysis

We used classification and regression trees (CART) as the approach for this study where the outcome was binary (i.e. missing vs. not missing). All models were stratified by self-reported sex (female, male). Consistent with decision tree approaches,[25] the data were split into training and testing datasets, which contained 80% and 20% of the data, respectively. The training dataset was used to fit the tree, while the testing dataset was used to assess the prediction accuracy of the training tree.

We used cost complexity pruning alongside the one standard error (1-SE) rule[25] to help correct for overfitting and yield a more parsimonious final tree. Decision tree analyses were conducted in R (R Foundation for Statistical Computing, Vienna, AT) using the rpart package, and final pruned trees were visualized using the rattle package. A pre-pruning restriction was set so that final nodes had to contain a minimum number of individuals. The minimum number of individuals in a school for each stratified sample was used to determine these cut-offs; this was 14 for females and 16 for males. Models included individuals with missing covariate data, as CART conveniently handles this by surrogate splitting; if a covariate value is missing, an observed variable with the most similar predictive capacity is used instead.

## Results

### Descriptive statistics

Table 1 shows stratified descriptive statistics for any variable that appeared in at least one of the CART models. Of the whole sample (n = 74 501), 31% were missing BMI values. Height missingness was slightly more prevalent among males (19%) than among females (15%), whereas body mass missingness was slightly more prevalent among females (22%) than among males (20%).

### Interpreting the CART models

Sex-stratified results of the CART models are shown in Figures 1 to 3. Figure 1 presents results for BMI missingness, Figure 2 for body mass missingness and Figure 3 for height missingness. All CART models can be read starting from the root node (node 1) at the top of the tree, which contains all the training data for that particular dataset. Nodes underneath node 1 represent splits in the tree, whereby a split to the left is always a "yes" and a split to right is always a "no"; this applies to continuous and categorical variables. The label and colour of each node, "present" (green) or "missing" (blue), represents the situation that is more probable for data in that node. The shade of colour reflects the probabilities (darker colours indicate higher probability); probabilities are also included in each node, where left side shows the probability of being present, and the right side shows the probability of being missing. Variables that appear higher up the tree (i.e. closer to node 1) and those that appear more often can be considered more relevant criteria than variables that only appear once further down the tree.

For example, in the female BMI missingness CART model (Figure 1), the data are first split by weight perception. If individuals in this sample perceived their weight to be "about right" or underweight, they are in node 2. Node 2 contains 74% of the sample, and in this node the probability of missing BMI values is 0.27. If individuals perceived themselves to be overweight (i.e. the other remaining category for this variable), they are in node 3, which contains 26% of the data and where the probability of missing BMI values is 0.38. Similarly, for continuous variables, cut-offs are identified by the CART models. For example, in the female BMI missingness model the second node indicates that the model determined that 15 years of age was the cut-off that most differentiated the following sub-nodes.

### CART model accuracy

Accuracy testing using the test partition of the dataset showed that all models

**TABLE 1**
**Descriptive statistics of COMPASS study sample, 2018/19 (n = 74 501)**

| Variables[a] | Females (n = 36 546) | Males (n = 37 126) | Total[b] (n = 74 501) |
|---|---|---|---|
| **BMI variables** | | | |
| Mean BMI[c], score (SD) | 20.98 (3.02) | 21.21 (3.24) | 21.10 (3.14) |
| Missing scores, % (n) | 30.35 (11 093) | 31.22 (11 591) | 31.31 (23 329) |
| Mean height, m (SD) | 163.4 (7.50) | 174.2 (10.24) | 168.7 (10.47) |
| Missing, % (n) | 14.88 (5439) | 19.04 (7067) | 17.52 (13 049) |
| Mean body mass, kg (SD) | 57.42 (13.13) | 66.59 (17.74) | 62.16 (16.44) |
| Missing, % (n) | 21.75 (7948) | 19.79 (7348) | 21.33 (15 894) |
| **Age** | | | |
| Mean age, years (SD) | 15.14 (1.50) | 15.18 (1.51) | 15.16 (1.51) |
| Missing, % (n) | 0.08 (31) | 0.19 (69) | 0.73 (541) |
| **Ethnicity[d]** | | | |
| Racialized, % (n) | 69.45 (25 383) | 68.62 (25 477) | 68.48 (51 017) |
| Non-racialized, % (n) | 30.27 (11 063) | 30.99 (11 505) | 30.63 (22 822) |
| Missing, % (n) | 0.27 (100) | 0.39 (144) | 0.89 (662) |
| **Weight perception** | | | |
| Underweight, % (n) | 11.47 (4190) | 21.00 (7795) | 16.30 (12 140) |
| Overweight, % (n) | 25.85 (9448) | 19.93 (7398) | 22.87 (17 038) |
| About right, % (n) | 61.14 (22 343) | 57.19 (21 233) | 58.92 (43 893) |
| Missing, % (n) | 1.55 (565) | 1.89 (700) | 1.92 (1430) |
| **Diet-related variables** | | | |
| Fruit/vegetable consumption (24-hour recall) | | | |
| Mean number of servings, n (SD) | 2.89 (1.89) | 3.06 (2.11) | 2.98 (2.01) |
| Missing, % (n) | 2.44 (890) | 4.74 (1759) | 3.79 (2822) |
| Meat/meat alternatives consumption (24-hour recall) | | | |
| Mean number of servings, n (SD) | 1.88 (1.03) | 2.41 (1.20) | 2.15 (1.15) |
| Missing, % (n) | 2.45 (896) | 4.76 (1766) | 3.80 (2833) |
| Breakfast consumption | | | |
| Mean days per week, n (SD) | 4.67 (2.37) | 5.05 (2.33) | 4.85 (2.36) |
| Missing, % (n) | 1.31 (479) | 2.30 (855) | 1.99 (1484) |
| Grain consumption (24-hour recall) | | | |
| Mean number of servings, n (SD) | 2.41 (1.52) | 2.98 (1.93) | 2.69 (1.77) |
| Missing, % (n) | 2.33 (851) | 4.61 (1711) | 3.67 (2737) |
| Milk/alternatives consumption (24-hour recall) | | | |
| Mean number of servings, n (SD) | 1.77 (1.32) | 2.39 (1.54) | 2.08 (1.47) |
| Missing, % (n) | 2.33 (853) | 4.57 (1697) | 3.66 (2724) |
| Fast-food consumption | | | |
| Mean number of days per week, n (SD) | 1.19 (1.34) | 1.43 (1.61) | 1.31 (1.49) |
| Missing, % (n) | 1.03 (380) | 2.16 (801) | 1.81 (1345) |
| **Movement-related variables** | | | |
| Sports participation | | | |
| Participated in sports, % (n) | 56.70 (20 720) | 62.05 (23 036) | 59.24 (44 135) |
| Did not participate in sports, % (n) | 41.70 (15 241) | 35.25 (13 088) | 38.41 (28 618) |
| Missing, % (n) | 1.60 (585) | 2.70 (1002) | 2.35 (1748) |
| Strength training | | | |
| Mean number of days per week, n (SD) | 2.24 (2.02) | 2.77 (2.27) | 2.51 (2.16) |
| Missing, % (n) | 1.29 (473) | 1.93 (717) | 1.80 (1344) |

**Continued on the following page**

**TABLE 1 (continued)**
**Descriptive statistics of COMPASS study sample, 2018/19 (n = 74 501)**

| Variables[a] | Females (n = 36 546) | Males (n = 37 126) | Total[b] (n = 74 501) |
|---|---|---|---|
| Physically active friends | | | |
| Mean number, n (SD) | 3.03 (1.68) | 3.52 (1.69) | 3.28 (1.71) |
| Missing, % (n) | 1.35 (494) | 2.13 (789) | 1.92 (1430) |
| Screen time sedentary behaviour | | | |
| Mean hours per day, n (SD) | 5.92 (3.35) | 6.37 (3.37) | 6.15 (3.37) |
| Missing, % (n) | 4.41 (1613) | 5.94 (2206) | 5.44 (4056) |
| Moderate-to-vigorous physical activity | | | |
| Mean hours per day, n (SD) | 1.60 (1.23) | 2.00 (1.47) | 1.80 (1.38) |
| Missing, % (n) | 1.87 (683) | 2.56 (949) | 2.39 (1777) |
| Sleep | | | |
| Mean hours per night, n (SD) | 7.47 (1.30) | 7.60 (1.28) | 7.54 (1.29) |
| Missing, % (n) | 7.33 (2679) | 8.92 (3310) | 8.38 (6241) |
| **Academic variables** | | | |
| English grade (or French grade, in the case of French-language schools) | | | |
| Grade < 50%, % (n) | 1.09 (399) | 2.44 (907) | 1.83 (1362) |
| Grade ≥ 50%, % (n) | 95.39 (34 862) | 91.92 (34 128) | 93.41 (69 590) |
| Missing, % (n) | 3.52 (1285) | 5.63 (2091) | 4.76 (3549) |
| **Mental health–related variables** | | | |
| Self-rated mental health | | | |
| Mean score (SD) | 2.76 (1.21) | 2.21 (1.15) | 2.49 (1.21) |
| Missing, % (n) | 3.37 (1230) | 6.05 (2245) | 4.93 (3670) |
| Well-being[e] | | | |
| Mean score (SD) | 31.78 (5.75) | 32.64 (5.60) | 32.19 (5.72) |
| Missing, % (n) | 4.84 (1770) | 6.78 (2518) | 6.02 (4486) |
| Self-concept[f] | | | |
| Mean score (SD) | 11.79 (4.69) | 9.76 (4.19) | 10.79 (4.58) |
| Missing, % (n) | 3.34 (1221) | 5.51 (2045) | 4.64 (3455) |
| **Substance use variables** | | | |
| Smoking | | | |
| In the last 30 days, % (n) | 6.64 (2425) | 8.00 (2969) | 7.43 (5532) |
| Not in the last 30 days, % (n) | 92.89 (33 949) | 91.01 (33 790) | 91.70 (68 320) |
| Missing, % (n) | 0.47 (172) | 0.99 (367) | 0.87 (649) |
| E-cigarette use | | | |
| In the last 30 days, % (n) | 25.48 (9312) | 30.34 (11 264) | 27.99 (20 852) |
| Not in the last 30 days, % (n) | 73.75 (26 951) | 67.98 (25 237) | 70.62 (52 614) |
| Missing, % (n) | 0.77 (172) | 1.68 (625) | 1.39 (1035) |
| Cannabis use | | | |
| In the last 30 days, % (n) | 10.95 (4001) | 14.70 (5458) | 12.97 (9662) |
| Not in the last 30 days, % (n) | 88.06 (32 183) | 83.36 (30 950) | 85.42 (63 637) |
| Missing, % (n) | 1.00 (362) | 2.32 (718) | 1.61 (1202) |

**Abbreviations:** BMI, body mass index; SD, standard deviation.

[a] Only those variables present in at least one of the final classification and regression tree (CART) models.

[b] Includes respondents who did not report sex, so sex-stratified counts may not add up to total counts.

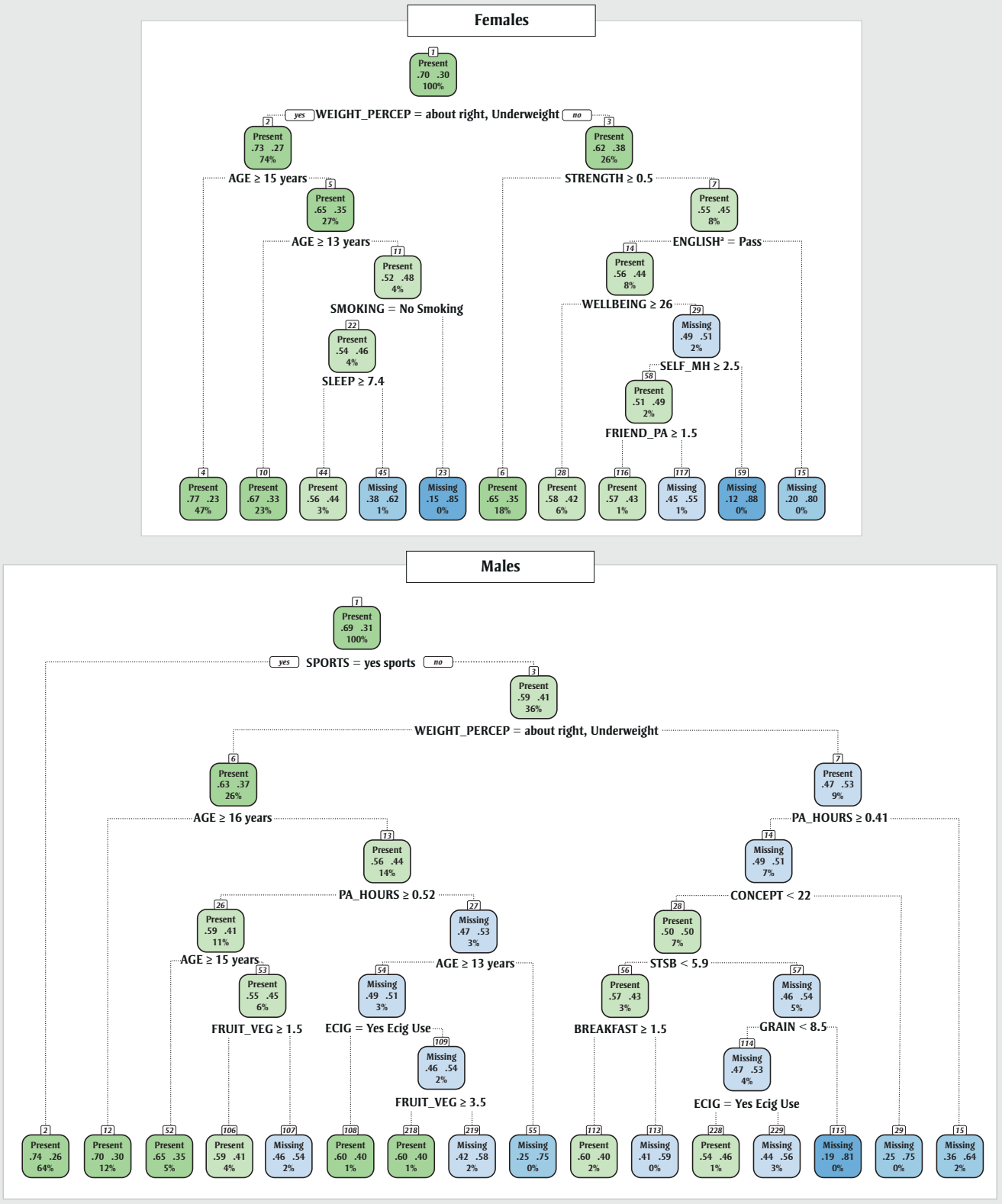
[c] Derived by dividing body mass (kg) by height squared ($m^2$).

[d] The survey question was "How would you describe yourself?" (Select all that apply), with the following response options: White, Black, Asian, Aboriginal (First Nations, Métis, Inuit), Latin American/Hispanic, Other. Respondents who selected "White" were classified as non-racialized, while respondents who selected any other option (including the selection of multiple options) were classified as racialized.

[e] Based on the Flourishing scale.[23]

[f] Based on the Self Description Questionnaire II short form.[24]

**FIGURE 1**
**BMI missingness CART models, for females (n = 36 546) and males (n = 37 126), COMPASS 2018/19**



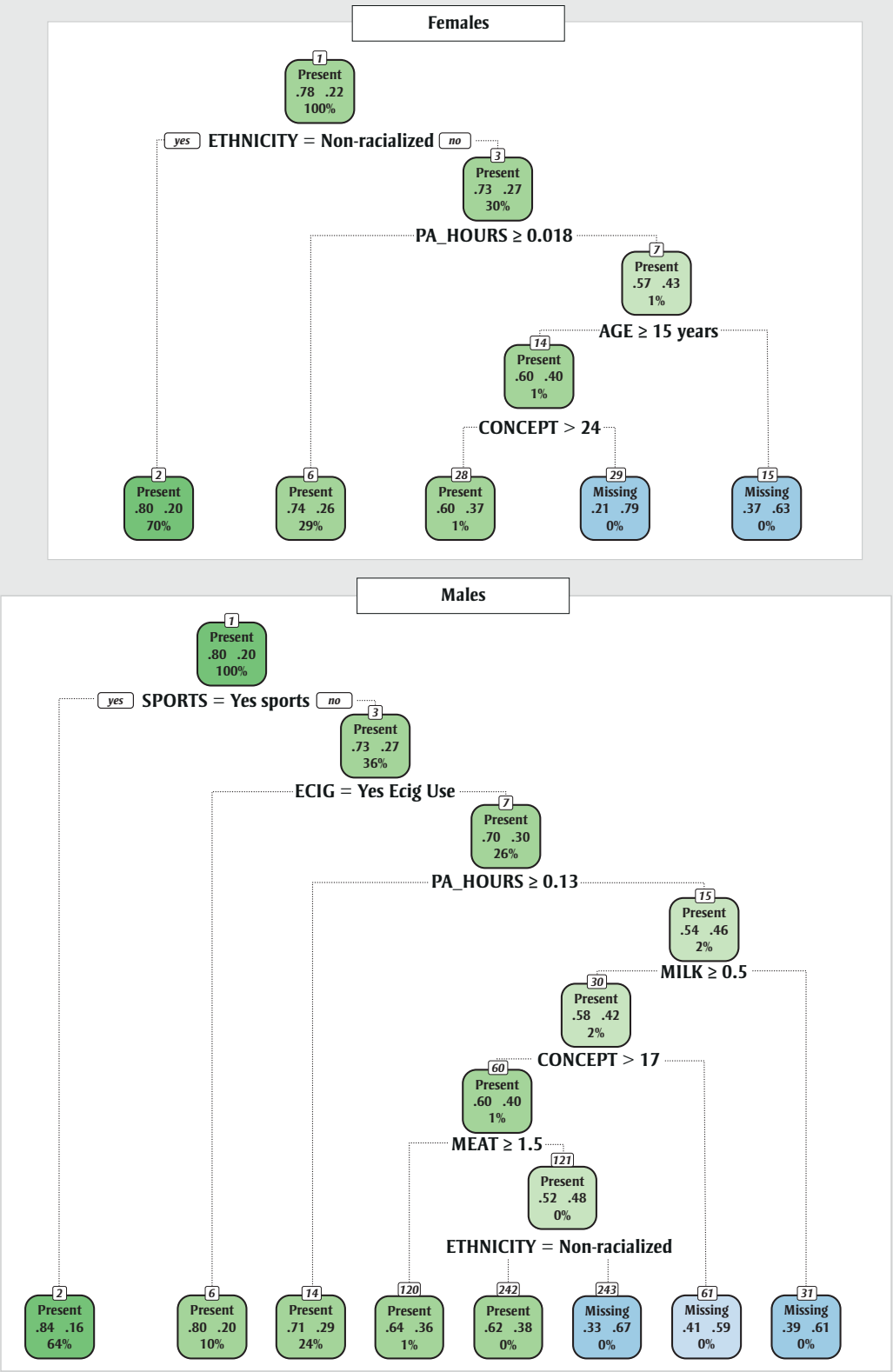

**Abbreviations:** BMI, body mass index; BREAKFAST, breakfast consumption; CART, classification and regression tree; CONCEPT, self-concept (based on the Self Description Questionnaire II short form[24]); ECIG, e-cigarette use; FRIEND_PA, physically active friends; FRUIT_VEG, fruit/vegetable consumption; GRAIN, grain consumption; PA_HOURS, moderate-to-vigorous physical activity; PERCEP, perception; SELF_MH, self-rated mental health; SPORTS, sports participation; STSB, screen time sedentary behaviour.

**Notes:** The label and colour of each node, "present" (green) or "missing" (blue), represents the situation that is more probable for data in that node; darker colours indicate higher probability. The left side of each node shows the probability of being present, and the right side shows the probability of being missing.

% indicates percentage of the sample in that node.

[a] In the case of French-language schools, this is the French grade.

**FIGURE 2**
**Body mass missingness CART models, for females (n = 36 546) and males (n = 37 126), COMPASS 2018/19**



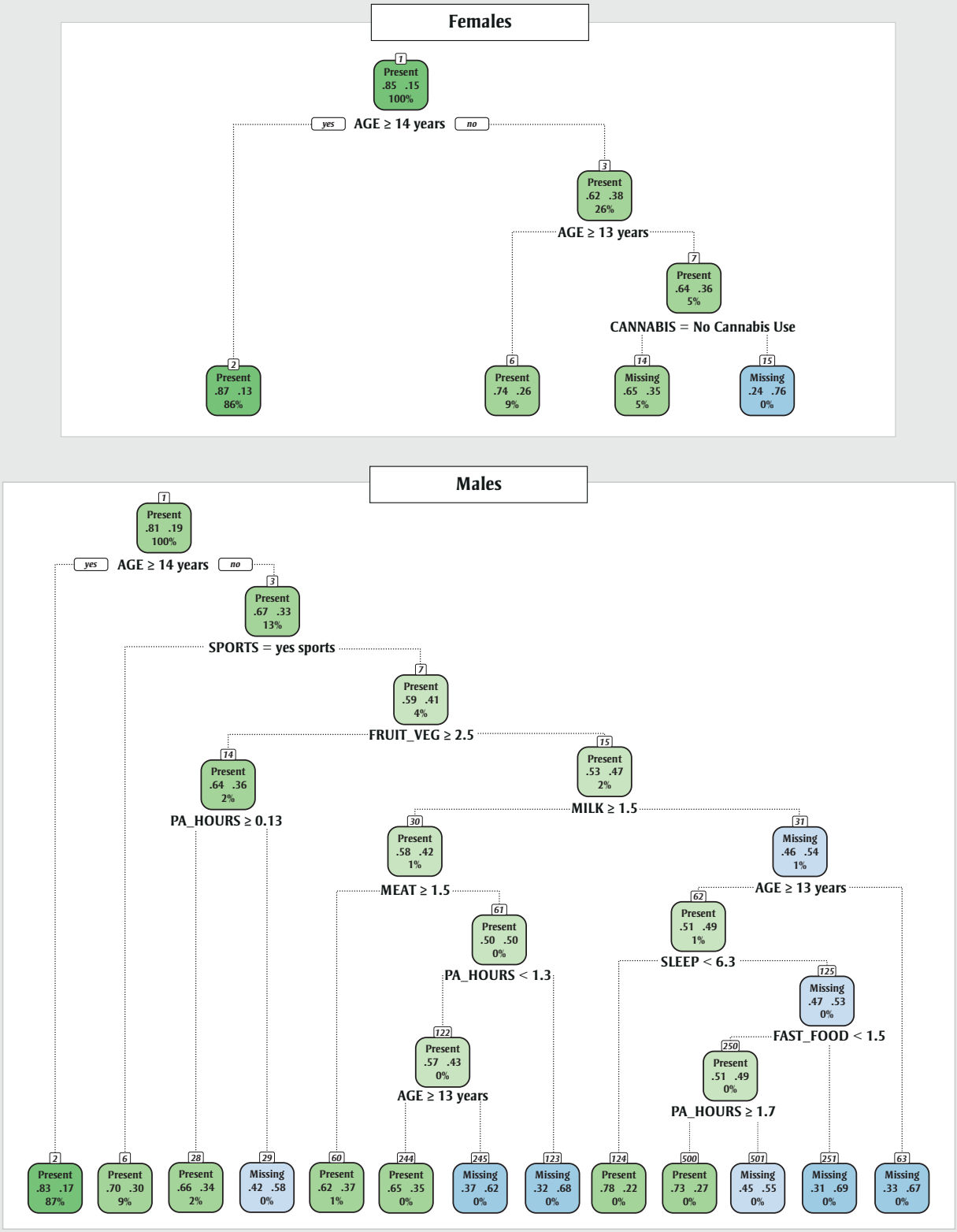

**Abbreviations:** CART, classification and regression tree; CONCEPT, self-concept (based on the Self Description Questionnaire II short form[24]); ECIG, e-cigarette use; MEAT, meat/meat alternatives consumption; MILK, milk/alternatives consumption; PA_HOURS, moderate-to-vigorous physical activity.

**Notes:** The label and colour of each node, "present" (green) or "missing" (blue), represents the situation that is more probable for data in that node; darker colours indicate higher probability. The left side of each node shows the probability of being present, and the right side shows the probability of being missing.

% indicates percentage of the sample in that node.

The survey question for the "Ethnicity" variable was "How would you describe yourself?" (Select all that apply), with the following response options: White, Black, Asian, Aboriginal (First Nations, Métis, Inuit), Latin American/Hispanic, Other. Respondents who selected "White" were classified as non-racialized, while respondents who selected any other option (including the selection of multiple options) were classified as racialized.

**FIGURE 3**
**Height missingness CART models for females (n = 36 546) and males (n = 37 126), COMPASS 2018/19**




**Abbreviations:** BMI, body mass index; CANNABIS, cannabis use; CART, classification and regression tree; FAST_FOOD, fast-food consumption; FRUIT_VEG, fruit/vegetable consumption; MEAT, meat/meat alternatives consumption; MILK, milk/alternatives consumption; PA_HOURS, moderate-to-vigorous physical activity; SLEEP, sleep duration; SPORTS, sports participation.

**Notes:** The label and colour of each node, "present" (green) or "missing" (blue), represents the situation that is more probable for data in that node; darker colours indicate higher probability. The left side of each node shows the probability of being present, and the right side shows the probability of being missing.

% indicates percentage of the sample in that node.

became more accurate after pruning. Pruned accuracy of CART BMI models was 69% for females and 70% for males, of CART body mass models was 78% for females and 80% for males and of CART height models was 85% for females and 81% for males.

## Discussion

This study used a decision tree approach to examine missingness in BMI, height and body mass in a large sample of Canadian youth. One of the aims of this study was to inform the structure of missingness in these variables, as youth self-reported height and body mass can be missing in large proportions and published examinations of this missingness are lacking. The other aim of this study was to employ a newer decision tree method to examining missingness in a dataset in order to overcome some of the barriers of regression-based approaches.

When we previously examined missing BMI, height and body mass data in this sample using a regression approach,[15] we found that more information was needed on the structure of missingness and hierarchy of the importance of variables. The decision tree approach used in this study yielded insights into the mechanisms of missingness in this sample that can inform future studies on youth OWOB.

### *Mechanisms of BMI, height and body mass missingness*

In the BMI missingness CART models we developed, age and weight perception were among the first few primary splits for both males and females. Previous research has suggested that individuals who are younger are more likely to be missing BMI values because they don't know their own height and body mass;[26] this is consistent with the CART models, as each split by age led to a node with a higher likelihood of missingness for the younger groups. Weight perception consistently split those who perceived themselves as overweight from their "about right" and underweight counterparts, leading to a higher likelihood of missingness in the group who perceived themselves as overweight. Previous studies examining BMI missingness mechanisms did not include a measure of weight perception, but two studies have found that poorer body satisfaction was associated with greater likelihood of missing BMI values.[14,27]

Physical activity was also one of the first few splits in both the male and female models. In the female model, strength training was identified as important split criteria, where individuals who did not do any strength training were more likely on average to be missing BMI values. A similar mechanism was observed for males, but with sports and hours of physical activity; not playing sports or being, on average, less physically active each day led to splits where the likelihood of missing BMI values was greater. This is consistent with previous research that included some measures of physical activity.[6,7,14]

Mental health–related variables also appeared in both male and female models. For females, well-being and self-rated mental health were used for splitting, and for males, self-concept was used. For all these mental health–related variables, lower scores (i.e. scores indicating poorer mental health) were associated with a greater likelihood of missing BMI values.

The consistent splitting of individuals who perceived themselves as overweight into a separate group more likely to be missing BMI values suggests that those with a higher BMI were more likely to be nonreporters. Notably, weight perception cannot be assumed as a direct proxy for BMI or body mass because youth may miscategorize themselves;[28-30] however, weight perception may be considered alongside other factors to determine which missingness pattern is most probable.

Findings related to physical activity support the idea that individuals missing BMI values are more likely to have a higher BMI, as those who are less physically active were also split into groups more likely to be missing BMI values, and inverse associations between physical activity and BMI are well-established.[31,32] These findings, along with what we know about heightened body image concerns during adolescence,[33] demonstrate that social desirability may be playing a role in youth nonreporting of height and body mass in this sample.

Height and body mass missingness CART models had some split criteria similar to those of the BMI missingness models, with age a common partitioning variable and physical activity, diet, mental health and substance use variables also observed. One finding exclusive to the body mass missingness models was ethnicity: the model indicated that racialized individuals were more likely to be missing body mass values. Interestingly, although weight perception was identified as a key variable for BMI missingness, it was not identified as important in the body mass missingness CART models for males and females.

### *Utility of CART in examining BMI, height and body mass missingness*

The decision tree approach used in this study to examine missingness appears to have several advantages over traditional regression approaches. The visual nature of decision tree models makes them particularly useful for understanding *how* missingness might be influenced by other variables. For example, the inclusion and directions of splitting related to weight perception, physical activity and mental health in the CART models suggest that the missingness in BMI may be not missing at random because missing data appear more likely among those with a higher BMI. While not missing at random is not a provable phenomenon, the CART models provide evidence against a missing-completely-at-random mechanism, as several subgroups who are highly likely to be missing BMI were identified based on observed covariates.[34] Future OWOB research should consider the mechanisms and degree of missingness in BMI, and where examinations indicate that data may be missing at random or not missing at random, certain statistical approaches (e.g. complete case analysis) may not be ideal because of the risk of bias.[9]

While a regression model could similarly highlight the associations between predictor variables and BMI missingness (e.g. observing a positive odds ratio for self-perception as overweight), one advantage of the CART models is the easily observed hierarchy of the importance of variables. In the BMI CART model, weight perception being among the top two splits for males and females indicates that this variable is of primary importance in predicting BMI missingness. We previously examined BMI missingness using regression;[15] while weight perception was significantly associated with missingness, it was only one of many significant variables

and relative importance couldn't be empirically discerned.

Another advantage of CART models is that one can follow through a decision tree order to identify important subgroups. For example, in the male BMI missingness tree, the 9% of this sample who did not participate in sports and perceived themselves as overweight were more likely than not to be missing BMI values. Moreover, following subgroups to the bottom of the trees reveals that, overall, individuals who perceive themselves as overweight and who were worse off in terms of their physical activity, dietary behaviours, academics and mental health are almost certain to be missing BMI values. In other words, CART models identified that those in the complete sample (i.e. those not missing BMI data) were physically, emotionally and mentally healthier than their counterparts with missing data. As such, a complete case analysis approach on these data would certainly be biased, potentially leading to incorrect research conclusions and inappropriate related policy and programming recommendations.

Examining missing data is often the first step in certain statistical approaches, such as multiple imputation. Although such examinations are needed to identify auxiliary variables that can inform reasonable imputed values, selecting these variables can be difficult if there are many variables related to missingness. This was the case with our previous work using regression; almost all variables were significantly associated with missingness in BMI, height and body mass, and comparing the effective sizes would not have been appropriate as these variables use different scales.[15]

The hierarchical nature of CART models makes the process of selecting auxiliary variables more systematic. For example, CART models can parse out redundant variables; while previous regression work identified weight goal as significantly related to BMI missingness,[15] the CART models in this study did not perform any splits based on this variable, possibly because BMI missingness is sufficiently explained by the weight perception variable alone.

In this study we demonstrated the utility of using CART models to examine missingness in youth height, body mass and BMI. However, missingness is pervasive, and a similar approach may be useful in many other applied research domains. Moreover, public availability of machine-learning packages in R as well as a wealth of online resources make this approach reasonably accessible and feasible for applied researchers.

## Conclusion

This study adds to the limited existing research examining missingness in youth BMI, height and body mass data. CART models demonstrated that age, self-perception as overweight, lower physical activity and poorer mental health identified the subgroups most likely to be missing BMI values. The direction of model partitioning for these variables suggests that youth with higher BMI may be more likely to be missing BMI values and that deleting missing cases in an analysis would likely lead to biased findings.

Future research using youth self-reported data may find that CART models are a particularly useful tool for examining missingness and help select a statistical approach appropriate for handling missing data.

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## Conflicts of interest

The authors report no conflicts of interest.

## Authors' contributions and statement

AD, AC, JPC and SL – Conceptualization; AD and AC – Methodology; AD – Formal analysis, Writing – Original draft; SL – Funding acquisition, Resources, Supervision; AD, AC, JPC and SL – Writing – Review and editing. All authors read and agreed upon the published version of the manuscript.

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

## References

1. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health. 2009;9(1):88. https://doi.org/10.1186/1471-2458-9-88

2. Maukonen M, Männistö S, Tolonen H. A comparison of measured versus self-reported anthropometrics for assessing obesity in adults: a literature review. Scand J Public Health. 2018;46(5):565-79. https://doi.org/10.1177/1403494818761971

3. Sherry B, Jefferds ME, Grummer-Strawn LM. Accuracy of adolescent self-report of height and weight in assessing overweight status: a literature review. Arch Pediatr Adolesc Med. 2007;161(12):1154-61. https://doi.org/10.1001/archpedi.161.12.1154

4. Lipsky LM, Haynie DL, Hill C, et al. Accuracy of self-reported height, weight, and BMI over time in emerging adults. Am J Prev Med. 2019;56(6):860-8. https://doi.org/10.1016/j.amepre.2019.01.004

5. Taylor AW, Dal Grande E, Gill TK, et al. How valid are self-reported height and weight? A comparison between CATI self-report and clinic measurements using a large cohort study. Aust N Z J Public Health. 2006;30(3):238-46. https://doi.org/10.1111/j.1467-842X.2006.tb00864.x

6. Aceves-Martins M, Whitehead R, Inchley J, Giralt M, Currie C, Solà R. Self-reported weight and predictors of missing responses in youth. Nutrition. 2018;53:54-8. https://doi.org/10.1016/j.nut.2018.01.003

7. Arbour-Nicitopoulos KP, Faulkner GE, Leatherdale ST. Learning from non-reported data: interpreting missing body mass index values in young children. Meas Phys Educ Exerc Sci. 2010;14(4):241-51. https://doi.org/10.1080/1091367X.2010.520243

8. Hallgren KA, Witkiewitz K. Missing data in alcohol clinical trials: a comparison of methods. Alcohol Clin Exp Res. 2013;37(12):2152-60. https://doi.org/10.1111/acer.12205

9. White IR, Carlin JB. Bias and efficiency of multiple imputation compared with complete-case analysis for missing covariate values. Stat Med. 2010;29(28):2920-31. http://doi.org/10.1002/sim.3944

10. Karahalios A, Baglietto L, Carlin JB, English DR, Simpson JA. A review of the reporting and handling of missing data in cohort studies with repeated assessment of exposure measures. BMC Med Res Methodol. 2012;12(1):96. https://doi.org/10.1186/1471-2288-12-96

11. Eekhout I, de Boer RM, Twisk JW, de Vet HC, Heymans MW. Missing data: a systematic review of how they are reported and handled. Epidemiology. 2012;23(5):729-32. https://doi.org/10.1097/EDE.0b013e3182576cdb

12. Lin JY, Lu Y, Tu X. How to avoid missing data and the problems they pose: design considerations. Shanghai Arch Psychiatry. 2012;24(3):181-4. https://doi.org/10.3969/j.issn.1002-0829.2012.03.010

13. Van Dyke N, Drinkwater EJ, Rachele JN. Improving the accuracy of self-reported height and weight in surveys: an experimental study. BMC Med Res Methodol. 2022;22(1):241. https://doi.org/10.1186/s12874-022-01690-x

14. Fonseca H, de Matos MG, Guerra A, Gomes-Pedro J. Emotional, behavioural and social correlates of missing values for BMI. Arch Dis Child. 2008;94(2):104-9. https://doi.org/10.1136/adc.2008.139915

15. Doggett A, Chaurasia A, Chaput JP, Leatherdale ST. Learning from missing data: examining nonreporting patterns of height, weight, and BMI among Canadian youth. Int J Obes. 2022;46(9):1598-607. https://doi.org/10.1038/s41366-022-01154-8

16. Ten Eyck P, Cavanaugh JE. An alternate approach to pseudo-likelihood model selection in the generalized linear mixed modeling framework. Sankhya B. 2018;80:98-122. https://doi.org/10.1007/s13571-017-0130-5

17. Loh WY. Fifty years of classification and regression trees. Int Stat Rev. 2014;82(3):329-48. https://doi.org/10.1111/insr.12016

18. Lemon SC, Roy J, Clark MA, Friedmann PD, Rakowski W. Classification and regression tree analysis in public health: methodological review and comparison with logistic regression. Ann Behav Med. 2003;26(3):172-81. https://doi.org/10.1207/S15324796ABM2603_02

19. Tierney NJ, Harden FA, Harden MJ, Mengersen KL. Using decision trees to understand structure in missing data. BMJ Open. 2015;5(6):e007450. https://doi.org/10.1136/bmjopen-2014-007450

20. Radloff LS. The CES-D Scale: a self-report depression scale for research in the general population. Appl Psychol Meas. 1977;1(3):385-401. https://doi.org/10.1177/014662167700100306

21. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med. 2006;166(10):1092-7. https://doi.org/10.1001/archinte.166.10.1092

22. Gratz KL, Roemer L. Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. J Psychopathol Behav Assess. 2004;26(1):41-54. https://doi.org/10.1023/B:JOBA.0000007455.08539.94

23. Diener E, Wirtz D, Tov W, et al. New well-being measures: short scales to assess flourishing and positive and negative feelings. Soc Indic Res. 2010;97(2):143-56. https://doi.org/10.1007/s11205-009-9493-y

24. Marsh HW, Ellis LA, Parada RH, Richards G, Heubeck BG. A short version of the Self Description Questionnaire II: operationalizing criteria for short-form evaluation with new applications of confirmatory factor analyses. Psychol Assess. 2005;17(1):81-102. https://doi.org/10.1037/1040-3590.17.1.81

25. Boehmke B, Greenwell B. Hands-on machine learning with R. Boca Raton (FL): CRC Press; 2020.

26. Himes JH. Challenges of accurately measuring and using BMI and other indicators of obesity in children. Pediatrics. 2009;124 Suppl 1:S3-22. https://doi.org/10.1542/peds.2008-3586D

27. Tiggemann M. Nonreporting of body mass index: a research note on the interpretation of missing data. Int J Eat Disord. 2006;39(4):346-9. http://doi.org/10.1002/eat.20264

28. Sirirassamee T, Phoolsawat S, Limkhunthammo S. Relationship between body weight perception and weight-related behaviours. J Int Med Res. 2018;46(9):3796-808. https://doi.org/10.1177/0300060518780138

29. Gaylis JB, Levy SS, Hong MY. Relationships between body weight perception, body mass index, physical activity, and food choices in Southern California male and female adolescents. Int J Adolesc Youth. 2020;25(1):264-75. https://doi.org/10.1080/02673843.2019.1614465

30. Wang Y, Liu H, Wu F, et al. The association between BMI and body weight perception among children and adolescents in Jilin City, China. PLoS One. 2018;13(3):e0194237. https://doi.org/10.1371/journal.pone.0194237

31. Peart T, Velasco Mondragon HE, Rohm-Young D, Bronner Y, Hossain MB. Weight status in US youth: the role of activity, diet, and sedentary behaviors. Am J Health Behav. 2011;35(6):756-65. https://doi.org/10.5993/AJHB.35.6.11

32. Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Musaiger AO. Lifestyle factors associated with overweight and obesity among Saudi adolescents. BMC Public Health. 2012;12(1):354. https://doi.org/10.1186/1471-2458-12-354

33. Voelker DK, Reel JJ, Greenleaf C. Weight status and body image perceptions in adolescents: current perspectives. Adolesc Health Med Ther. 2015;6:149-58. https://doi.org/10.2147/AHMT.S68344

34. Rubin DB. Inference and missing data. Biometrika. 1976;63(3):581-92. https://doi.org/10.1093/biomet/63.3.581

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# Original quantitative research

# Associations of sleep duration and sleep quality with indicators of mental health among youth and adults: findings from the 2015 Canadian Community Health Survey

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## Abstract

**Introduction:** A growing number of Canadian studies have examined the link between sleep and mental health. This research builds upon that work by investigating associations of sleep duration and quality with positive mental health (PMH) and mental illness and suicidal ideation (MI/SI) outcomes among youth and adults from three Canadian provinces (i.e. Ontario, Manitoba and Saskatchewan).

**Methods:** Using cross-sectional data from respondents 12 years and older (n = 18 683) who were asked questions on their sleep in the 2015 Canadian Community Health Survey – Annual Component, we conducted unadjusted and adjusted logistic regressions with self-reported measures of sleep duration and sleep quality as independent variables and a range of PMH (e.g. high self-rated mental health) and MI/SI indicators (e.g. mood disorder diagnosis) as dependent variables. Analyses were conducted of all complete cases and also stratified by sex and age group.

**Results:** Good sleep quality was associated with higher odds of PMH indicators (adjusted odds ratio [aOR]: 1.52–4.24) and lower odds of MI/SI indicators (aOR: 0.23–0.47); associations remained significant when analyses were stratified. Meeting sleep duration recommendations was positively associated with PMH indicators (aOR: 1.27–1.56) and negatively associated with MI/SI indicators (aOR: 0.41–0.80), but some associations did not remain significant when stratified.

**Conclusions:** This study provides support for associations between sleep duration and quality and indicators of PMH and MI/SI. Findings can inform future research and surveillance efforts that monitor sleep behaviours and indicators of PMH and MI/SI.

***Keywords:*** *sleep, positive mental health, anxiety disorders, mood disorders, population health, suicidal ideation, suicide*

### *Highlights*

- We examined associations between self-reported measures of sleep (duration, quality) and mental health outcomes among youth (12–17 years old) and adults (18 years and older) in three Canadian provinces.
- Good sleep quality was consistently associated with higher odds of positive mental health and lower odds of mental illness and suicidal ideation across all sex and age groups.
- Meeting sleep duration recommendations was associated with higher odds of positive mental health and lower odds of mental illness and suicidal ideation overall, although these associations were not consistent across sex and age groups.

## Introduction

Insufficient sleep and poor sleep quality are common issues. Over one-third of Canadians between 5 and 79 years old fail to obtain the daily recommended amount of sleep.[1] Furthermore, one-quarter of adults aged 18 to 79 and one-tenth of children and youth aged 5 to 17 years in Canada report problems with falling or staying asleep most or all of the time.[2,3] Research suggests that poor sleep is associated with a range of adverse physical health outcomes, including poor self-rated health, obesity, cardiovascular disease and increased risk of all-cause mortality.[4-7]

Previous studies suggest that poor sleep is associated with various negative psychological outcomes. For example, international research has shown that poor sleep quality is associated with increased risk of depression and anxiety throughout the lifespan.[8,9] Furthermore, researchers have observed a U-shaped association between sleep duration and risk of depressed mood and suicidal behaviour in youth and adults, with the greatest risk at short (e.g. less than 6–7 hours for adults) and long (e.g. more than 8–9 hours for adults) sleep durations.[10-12] Among adults in Canada,

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associations between long sleep duration and diagnosis of major depression,[13,14] short sleep duration and chronic stress[15] and poor sleep quality and self-reported symptoms of depression and anxiety[16] have been documented. Among youth in Canada, meeting sleep duration recommendations has been associated with lower stress,[17] and additional time spent sleeping has been associated with fewer symptoms of anxiety and depression for those who slept less than 8 hours each day.[18]

Fewer studies have examined the associations between sleep and positive mental health (PMH). Research among young adults in South Korea found that better sleep quality was associated with greater life satisfaction,[19] and a recent meta-analysis of studies from several countries reported that adequate sleep duration among adolescents was generally associated with positive mood.[20] However, Canadian studies have had mixed findings. One reported that short and long sleep durations were associated with lower self-rated mental health (SRMH), community belonging and life satisfaction among adults, even after adjusting for numerous covariates.[21] Another study of adults with mood and/or anxiety disorders found that the association of short sleep duration (< 6 hours) with lower SRMH and life satisfaction did not persist after controlling for other variables, and long sleep duration was not associated with either PMH outcome in unadjusted or adjusted analyses.[22]

Sleep and PMH research findings in Canada have also varied by age group. One study reported associations between short and long sleep durations and lower SRMH and community belonging in adults, but only the association between long sleep duration and lower community belonging was statistically significant for older adults aged 65 to 79 years.[13] Furthermore, the authors reported that short sleep duration was not significantly associated with SRMH or community belonging for youth aged 14 to 17 years (long sleep duration was not assessed in this age group).[13] Nevertheless, other findings involving youth suggest that meeting sleep duration recommendations is associated with high SRMH[17] and that additional time spent sleeping is associated with greater psychological well-being among youth who slept less than 8 hours each day.[18]

Given these varied findings, there is a need for more population-based research examining associations between good sleep quality, meeting sleep duration recommendations and a breadth of PMH and mental illness and suicidal ideation (MI/SI) indicators among Canadian youth, adults and older adults. Indeed, exploring the association between sleep and well-being was a research need identified in the process of developing the Canadian 24-Hour Movement Guidelines.[23,24]

PMH and mental illness are not at opposite ends of the same spectrum; rather, they represent distinct constructs that can have unique antecedents and consequences.[25,26] It is possible to concurrently experience high/low levels of PMH and high/low levels of mental illness,[22,25] which strengthens the argument for examining both constructs.

Preventing or reducing the impacts of physical and mental ill-health and promoting PMH are important priorities for research and public health strategies in Canada and globally.[27-29] Both poor sleep quality and duration and mental health difficulties carry substantial economic and societal burdens, including reduced life expectancy, lost productivity and high health care costs.[30-32] Conversely, PMH has been shown to protect against the onset and lessen the severity of both mental and physical illnesses.[33,34] Examining the associations between sleep and several PMH and MI/SI indicators in a large Canadian sample can inform future surveillance and research on sleep behaviours and mental health in the population.

The aim of this study was to examine the associations of sleep duration and sleep quality with indicators of PMH and MI/SI among individuals aged 12 years and older from three Canadian provinces. We anticipated that individuals would be more likely to report PMH and less likely to report MI/SI if they met sleep duration recommendations or had good sleep quality.

## Methods

### *Data and participants*

We analyzed data from the 2015 Canadian Community Health Survey (CCHS) – Annual Component.[35] The CCHS is a voluntary cross-sectional survey conducted by Statistics Canada to obtain representative estimates of health-related information on the target population of community-dwelling individuals aged 12 years and older living in all Canadian provinces and territories. We selected the 2015 CCHS as this dataset was the most recent one with a variety of sleep and mental health measures.

Data from the 2015 CCHS were collected from January to December 2015 using computer-assisted telephone and personal interviews. The CCHS uses a list frame based on the Canadian Child Tax Benefit to sample youth aged 12 to 17 years and an area frame used by the Canadian Labour Force Survey to sample households with adults aged 18 years and older. Excluded from CCHS data collection were institutionalized individuals, full-time members of the Canadian Forces and people living in foster homes, on reserves and other Indigenous settlements, or in two health regions in Quebec; these exclusions represent just under 3% of the Canadian population.

Our analyses were limited to respondents from Ontario, Manitoba and Saskatchewan as the sleep module was optional content that was only asked of respondents from these three provinces (n = 18 683). The overall CCHS 2015 response rate was 57.5%, and response rates from Ontario, Manitoba and Saskatchewan were 55.7%, 63.8% and 61.5%, respectively.

### *Measures*

#### Sleep measures

Sleep duration was ascertained with the question, "How long do you usually spend sleeping each night?" Response options started at "under 2 hours" and increased in hourly intervals (e.g. "2 hours to less than 3 hours") up to "12 hours or more." We constructed a dichotomous variable to identify respondents who met age-specific sleep recommendations, based on the sleep times from the Canadian 24-Hour Movement Guidelines.[23,24] Using the suggested surveillance cut-points for defining adherence that were released with the 24-Hour Movement Guidelines,[24] we operationalized adherence to the recommendation of 7 to 9 hours of sleep per night for adults (18–64 years) as 7 hours 0 minutes to 9 hours 59 minutes (i.e. response options "7 hours to less than 8 hours" to "9 hours to less than 10 hours"), and adherence to the recommendation of 7 to 8 hours of sleep per night for older adults

(≥65 years) as 7 hours 0 minutes to 8 hours 59 minutes (i.e. response options "7 hours to less than 8 hours" to "8 hours to less than 9 hours").

Suggested surveillance cut-points for defining adherence to sleep duration recommendations are not as specific for youth (i.e. not to the exact number of minutes).[23] We used an approach consistent with that for adults: we operationalized adherence to the recommendation of 9 to 11 hours per night for youth 12 to 13 years old as 9 hours 0 minutes to 11 hours 59 minutes (i.e. response options "9 hours to less than 10 hours" to "11 hours to less than 12 hours"), and adherence to the recommendation of 8 to 10 hours per night for youth 14 to 17 years old as 8 hours 0 minutes to 10 hours 59 minutes (i.e. response options "8 hours to less than 9 hours" to "10 hours to less than 11 hours"). Those in categories above or below the recommended ranges were classified as not meeting recommendations.

The first sleep quality indicator was assessed with the question, "How often do you have trouble going to sleep or staying asleep?" Response options included "never," "rarely," "sometimes," "most of the time" and "all of the time." Similar to the Physical Activity, Sedentary Behaviour and Sleep (PASS) Indicators and previous research,[2,21,36,37] respondents who answered "never," "rarely" or "sometimes" were categorized as having few difficulties going to sleep or staying asleep.

The second sleep quality indicator was assessed with the question, "How often do you find your sleep refreshing?" Response options included "never," "rarely," "sometimes," "most of the time" and "all of the time." Mirroring the coding of our first sleep quality indicator, respondents who answered "most of the time" or "all of the time" were categorized as having refreshing sleep.

### MI/SI measures

The four MI/SI measures we examine in the current study have been previously used by the Public Health Agency of Canada (PHAC) in reporting initiatives like the Health Inequalities Data Tool.[38]

Respondents were asked if they have been diagnosed, by a health professional, with various conditions that have lasted or are expected to last 6 months or more. One of the questions was, "Do you have a mood disorder such as depression, bipolar disorder, mania or dysthymia?" Respondents who answered "yes" were categorized as diagnosed with a mood disorder.[38] Respondents were similarly asked, "Do you have an anxiety disorder such as a phobia, obsessive-compulsive disorder or a panic disorder?" Respondents who answered "yes" were categorized as diagnosed with an anxiety disorder.[38]

Lifetime and recent suicidal ideation questions were asked of respondents aged 15 years or older. Lifetime suicidal ideation was assessed via the question, "Have you ever seriously contemplated suicide?" Individuals who responded "yes" were coded as having a lifetime history of suicidal ideation.[38-40] Those who answered "yes" were asked, "Has this happened in the past 12 months?" Individuals who answered "yes" to the second question were coded as having recent suicidal ideation.[38-40] Due to small cell sizes, we examined recent suicidal ideation in overall and sex-stratified analyses, but not in analyses stratified by age group.

### PMH measures

The five PMH measures we examine in the current study have been previously used by PHAC to monitor the PMH of Canadians in the Positive Mental Health Surveillance Indicator Framework (PMHSIF).[41,42]

SRMH was examined using the question, "In general, would you say your mental health is …?" Response options included "excellent," "very good," "good," "fair" and "poor." Respondents who answered "excellent" or "very good" were categorized as having high SRMH.

Life satisfaction was examined using the question, "In the past month, how often did you feel: satisfied with your life?" This question was based on the Mental Health Continuum Short-Form (MHC-SF).[43] Response options for the MHC-SF included "every day," "almost every day," "about 2 or 3 times a week," "about once a week," "once or twice" or "never." Individuals who answered "every day" or "almost every day" were categorized as having high life satisfaction.[41]

Happiness was examined using the question, "In the past month, how often did you feel: happy?" based on the MHC-SF.[43] Individuals who answered "every day" or "almost every day" were categorized as having high levels of happiness.[41]

Psychological well-being was measured using six items from the MHC-SF that asked about feelings of self-acceptance, environmental mastery, positive relations with others, personal growth, autonomy and purpose in life during the past month.[43] In keeping with the PMHSIF for adults and previous research,[41,42,44] we converted response options into number of days in the past month as follows: "every day" as 28 days (4 weeks × 7 days per week); "almost every day" as 20 days (4 weeks × 5 days per week); "about 2 or 3 times a week" as 10 days (4 weeks × 2.5 days per week); "about once a week" as 4 days (4 weeks × 1 day per week); "once or twice" as 1.5 days; and "never" as 0 days. We generated mean scores after converting the response options and categorized scores of 20 and greater (corresponding to experiencing psychological well-being, on average, "almost every day" or more frequently) as high psychological well-being.

Community belonging was examined using the question, "How would you describe your sense of belonging to your local community? Would you say it is …?" Response options included "very strong," "somewhat strong," "somewhat weak" and "very weak." We categorized individuals who responded with "very strong" or "somewhat strong" as having high community belonging.

### *Covariates*

We adjusted for several key sociodemographic variables in the logistic regression analyses: sex (male, female); age (youth 12–17 years, adults 18–64 years, older adults 65 years or greater); immigrant status (yes, no); household income adequacy quintile (based on the adjusted ratio of the respondent's household income to the low-income cut-off for their community and household size); place of residence (population centre, rural area); and racialized background (yes, no).

Individuals who reported being born in Canada were classified as non-immigrants, and non-permanent residents and landed immigrants as immigrants. Household income was either reported by the respondent (or, for youth, "the person most knowledgeable") or imputed by Statistics Canada. Population centres were defined

as areas with a population density of at least 400/km$^2$ and a population concentration of at least 1000.

Individuals who identified as White only were coded as non-racialized; those who identified as other ethnicities or as belonging to other cultural backgrounds (e.g. South Asian, Chinese, Black) were coded as racialized. (Those who identified as First Nations, Métis or Inuk [Inuit] were not asked this question about their ethnic or cultural background and were excluded from regression analyses.)

These covariates were selected a priori as PHAC surveillance tools frequently break down results by these sociodemographic characteristics, revealing inequalities in some mental health outcomes in these groups.[2,38,39,42,45]

### *Analyses*

Descriptive statistics for the eligible sample were reported using weighted percentages with 95% confidence intervals (CIs). Unadjusted logistic regressions and logistic regressions adjusted for covariates were conducted to examine the associations between sleep variables and mental health outcomes. These regression analyses included only individuals who provided complete data on all the study variables, that is, 89.2% of eligible participants (n = 16 674); those who responded "don't know" or gave no response on one or more items were removed from the regression analyses. Odds ratios (ORs) with 95% CIs that do not include 1.00 were considered statistically significant.

To account for complex survey design, we used sampling weights from Statistics Canada to generate estimates representative of the population[35] and we estimated variances using bootstrap weights that were also provided by Statistics Canada. We calculated overall estimates as well as results stratified by sex (male and female) and age (youth aged 12–17 years, adults aged 18–64 years and older adults aged ≥65 years).

Analyses were conducted using SAS Enterprise Guide version 7.1 (SAS Institute, Cary, NC, USA).

## Results

Descriptive statistics (sociodemographic, sleep, PMH and MI/SI measures) are shown in Table 1. Most individuals reported good sleep quality: 85.3% reported few difficulties going to sleep or staying asleep, and 61.9% reported refreshing sleep. Half (51.0%) met age-specific sleep duration recommendations.

Small proportions of individuals reported lifetime suicidal ideation (10.8%), suicidal ideation in the past 12 months (2.2%), and being diagnosed with a mood disorder (8.1%) or an anxiety disorder (8.0%). Most individuals reported high SRMH (72.4%), life satisfaction (87.4%), psychological well-being (70.9%) and community belonging (70.6%) as well as high levels of happiness (86.2%).

Sex-stratified and age-stratified descriptive statistics (sleep, PMH and MI/SI measures) are shown in Table 2.

### *Sleep duration recommendations and mental health*

Compared to not meeting sleep recommendations, meeting sleep duration recommendations was associated with overall lower odds of all MI/SI variables and higher odds of all PMH variables, prior to and after covariate adjustment (see Table 3).

In sex-stratified analyses, meeting sleep recommendations was associated with lower odds of reporting an anxiety disorder diagnosis and lifetime suicidal ideation and higher odds of high SRMH, life satisfaction and happiness in unadjusted and adjusted analyses for both males and females. Among females (but not males), meeting sleep recommendations was associated with lower odds of being diagnosed with a mood disorder and reporting suicidal ideation in the past 12 months and higher odds of reporting high psychological well-being in both unadjusted and adjusted analyses. Among males (but not females), meeting sleep recommendations was associated with higher odds of reporting high community belonging in unadjusted and adjusted analyses (see Table 3).

Meeting sleep recommendations was associated with higher odds of reporting high SRMH and community belonging across all age groups in unadjusted and adjusted analyses. Among youth, meeting sleep recommendations was also associated with lower odds of reporting lifetime suicidal ideation and higher odds of reporting high levels of happiness in unadjusted and adjusted analyses, and high psychological well-being in unadjusted analyses. Among adults, meeting sleep recommendations was associated with lower odds of all MI/SI variables and higher odds of all PMH variables in unadjusted and adjusted analyses. In older adults, meeting sleep recommendations was also associated with higher odds of reporting high life satisfaction and high levels of happiness in unadjusted and adjusted analyses (see Table 4).

### *Sleep quality and mental health*

Reporting good sleep quality (measured by either sleep quality indicator) was associated with overall lower odds of all MI/SI variables and higher odds of all PMH variables in both unadjusted and adjusted analyses. All unadjusted and adjusted associations remained statistically significant after stratifying analyses by sex and by age group (see Tables 5, 6, 7 and 8).

## Discussion

We examined the associations of sleep duration and sleep quality with a number of PMH and MI/SI indicators in a large sample of Canadians living in Ontario, Manitoba and Saskatchewan. Overall, good sleep quality and meeting sleep duration recommendations were positively associated with PMH outcomes and negatively associated with MI/SI outcomes. Whereas the associations between measures of sleep quality and PMH and MI/SI outcomes were consistent across sex and age groups, associations between meeting sleep duration recommendations and some mental health outcomes were inconsistent in sex- and age-stratified analyses.

Poor sleep quality was prevalent among individuals in the current study: over one-tenth of the population report experiencing frequent difficulties with falling or staying asleep, and over one-third report that their sleep is often not refreshing. This is of concern because our findings demonstrate strong and consistent associations between reporting good sleep quality and higher odds of PMH and lower odds of MI/SI across sex and age groups. Other Canadian studies have also reported associations between poor sleep quality and life dissatisfaction, poorer SRMH and lower community belonging among adults 18 years and older in Nova Scotia, Quebec,

**TABLE 1**
**Descriptive characteristics of eligible study sample, CCHS 2015 (n = 18 683)**

| Variables | %[a] | 95% LCL | 95% UCL |
|---|---|---|---|
| **Sociodemographic characteristics** | | | |
| Sex (n = 18 683) | | | |
| Male | 48.9 | 48.6 | 49.1 |
| Female | 51.1 | 50.9 | 51.4 |
| Province (n = 18 683) | | | |
| Ontario | 86.0 | 85.8 | 86.1 |
| Manitoba | 7.5 | 7.4 | 7.6 |
| Saskatchewan | 6.5 | 6.4 | 6.6 |
| Age group in years (n = 18 683) | | | |
| 12–17 | 7.6 | 7.4 | 7.7 |
| 18–24 | 11.1 | 10.3 | 11.9 |
| 25–44 | 31.5 | 30.4 | 32.5 |
| 45–64 | 33.3 | 32.6 | 34.0 |
| ≥65 | 16.5 | 16.3 | 16.8 |
| Immigrant status (n = 18 342) | | | |
| Immigrant | 30.7 | 29.4 | 32.0 |
| Non-immigrant | 69.3 | 68.0 | 70.6 |
| Racialized background[b] (n = 17 264) | | | |
| No | 73.4 | 72.2 | 74.7 |
| Yes | 26.6 | 25.3 | 27.8 |
| Household income adequacy quintile (n = 18 646) | | | |
| Q1 (Lowest income) | 19.9 | 18.8 | 21.0 |
| Q2 | 19.7 | 18.7 | 20.8 |
| Q3 | 20.1 | 19.1 | 21.1 |
| Q4 | 20.1 | 19.1 | 21.1 |
| Q5 (Highest income) | 20.2 | 19.1 | 21.2 |
| Place of residence (n = 18 683) | | | |
| Population centre | 84.9 | 83.9 | 85.8 |
| Rural area | 15.1 | 14.2 | 16.1 |
| **Sleep measures** | | | |
| Sleep duration, hours (n = 18 683) | | | |
| <3[d] | 0.7[c] | 0.4 | 0.9 |
| 3 to <4 | 1.3 | 1.1 | 1.6 |
| 4 to <5 | 3.8 | 3.4 | 4.3 |
| 5 to <6 | 11.6 | 10.7 | 12.4 |
| 6 to <7 | 26.7 | 25.6 | 27.9 |
| 7 to <8 | 32.9 | 31.7 | 34.1 |
| 8 to <9 | 17.4 | 16.5 | 18.3 |
| 9 to <10 | 3.6 | 3.1 | 4.1 |
| 10 to <11 | 1.2 | 1.0 | 1.5 |
| 11 to <12 | 0.4[c] | 0.3 | 0.5 |
| ≥12 | 0.4[c] | 0.2 | 0.5 |

**Continued on the following page**

**TABLE 1 (continued)**
**Descriptive characteristics of eligible study sample, CCHS 2015 (n = 18 683)**

| Variables | %[a] | 95% LCL | 95% UCL |
|---|---|---|---|
| Met sleep duration recommendations (n = 18 683) | | | |
| Yes | 51.0 | 49.7 | 52.3 |
| No | 49.0 | 47.7 | 50.3 |
| Sleep difficulties (n = 18 683) | | | |
| Few | 85.3 | 84.4 | 86.2 |
| Never | 26.7 | 25.5 | 28.0 |
| Rarely | 29.1 | 28.0 | 30.3 |
| Sometimes | 29.4 | 28.3 | 30.6 |
| Frequent | 14.7 | 13.8 | 15.6 |
| Most of the time | 10.5 | 9.8 | 11.3 |
| All of the time | 4.2 | 3.7 | 4.6 |
| Refreshing sleep (n = 18 683) | | | |
| Yes | 61.9 | 60.7 | 63.1 |
| Most of the time | 44.6 | 43.4 | 45.9 |
| All of the time | 17.2 | 16.2 | 18.3 |
| No | 38.1 | 36.9 | 39.3 |
| Never | 4.1 | 3.6 | 4.6 |
| Rarely | 10.1 | 9.3 | 10.8 |
| Sometimes | 24.0 | 22.9 | 25.1 |
| **Mental illness and suicidal ideation measures** | | | |
| Mood disorder (n = 18 644) | | | |
| Yes | 8.1 | 7.4 | 8.7 |
| No | 91.9 | 91.3 | 92.6 |
| Anxiety disorder (n = 18 652) | | | |
| Yes | 8.0 | 7.3 | 8.7 |
| No | 92.0 | 91.3 | 92.7 |
| Suicidal ideation, lifetime[e] (n = 17 790) | | | |
| Yes | 10.8 | 10.0 | 11.5 |
| No | 89.2 | 88.5 | 90.0 |
| Suicidal ideation, past 12 months[e] (n = 17 785) | | | |
| Yes | 2.2 | 1.8 | 2.5 |
| No | 97.8 | 97.5 | 98.2 |
| **Positive mental health measures** | | | |
| High SRMH (n = 18 642) | 72.4 | 71.2 | 73.6 |
| High life satisfaction (n = 18 465) | 87.4 | 86.4 | 88.3 |
| High levels of happiness (n = 18 487) | 86.2 | 85.2 | 87.1 |
| High psychological well-being (n = 18 683) | 70.9 | 69.7 | 72.1 |
| High community belonging (n = 18 442) | 70.6 | 69.4 | 71.9 |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Percentages may not sum to the exact total due to rounding.

[a] All estimates weighted.

[b] Individuals who identified as White only were coded as non-racialized; those who identified as other ethnicities or as belonging to other cultural backgrounds (e.g. South Asian, Chinese, Black) were coded as racialized. Individuals who identified as Indigenous were excluded from this sociodemographic variable because they were not asked the question about their ethnic or cultural background.

[c] Estimate should be interpreted with caution due to high sampling variability (coefficient of variation between 15 and 25).

[d] The "<3 hours" sleep duration category combines response options "under 2 hours" and “2 hours to less than 3 hours."

[e] Item only asked of respondents ≥15 years old.

**TABLE 2**
**Prevalence of sleep, mental illness, suicidal ideation and positive mental health outcomes in eligible study sample, stratified by sex and by age group, CCHS 2015 (n = 18 683)**

| Measures | Male (n = 8525) | | | Female (n = 10 158) | | | Youth[a] (n = 1573) | | | Adults[b] (n = 12 313) | | | Older adults[c] (n = 4797) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | %[d] | 95% LCL | 95% UCL | %[d] | 95% LCL | 95% UCL | %[d] | 95% LCL | 95% UCL | %[d] | 95% LCL | 95% UCL | %[d] | 95% LCL | 95% UCL |
| Sleep | | | | | | | | | | | | | | | |
| Met sleep duration recommendations | 50.9 | 49.0 | 52.7 | 51.1 | 49.3 | 52.9 | 43.7 | 40.0 | 47.4 | 52.1 | 50.5 | 53.6 | 49.3 | 46.8 | 51.9 |
| Few sleep difficulties | 88.5 | 87.4 | 89.6 | 82.2 | 80.9 | 83.5 | 91.3 | 89.5 | 93.1 | 84.8 | 83.7 | 85.8 | 84.9 | 83.2 | 86.6 |
| Refreshing sleep | 65.2 | 63.5 | 66.9 | 58.7 | 57.0 | 60.4 | 69.3 | 66.1 | 72.6 | 59.0 | 57.4 | 60.5 | 71.9 | 69.7 | 74.1 |
| Mental illness and suicidal ideation | | | | | | | | | | | | | | | |
| Mood disorder | 6.1 | 5.2 | 7.0 | 10.0 | 9.0 | 10.9 | 5.3 | 3.8 | 6.9 | 8.7 | 7.9 | 9.6 | 6.2 | 5.2 | 7.2 |
| Anxiety disorder | 5.5 | 4.7 | 6.3 | 10.4 | 9.3 | 11.4 | 7.7 | 5.6 | 9.9 | 8.6 | 7.8 | 9.5 | 5.2 | 4.2 | 6.1 |
| Suicidal ideation, lifetime[e] | 8.6 | 7.6 | 9.7 | 12.8 | 11.8 | 13.9 | 9.7 | 7.2 | 12.2 | 11.8 | 10.9 | 12.7 | 6.3 | 5.4 | 7.2 |
| Suicidal ideation, past 12 months[e] | 1.4 | 1.0 | 1.7 | 2.9 | 2.3 | 3.5 | – | – | – | – | – | – | – | – | – |
| Positive mental health | | | | | | | | | | | | | | | |
| High SRMH | 74.1 | 72.5 | 75.7 | 70.8 | 69.2 | 72.4 | 76.5 | 73.4 | 79.6 | 72.5 | 71.1 | 74.0 | 69.9 | 67.8 | 72.1 |
| High life satisfaction | 87.5 | 86.0 | 88.9 | 87.3 | 86.0 | 88.5 | 91.7 | 89.5 | 93.9 | 86.1 | 85.0 | 87.3 | 91.1 | 89.8 | 92.5 |
| High levels of happiness | 86.5 | 85.1 | 87.9 | 85.9 | 84.6 | 87.1 | 92.2 | 90.4 | 94.1 | 85.3 | 84.1 | 86.5 | 87.6 | 86.0 | 89.2 |
| High psychological well-being | 71.8 | 70.0 | 73.6 | 70.0 | 68.5 | 71.6 | 73.7 | 70.7 | 76.7 | 71.5 | 70.0 | 73.0 | 66.9 | 64.5 | 69.2 |
| High community belonging | 70.3 | 68.4 | 72.1 | 71.0 | 69.4 | 72.6 | 84.5 | 81.6 | 87.3 | 67.9 | 66.4 | 69.4 | 77.0 | 74.7 | 79.3 |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Sample sizes differed for the different measures because of missing responses.

[a] 12–17 years old.

[b] 18–64 years old.

[c] ≥65 years old.

[d] All estimates weighted.

[e] Item only asked of respondents ≥15 years old.

**TABLE 3**
**Associations between meeting (vs. not meeting) sleep duration recommendations and mental illness, suicidal ideation and positive mental health outcomes, overall and stratified by sex, CCHS 2015**

| Outcome | Overall (n = 16 674) | | | | | | Males (n = 7649) | | | | | | Females (n = 9025) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | |
| | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL |
| Mental illness and suicidal ideation | | | | | | | | | | | | | | | | | | |
| Mood disorder | **0.79** | **0.65** | **0.96** | **0.80** | **0.66** | **0.97** | 0.94 | 0.65 | 1.35 | 0.96 | 0.68 | 1.37 | **0.71** | **0.57** | **0.89** | **0.71** | **0.56** | **0.89** |
| Anxiety disorder | **0.68** | **0.56** | **0.85** | **0.66** | **0.54** | **0.81** | **0.66** | **0.48** | **0.91** | **0.63** | **0.46** | **0.88** | **0.70** | **0.54** | **0.92** | **0.67** | **0.51** | **0.87** |
| Suicidal ideation, lifetime[a] | **0.72** | **0.62** | **0.85** | **0.70** | **0.59** | **0.82** | **0.78** | **0.61** | **1.00** | **0.76** | **0.60** | **0.97** | **0.68** | **0.55** | **0.84** | **0.66** | **0.53** | **0.81** |
| Suicidal ideation, past 12 months[a] | **0.42** | **0.29** | **0.61** | **0.41** | **0.28** | **0.58** | 0.72 | 0.40 | 1.28 | 0.60 | 0.35 | 1.04 | **0.31** | **0.19** | **0.50** | **0.32** | **0.20** | **0.51** |
| Positive mental health | | | | | | | | | | | | | | | | | | |
| High SRMH | **1.44** | **1.27** | **1.62** | **1.46** | **1.29** | **1.64** | **1.46** | **1.22** | **1.76** | **1.46** | **1.22** | **1.76** | **1.41** | **1.19** | **1.67** | **1.43** | **1.20** | **1.70** |
| High life satisfaction | **1.54** | **1.30** | **1.83** | **1.56** | **1.32** | **1.85** | **1.32** | **1.04** | **1.69** | **1.31** | **1.02** | **1.68** | **1.80** | **1.42** | **2.28** | **1.82** | **1.44** | **2.31** |
| High levels of happiness | **1.56** | **1.31** | **1.86** | **1.55** | **1.31** | **1.84** | **1.35** | **1.05** | **1.73** | **1.31** | **1.02** | **1.69** | **1.79** | **1.41** | **2.28** | **1.81** | **1.42** | **2.29** |
| High psychological well-being | **1.31** | **1.16** | **1.49** | **1.33** | **1.18** | **1.50** | 1.09 | 0.91 | 1.30 | 1.13 | 0.94 | 1.36 | **1.57** | **1.33** | **1.85** | **1.55** | **1.31** | **1.83** |
| High community belonging | **1.23** | **1.09** | **1.39** | **1.27** | **1.12** | **1.43** | **1.38** | **1.14** | **1.66** | **1.43** | **1.19** | **1.73** | 1.10 | 0.94 | 1.30 | 1.14 | 0.97 | 1.34 |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; OR, odds ratio; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Statistically significant results ($p < 0.05$) bolded. Covariates adjusted for in analyses include age group, sex (except in sex-stratified analyses), immigrant status, racialized background, place of residence and household income adequacy quintile.

[a] Restricted to respondents ≥15 years old.

**TABLE 4**
**Associations between meeting (vs. not meeting) sleep duration recommendations and mental illness, suicidal ideation and positive mental health outcomes, stratified by age group, CCHS 2015**

| Outcome | Youth[a] (n = 1356) | | | | | | Adults[b] (n = 11 030) | | | | | | Older adults[c] (n = 4288) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | |
| | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL |
| Mental illness and suicidal ideation | | | | | | | | | | | | | | | | | | |
| Mood disorder | 0.86 | 0.36 | 2.04 | 0.88 | 0.37 | 2.08 | **0.75** | **0.60** | **0.95** | **0.75** | **0.59** | **0.95** | 0.95 | 0.67 | 1.36 | 0.94 | 0.65 | 1.34 |
| Anxiety disorder | 0.77 | 0.38 | 1.57 | 0.83 | 0.42 | 1.64 | **0.67** | **0.53** | **0.86** | **0.66** | **0.52** | **0.84** | 0.72 | 0.45 | 1.15 | 0.68 | 0.43 | 1.10 |
| Suicidal ideation, lifetime[d] | **0.47** | **0.23** | **0.94** | **0.42** | **0.22** | **0.81** | **0.71** | **0.59** | **0.85** | **0.70** | **0.58** | **0.84** | 0.91 | 0.64 | 1.29 | 0.87 | 0.60 | 1.25 |
| Positive mental health | | | | | | | | | | | | | | | | | | |
| High SRMH | **1.76** | **1.16** | **2.69** | **1.65** | **1.05** | **2.60** | **1.44** | **1.24** | **1.67** | **1.46** | **1.26** | **1.69** | **1.36** | **1.08** | **1.70** | **1.27** | **1.01** | **1.60** |
| High life satisfaction | 1.63 | 0.73 | 3.62 | 1.39 | 0.58 | 3.35 | **1.55** | **1.28** | **1.88** | **1.58** | **1.30** | **1.92** | **1.74** | **1.18** | **2.56** | **1.64** | **1.10** | **2.45** |
| High levels of happiness | **2.47** | **1.27** | **4.79** | **2.25** | **1.14** | **4.56** | **1.58** | **1.29** | **1.94** | **1.59** | **1.30** | **1.95** | **1.51** | **1.06** | **2.15** | **1.44** | **1.00** | **2.07** |
| High psychological well-being | **1.56** | **1.04** | **2.36** | 1.35 | 0.87 | 2.10 | **1.32** | **1.14** | **1.54** | **1.33** | **1.15** | **1.54** | 1.22 | 0.98 | 1.51 | 1.19 | 0.96 | 1.47 |
| High community belonging | **1.78** | **1.11** | **2.87** | **1.81** | **1.08** | **3.01** | **1.23** | **1.07** | **1.43** | **1.23** | **1.06** | **1.42** | **1.35** | **1.04** | **1.75** | **1.33** | **1.02** | **1.72** |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; OR, odds ratio; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Statistically significant results ($p < 0.05$) bolded. Covariates adjusted for in analyses include sex, immigrant status, racialized background, place of residence and household income adequacy quintile.

[a] 12–17 years old.

[b] 18–64 years old.

[c] ≥65 years old.

[d] Restricted to respondents ≥15 years old.

**TABLE 5**
**Associations between few (vs. frequent) difficulties falling or staying asleep and mental illness, suicidal ideation and positive mental health outcomes, overall and stratified by sex, CCHS 2015**

| Outcome | Overall (n = 16 674) | | | | | | Males (n = 7649) | | | | | | Females (n = 9025) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | |
| | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL |
| Mental illness and suicidal ideation | | | | | | | | | | | | | | | | | | |
| Mood disorder | **0.24** | **0.19** | **0.29** | **0.29** | **0.23** | **0.36** | **0.22** | **0.15** | **0.31** | **0.24** | **0.16** | **0.26** | **0.26** | **0.21** | **0.22** | **0.32** | **0.25** | **0.41** |
| Anxiety disorder | **0.27** | **0.22** | **0.34** | **0.31** | **0.25** | **0.38** | **0.26** | **0.26** | **0.37** | **0.28** | **0.20** | **0.40** | **0.31** | **0.24** | **0.40** | **0.33** | **0.25** | **0.43** |
| Suicidal ideation, lifetime[a] | **0.32** | **0.27** | **0.38** | **0.36** | **0.30** | **0.42** | **0.28** | **0.21** | **0.36** | **0.29** | **0.22** | **0.39** | **0.37** | **0.29** | **0.46** | **0.40** | **0.32** | **0.50** |
| Suicidal ideation, past 12 months[a] | **0.24** | **0.17** | **0.35** | **0.27** | **0.19** | **0.38** | **0.25** | **0.15** | **0.42** | **0.23** | **0.14** | **0.40** | **0.27** | **0.17** | **0.42** | **0.27** | **0.17** | **0.42** |
| Positive mental health | | | | | | | | | | | | | | | | | | |
| High SRMH | **2.64** | **2.28** | **3.06** | **2.54** | **2.19** | **2.95** | **2.53** | **2.01** | **3.19** | **2.42** | **1.90** | **3.08** | **2.69** | **2.21** | **2.37** | **2.64** | **2.16** | **3.22** |
| High life satisfaction | **3.56** | **2.94** | **4.30** | **3.77** | **3.10** | **4.57** | **4.42** | **3.35** | **5.84** | **4.69** | **3.52** | **6.25** | **3.08** | **2.38** | **3.98** | **3.23** | **2.51** | **4.14** |
| High levels of happiness | **3.34** | **2.77** | **4.02** | **3.46** | **2.85** | **4.19** | **3.78** | **2.88** | **4.97** | **4.00** | **2.99** | **5.36** | **3.09** | **2.41** | **3.94** | **3.14** | **2.45** | **4.03** |
| High psychological well-being | **2.01** | **1.74** | **2.31** | **2.02** | **1.75** | **2.33** | **2.19** | **1.74** | **2.77** | **2.20** | **1.75** | **2.78** | **1.87** | **1.55** | **2.26** | **1.91** | **1.58** | **2.31** |
| High community belonging | **1.58** | **1.36** | **1.82** | **1.57** | **1.36** | **1.82** | **1.52** | **1.22** | **1.88** | **1.49** | **1.18** | **1.86** | **1.65** | **1.35** | **2.01** | **1.64** | **1.34** | **2.01** |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; OR, odds ratio; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Statistically significant results ($p < 0.05$) are bolded. Covariates adjusted for in analyses include age group, sex (except in sex-stratified analyses), immigrant status, racialized background, place of residence, and household income adequacy quintile.

[a] Restricted to respondents ≥15 years old.

**TABLE 6**
**Associations between few (vs. frequent) difficulties falling or staying asleep and mental illness, suicidal ideation and positive mental health outcomes, stratified by age group, CCHS 2015**

| Outcome | Youth[a] (n = 1356) | | | | | | Adults[b] (n = 11 030) | | | | | | Older adults[c] (n = 4288) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | |
| | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL |
| Mental illness and suicidal ideation | | | | | | | | | | | | | | | | | | |
| Mood disorder | **0.11** | **0.05** | **0.24** | **0.13** | **0.06** | **0.26** | **0.23** | **0.18** | **0.29** | **0.27** | **0.21** | **0.35** | **0.41** | **0.28** | **0.61** | **0.43** | **0.28** | **0.65** |
| Anxiety disorder | **0.20** | **0.10** | **0.40** | **0.20** | **0.11** | **0.39** | **0.26** | **0.20** | **0.32** | **0.30** | **0.24** | **0.39** | **0.50** | **0.31** | **0.81** | **0.52** | **0.32** | **0.85** |
| Suicidal ideation, lifetime[d] | **0.12** | **0.06** | **0.25** | **0.15** | **0.08** | **0.31** | **0.31** | **0.25** | **0.38** | **0.35** | **0.29** | **0.44** | **0.49** | **0.34** | **0.73** | **0.51** | **0.35** | **0.76** |
| Positive mental health | | | | | | | | | | | | | | | | | | |
| High SRMH | **7.94** | **4.73** | **13.32** | **8.06** | **4.66** | **13.94** | **2.76** | **2.30** | **3.31** | **2.75** | **2.38** | **3.19** | **2.65** | **2.21** | **3.18** | **1.56** | **1.15** | **2.12** |
| High life satisfaction | **4.22** | **2.14** | **8.31** | **4.22** | **2.07** | **8.59** | **3.52** | **2.81** | **4.39** | **3.86** | **3.09** | **4.82** | **3.40** | **2.27** | **5.10** | **3.29** | **2.20** | **4.92** |
| High levels of happiness | **8.49** | **4.37** | **16.49** | **9.55** | **4.65** | **19.61** | **3.28** | **2.64** | **4.09** | **3.62** | **2.91** | **4.52** | **2.56** | **1.83** | **3.57** | **2.59** | **1.84** | **3.64** |
| High psychological well-being | **4.82** | **2.89** | **8.04** | **4.81** | **2.81** | **8.24** | **2.02** | **1.71** | **2.39** | **2.04** | **1.72** | **2.42** | **1.13** | **1.13** | **2.00** | **1.46** | **1.09** | **1.95** |
| High community belonging | **2.13** | **1.19** | **3.81** | **2.77** | **1.45** | **5.27** | **1.53** | **1.30** | **1.82** | **1.55** | **1.30** | **1.83** | **1.08** | **1.08** | **1.93** | **1.42** | **1.04** | **1.94** |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; OR, odds ratio; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Statistically significant results ($p < 0.05$) bolded. Covariates adjusted for in analyses include sex, immigrant status, racialized background, place of residence, and household income adequacy quintile.

[a] 12–17 years old.

[b] 18–64 years old.

[c] ≥65 years old.

[d] Restricted to respondents ≥15 years old.

**TABLE 7**
**Associations between refreshing (vs. not refreshing) sleep and mental illness, suicidal ideation and positive mental health measures, overall and stratified by sex, CCHS 2015**

| Outcome | Overall (n = 16 674) | | | | | | Males (n = 7649) | | | | | | Females (n = 9025) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | |
| | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL |
| Mental illness and suicidal ideation | | | | | | | | | | | | | | | | | | |
| Mood disorder | **0.30** | **0.25** | **0.36** | **0.34** | **0.27** | **0.41** | **0.29** | **0.20** | **0.41** | **0.33** | **0.23** | **0.47** | **0.32** | **0.25** | **0.40** | **0.34** | **0.26** | **0.43** |
| Anxiety disorder | **0.31** | **0.25** | **0.38** | **0.34** | **0.28** | **0.42** | **0.34** | **0.25** | **0.48** | **0.38** | **0.27** | **0.52** | **0.30** | **0.23** | **0.39** | **0.32** | **0.24** | **0.43** |
| Suicidal ideation, lifetime[a] | **0.42** | **0.36** | **0.50** | **0.47** | **0.40** | **0.55** | **0.47** | **0.37** | **0.60** | **0.52** | **0.40** | **0.66** | **0.41** | **0.33** | **0.51** | **0.44** | **0.35** | **0.54** |
| Suicidal ideation, past 12 months[a] | **0.21** | **0.14** | **0.31** | **0.23** | **0.15** | **0.35** | **0.18** | **0.10** | **0.33** | **0.17** | **0.09** | **0.32** | **0.24** | **0.14** | **0.40** | **0.26** | **0.15** | **0.45** |
| Positive mental health | | | | | | | | | | | | | | | | | | |
| High SRMH | **2.69** | **2.40** | **3.02** | **2.68** | **2.38** | **3.02** | **2.75** | **2.33** | **3.25** | **2.74** | **2.31** | **3.25** | **2.63** | **2.23** | **3.09** | **2.65** | **2.24** | **3.13** |
| High life satisfaction | **4.43** | **3.71** | **5.30** | **4.24** | **3.55** | **5.08** | **4.05** | **3.12** | **5.27** | **3.82** | **2.91** | **5.02** | **4.98** | **3.92** | **6.32** | **4.78** | **3.76** | **6.07** |
| High levels of happiness | **3.58** | **3.02** | **4.24** | **3.53** | **2.95** | **4.21** | **3.64** | **2.89** | **4.58** | **3.59** | **2.81** | **4.57** | **3.55** | **2.78** | **4.57** | **3.48** | **2.69** | **4.49** |
| High psychological well-being | **2.40** | **2.11** | **2.72** | **2.40** | **2.11** | **2.73** | **2.31** | **1.91** | **2.78** | **2.32** | **1.91** | **2.81** | **2.48** | **2.11** | **2.91** | **2.47** | **2.10** | **2.91** |
| High community belonging | **1.62** | **1.42** | **1.84** | **1.52** | **1.33** | **1.74** | **1.55** | **1.27** | **1.87** | **1.39** | **1.14** | **1.70** | **1.71** | **1.44** | **2.02** | **1.63** | **1.37** | **1.94** |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; OR, odds ratio; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Statistically significant results ($p < 0.05$) bolded. Covariates adjusted for in analyses include age group, sex (except in sex-stratified analyses), immigrant status, racialized background, place of residence and household income adequacy quintile.

[a] Restricted to respondents ≥15 years old.

**TABLE 8**
**Associations between refreshing (vs. not refreshing) sleep and mental illness, suicidal ideation and positive mental health measures, stratified by age group, CCHS 2015**

| Outcome | Youth[a] (n = 1356) | | | | | | Adults[b] (n = 11 030) | | | | | | Older adults[c] (n = 4288) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | | Unadjusted | | | Adjusted | | |
| | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL | OR | 95% LCL | 95% UCL |
| Mental illness and suicidal ideation | | | | | | | | | | | | | | | | | | |
| Mood disorder | **0.22** | **0.10** | **0.53** | **0.22** | **0.09** | **0.54** | **0.29** | **0.23** | **0.37** | **0.33** | **0.26** | **0.42** | **0.41** | **0.29** | **0.59** | **0.43** | **0.29** | **0.62** |
| Anxiety disorder | **0.40** | **0.20** | **0.80** | **0.42** | **0.23** | **0.77** | **0.31** | **0.24** | **0.39** | **0.34** | **0.27** | **0.43** | **0.30** | **0.19** | **0.48** | **0.30** | **0.19** | **0.49** |
| Suicidal ideation, lifetime[d] | **0.32** | **0.16** | **0.62** | **0.35** | **0.18** | **0.69** | **0.45** | **0.37** | **0.54** | **0.48** | **0.40** | **0.58** | **0.41** | **0.29** | **0.60** | **0.41** | **0.28** | **0.59** |
| Positive mental health | | | | | | | | | | | | | | | | | | |
| High SRMH | **2.62** | **1.76** | **3.91** | **2.54** | **1.67** | **3.86** | **3.01** | **2.62** | **3.46** | **2.90** | **2.52** | **3.34** | **1.81** | **1.45** | **2.26** | **1.74** | **1.39** | **2.19** |
| High life satisfaction | **7.03** | **3.39** | **14.57** | **6.83** | **3.21** | **14.55** | **4.41** | **3.59** | **5.41** | **4.37** | **3.54** | **5.38** | **3.12** | **2.15** | **4.54** | **3.03** | **2.08** | **4.43** |
| High levels of happiness | **5.64** | **2.74** | **11.58** | **5.77** | **2.70** | **12.31** | **3.57** | **2.91** | **4.37** | **3.58** | **2.91** | **4.39** | **2.90** | **2.11** | **4.00** | **2.92** | **2.13** | **4.00** |
| High psychological well-being | **2.91** | **1.95** | **4.35** | **2.79** | **1.85** | **4.20** | **2.55** | **2.19** | **2.97** | **2.49** | **2.14** | **2.91** | **1.79** | **1.44** | **2.22** | **1.76** | **1.42** | **2.19** |
| High community belonging | **1.73** | **1.08** | **2.76** | **1.95** | **1.18** | **3.23** | **1.50** | **1.29** | **1.75** | **1.49** | **1.28** | **1.74** | **1.81** | **1.42** | **2.30** | **1.80** | **1.41** | **2.30** |

**Abbreviations:** CCHS, Canadian Community Health Survey; LCL, lower confidence limit; OR, odds ratio; SRMH, self-rated mental health; UCL, upper confidence limit.

**Note:** Statistically significant results ($p < 0.05$) bolded. Covariates adjusted for in analyses include sex, immigrant status, racialized background, place of residence and household income adequacy quintile.

[a] 12–17 years old.

[b] 18–64 years old.

[c] ≥65 years old.

[d] Restricted to respondents ≥15 years old.

Manitoba, Alberta and Yukon;[21] symptoms of depression and anxiety among public safety personnel;[16] and higher internalizing problems at ages 12 to 15 years in girls and 12 to 13 years in boys, cross-sectionally.[46] Longitudinal research into these relationships and their potential mechanisms is needed, as growing evidence suggests that the associations between sleep quality and mental health are complex and bidirectional.[47,48] For example, research from Sweden and the United Kingdom has found that baseline depression and anxiety were associated with disturbed sleep 12 months later, with baseline disturbed sleep also predicting subsequent depression and anxiety.[47,48]

Few Canadian studies have investigated the associations of other measures of sleep quality with PMH and MI/SI. Research conducted among adolescents in Ontario suggests that daytime sleepiness is prevalent and may be associated with poorer outcomes,[49] calling for further inquiry into how other measures may be associated with mental health. Nonetheless, the current study contributes to existing research by examining a breadth of associations between sleep duration, sleep quality and indicators of PMH and MI/SI by sex and age groups. This adds to the evidence base and addresses research gaps that have been highlighted elsewhere.[23,24]

Approximately half of people aged 12 years and older in Ontario, Manitoba and Saskatchewan met sleep duration recommendations, lower than the almost two-thirds previously estimated based on the 2014–2015 Canadian Health Measures Survey.[1] This could be due to differences in the populations sampled (e.g. individuals living in different provinces), question wording (e.g. "each night" vs. "in a 24-hour period"), response options (e.g. categorical vs. continuous), etc. We found that meeting sleep duration recommendations was generally associated with higher odds of PMH and lower odds of MI/SI; however, these associations were inconsistent across sex and age groups.

Some other Canadian studies have reported inconsistent associations between short and long sleep durations and outcomes including SRMH and community belonging,[13,21] depression[14] and life satisfaction in general populations[21] and SRMH and life satisfaction among individuals with mood and/or anxiety disorders.[22] Such inconsistencies may be due to differences in conceptualizing and operationalizing sleep measures or mental health outcomes, with some studies using different instruments, devices or scoring methods or different cut-offs to measure short, medium and long sleep durations, for example.[14,21,22] Furthermore, the association between sleep duration and well-being may be mediated by other sleep indicators including sleep quality.[50] The associations of sleep duration and sleep quality with mental health may be complex and bidirectional, and longitudinal research into these relationships is needed. An initial study with youth in British Columbia and Ontario found that psychological well-being increased over one year among females who started meeting sleep duration recommendations.[51]

### *Strengths and limitations*

This study has a number of strengths. The use of data from a large population-based sample affords sufficient statistical power to conduct stratified analyses, by sex and age group, of associations between several sleep measures and indicators of PMH and MI/SI. The examination of both sleep quality and sleep duration is in line with recommendations to investigate both types of measures and their associations with health,[52] as they may be differentially associated with mental health.[53] Indeed, compared to meeting sleep duration recommendations, our two measures of sleep quality were more robust correlates of PMH and MI/SI.

In terms of limitations, the data analyzed were cross-sectional, and as a result, causality and directionality of associations could not be ascertained. Second, although the CCHS is conducted annually, we were limited to using data from 2015 due to availability of study measures; it is possible that the observed associations may have changed over time. For example, preliminary research has suggested that sleep quality and PMH have declined and symptoms of mental disorders have increased in a number of different populations, including Canadians, during the COVID-19 pandemic,[54-56] which may affect associations between sleep and mental health. However, the current study analyzes more recent data than some Canadian studies,[14,21] which may provide recent baseline data for investigating impacts of the COVID-19 pandemic. Findings may also inform sleep and mental health surveillance as well as future data collection and analysis.

Third, given that the sleep measures were collected only in Ontario, Manitoba and Saskatchewan, findings may not reflect other Canadian provinces or the territories, or individuals excluded from CCHS data collection or regression analyses (e.g. Indigenous Peoples). Fourth, all of the measures were self-reported and therefore subject to recall or social desirability bias. While generally not feasible for large-scale population-based surveillance given the additional costs and time needed for data collection, measuring sleep duration and quality through more detailed (e.g. sleep diaries over several days) or objective means (e.g. actigraphy) are considered to have greater validity for assessing sleep duration and sleep quality.[57] Interestingly, research from the UK that assessed sleep more objectively, using accelerometers, found that previous mental illness diagnoses were more strongly and consistently associated with measures of sleep quality than of sleep duration.[58]

Fifth, we applied sampling weights that take household and individual nonresponse into account in our analyses, but there is still a possibility that estimates could be biased due to issues like self-selection given the response rate.[59] Sixth, the PMH and MI/SI measures were examined as independent outcomes in our analyses. Other research has simultaneously examined PMH and mental illness, finding that Canadian youth with high psychological well-being and low depressive symptoms were the most likely to meet sleep duration recommendations, and those with low psychological well-being and high depressive symptoms were the least likely.[60]

Seventh, respondents with partially missing data who were excluded from the regression analyses could have differed from those with complete data, and results could have differed if variables were coded differently. Nevertheless, sensitivity analyses (not reported here) that included respondents with partially complete data or that dichotomized the sleep quality measures differently (i.e. "sometimes" included in the frequent sleep difficulties group; "sometimes" included in the refreshing sleep group) still found significant overall unadjusted and adjusted associations in the expected direction between the sleep measures and all the PMH and MI/SI outcomes. Finally, we cannot rule out the potential for residual confounding of the observed associations,

as other measures that have been associated with sleep and mental health were not measured in the 2015 CCHS (e.g. sleep hygiene) or not controlled for in our analyses (e.g. physical activity).[61,62]

## Conclusion

Sleep difficulties are prevalent among Canadians, and poor sleep quality and duration have been associated with lower well-being and mental ill-health. The current study demonstrates strong associations between good sleep quality and lower MI/SI and higher PMH across sex and age groups. Although less consistent, meeting sleep duration recommendations was also generally associated with PMH and MI/SI. Additional longitudinal research is needed to ascertain directionality of the associations. Future research may also benefit from examining how sleep interacts with other health behaviours (e.g. physical activity), from using objective or more detailed sleep measures (e.g. measures of sleep consistency and continuity) and from examining how sleep quality and sleep duration interact to affect health. Surveillance efforts should continue to monitor sleep behaviours and indicators of PMH and MI/SI to inform public health strategies targeted at promoting improved sleep and well-being among Canadians.

## Conflicts of interest

The authors do not have any conflicts of interest to disclose.

## Authors' contributions and statement

RD, CC and MB conceptualized the study. ZC conducted the statistical analyses and drafted the initial manuscript. All authors were involved in study design and analytic approach, contributed to interpretation of results, and reviewed and edited the draft manuscript. All authors approved the manuscript for publication.

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## References


1. Centre for Surveillance and Applied Research. Canadian chronic disease indicators (CCDI): data tool [Internet]. Ottawa (ON): Public Health Agency of Canada; 2021 [modified 2021 Dec 30; cited 2022 Jul 28]. Available from: https://health-infobase.canada.ca/ccdi/data-tool/

2. Centre for Surveillance and Applied Research. Physical activity, sedentary behaviour and sleep (PASS) indicators: data tool [Internet]. Ottawa (ON): Public Health Agency of Canada; 2021 [modified 2021 Dec 24; cited 2022 Jul 28]. Available from: https://health-infobase.canada.ca/pass/data-tool

3. Public Health Agency of Canada. Are Canadian children getting enough sleep? Infographic. Ottawa (ON): Public Health Agency of Canada; 2019 [cited 2021 Mar 17]. Available from: https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-children-getting-enough-sleep-infographic.html

4. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. Sleep. 2010;33(5):585-92. https://doi.org/10.1093/sleep/33.5.585

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

6. Steptoe A, Peacey V, Wardle J. Sleep duration and health in young adults. Arch Intern Med. 2006;166(16):1689-92. https://doi.org/10.1001/archinte.166.16.1689

7. Lao XQ, Liu X, Deng H-B, et al. Sleep quality, sleep duration, and the risk of coronary heart disease: a prospective cohort study with 60,586 adults. J Clin Sleep Med. 2018;14(1):109-17. https://doi.org/10.5664/jcsm.6894

8. João KA, Jesus SN, Carmo C, Pinto P. The impact of sleep quality on the mental health of a non-clinical population. Sleep Med. 2018;46:69-73. https://doi.org/10.1016/j.sleep.2018.02.010

9. Becker NB, Jesus SN, João KA, Viseu JN, Martins RI. Depression and sleep quality in older adults: a meta-analysis. Psychol Heal Med. 2017;22(8):889-95. https://doi.org/10.1080/13548506.2016.1274042

10. Zhai L, Zhang H, Zhang D. Sleep duration and depression among adults: a meta-analysis of prospective studies. Depress Anxiety. 2015;32(9):664-70. https://doi.org/10.1002/da.22386

11. Chiu HY, Lee HC, Chen PY, Lai YF, Tu YK. Associations between sleep duration and suicidality in adolescents: a systematic review and dose–response meta-analysis. Sleep Med Rev. 2018;42:119-26. https://doi.org/10.1016/j.smrv.2018.07.003

12. Kim JH, Park EC, Cho WH, Park JY, Choi WJ, Chang HS. Association between total sleep duration and suicidal ideation among the Korean general adult population. Sleep. 2013;36(10):1563-72. https://doi.org/10.5665/sleep.3058

13. Chang VC, Chaput JP, Roberts KC, Jayaraman G, Do MT. Factors associated with sleep duration across life stages: results from the Canadian Health Measures Survey. Health Promot Chronic Dis Prev Can. 2018;38(11):404-18. https://doi.org/10.24095/hpcdp.38.11.02

14. Singh M, Hall KA, Reynolds A, Palmer LJ, Mukherjee S. The relationship of sleep duration with ethnicity and chronic disease in a Canadian general population cohort. Nat Sci Sleep. 2020;12:239-51. https://doi.org/10.2147/NSS.S226834

15. Public Health Agency of Canada. Are Canadian adults getting enough sleep? Ottawa (ON): Public Health Agency of Canada; 2019 [modified 2019 Sep 06; cited 2021 Mar 17]. Available from: https://www.canada.ca/en/public-health/services/publications/healthy-living/canadian-adults-getting-enough-sleep-infographic.html

16. Angehrn A, Teale Sapach MJ, Ricciardelli R, MacPhee RS, Anderson GS, Carleton RN. Sleep quality and mental disorder symptoms among Canadian public safety personnel. Int J Environ Res Public Health. 2020;17(8):2708. https://doi.org/10.3390/ijerph17082708

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

18. Gilchrist JD, Battista K, Patte KA, Faulkner G, Carson V, Leatherdale ST. Effects of reallocating physical activity, sedentary behaviors, and sleep on mental health in adolescents. Ment Health Phys Act. 2021;20:100380. https://doi.org/10.1016/j.mhpa.2020.100380

19. Shin JE, Kim JK. How a good sleep predicts life satisfaction: the role of zero-sum beliefs about happiness. Front Psychol. 2018;9:1589. https://doi.org/10.3389/fpsyg.2018.01589

20. Short MA, Booth SA, Omar O, Ostlundh L, Arora T. The relationship between sleep duration and mood in adolescents: a systematic review and meta-analysis. Sleep Med Rev. 2020; 52:101311. https://doi.org/10.1016/j.smrv.2020.101311

21. Dai H, Mei Z, An A, Lu Y, Wu J. Associations of sleep problems with health-risk behaviors and psychological well-being among Canadian adults. Sleep Health. 2020;6(5):657-61. https://doi.org/10.1016/j.sleh.2020.02.003

22. Orpana H, Vachon J, Pearson C, Elliott K, Smith M, Branchard B. Correlates of well-being among Canadians with mood and/or anxiety disorders. Health Promot Chronic Dis Prev Can. 2016;36(12):302-13. https://doi.org/10.24095/hpcdp.36.12.04

23. Tremblay MS, Carson V, Chaput JP, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2016;41(6):S311-27. https://doi.org/10.1139/apnm-2016-0151

24. Ross R, Chaput JP, Giangregorio LM, et al. Canadian 24-hour movement guidelines for adults aged 18–64 years and adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2020; 45(10 (Suppl. 2)):S57-102. https://doi.org/10.1139/apnm-2020-0467

25. Huppert FA, Whittington JE. Evidence for the independence of positive and negative well-being: implications for quality of life assessment. Br J Health Psychol. 2003;8(1):107-22. https://doi.org/10.1348/135910703762879246

26. Ryff CD, Dienberg Love G, Urry HL, et al. Psychological well-being and ill-being: do they have distinct or mirrored biological correlates? Psychother Psychosom. 2006;75(2):85-95. https://doi.org/10.1159/000090892

27. World Health Organization. Mental health action plan 2013-2020. Geneva (CH): World Health Organization; 2013. https://apps.who.int/iris/bitstream/handle/10665/89966/9789241506021_eng.pdf

28. Bartram M, Chodos H, Gosling S, et al.; Mental Health Commission of Canada. Changing directions, changing lives: the mental health strategy for Canada. Calgary (AB): Mental Health Commission of Canada; 2012. https://www.mentalhealthcommission.ca/wp-content/uploads/drupal/MHStrategy_StrategySummary_ENG_0_1.pdf

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

30. Evans-Lacko S, Knapp M. Global patterns of workplace productivity for people with depression: absenteeism and presenteeism costs across eight diverse countries. Soc Psychiatry Psychiatr Epidemiol. 2016;51(11):1525-37. https://doi.org/10.1007/s00127-016-1278-4

31. Steensma C, Loukine L, Orpana H, et al. Describing the population health burden of depression: health-adjusted life expectancy by depression status in Canada. Health Promot Chronic Dis Prev Can. 2016;36(10):205-13. https://doi.org/10.24095/hpcdp.36.10.01

32. Hafner M, Stepanek M, Taylor J, Troxel WM, van Stolk C. Why sleep matters – the economic costs of insufficient sleep: a cross-country comparative analysis. Rand Heal Q. 2017; 6(4):11.

33. Keyes CL, Dhingra SS, Simoes EJ. Change in level of positive mental health as a predictor of future risk of mental illness. Am J Public Health. 2010;100(12):2366-71. https://doi.org/10.2105/AJPH.2010.192245

34. Hernandez R, Bassett SM, Boughton SW, Schuette SA, Shiu EW, Moskowitz JT. Psychological well-being and physical health: associations, mechanisms, and future directions. Emot Rev. 2018;10(1):18-29. https://doi.org/10.1177/1754073917697824

35. Statistics Canada. Canadian Community Health Survey (CCHS) - 2015. Ottawa (ON): Statistics Canada; 2016 [cited 2022 Jul 28]. Available from: https://www23.statcan.gc.ca/imdb/p3Instr.pl?Function=assembleInstr&a=1&&lang=en&Item_Id=238890

36. Chaput JP, Yau J, Rao DP, Morin CM. Prevalence of insomnia for Canadians aged 6 to 79. Health Rep. 2018;19; 29(12):16-21.

37. Chaput JP, Wong SL, Michaud I. Duration and quality of sleep among Canadians aged 18 to 79. Health Rep. 2017;28(9):28-33.

38. Public Health Agency of Canada. Health inequalities data tool: 2022 edition [Internet]. Ottawa (ON): Public Health Agency of Canada; 2022 [modified 2022 Jul 05; cited 2022 Nov 27]. Available from: https://health-infobase.canada.ca/health-inequalities/data-tool/

39. Centre for Surveillance and Applied Research. Suicide surveillance indicator framework: quick stats [Internet]. Ottawa (ON): Public Health Agency of Canada; 2019 [modified 2021 Oct 06; cited 2022 Nov 27]. Available from: https://health-infobase.canada.ca/ssif/

40. Liu L, Capaldi CA, Dopko RL. Suicide ideation in Canada during the COVID-19 pandemic. Health Promot Chronic Dis Prev Can. 2021;41(11):378-91. https://doi.org/10.24095/hpcdp.41.11.06

41. Varin M, Palladino E, Lary T, Baker M. An update on positive mental health among adults in Canada. Health Promot Chronic Dis Prev Can. 2020; 40(3):86-91. https://doi.org/10.24095/hpcdp.40.3.04

42. Centre for Surveillance and Applied Research. Positive mental health surveillance indicator framework: data tool [Internet]. Ottawa (ON): Public Health Agency of Canada; 2022 [modified 2022 Mar 10; cited 2022 Jul 28]. Available from: https://health-infobase.canada.ca/positive-mental-health/data-tool/

43. Keyes CL. Brief description of the Mental Health Continuum short form (MHC-SF) [Internet]. Atlanta (GA): Emory University; 2009 [cited 2022 Nov 27]. Available from: https://peplab.web.unc.edu/wp-content/uploads/sites/18901/2018/11/MHC-SFoverview.pdf

44. Orpana H, Vachon J, Dykxhoorn J, Jayaraman G. Measuring positive mental health in Canada: construct validation of the Mental Health Continuum-Short Form. Health Promot Chronic Dis Prev Can. 2017;37(4):123-30. https://doi.org/10.24095/hpcdp.37.4.03

45. Public Health Agency of Canada. Inequalities in the mental health of adults before and during the COVID-19 pandemic: data tool [Internet]. Ottawa (ON): Public Health Agency of Canada; 2022 [modified 2022 Oct 31; cited 2022 Nov 27]. Available from: https://health-infobase.canada.ca/covid-19/mental-health-inequalities/

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

47. Jansson-Fröjmark M, Lindblom K. A bidirectional relationship between anxiety and depression, and insomnia? A prospective study in the general population. J Psychosom Res. 2008;64(4):443-9. https://doi.org/10.1016/j.jpsychores.2007.10.016

48. Morphy H, Dunn KM, Lewis M, Boardman HF, Croft PR. Epidemiology of insomnia: a longitudinal study in a UK population. Sleep. 2007;30(3):274-80. https://doi.org/10.1093/sleep/30.3.274

49. Gibson ES, Powles AP, Thabane L, et al. "Sleepiness" is serious in adolescence: two surveys of 3235 Canadian students. BMC Public Health. 2006; 6(1):116. https://doi.org/10.1186/1471-2458-6-116

50. Lemola S, Ledermann T, Friedman EM. Variability of sleep duration is related to subjective sleep quality and subjective well-being: an actigraphy study. PLoS One. 2013;8(8):e71292. https://doi.org/10.1371/journal.pone.0071292

51. Faulkner G, Weatherson K, Patte K, Qian W, Leatherdale ST. Are one-year changes in adherence to the 24-hour movement guidelines associated with flourishing among Canadian youth? Prev Med. 2020;139:106179. https://doi.org/10.1016/j.ypmed.2020.106179

52. Bin YS. Is sleep quality more important than sleep duration for public health? Sleep. 2016;39(9):1629-30. https://doi.org/10.5665/sleep.6078

53. Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. J Psychosom Res. 1997;42(6):583-96. https://doi.org/10.1016/S0022-3999(97)00004-4

54. Jahrami H, BaHammam AS, Bragazzi NL, Saif Z, Faris M, Vitiello MV. Sleep problems during the COVID-19 pandemic by population: a systematic review and meta-analysis. J Clin Sleep Med. 2021;17(2):299-313. https://doi.org/10.5664/jcsm.8930

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

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

57. Matthews KA, Patel SR, Pantesco EJ, et al. Similarities and differences in estimates of sleep duration by polysomnography, actigraphy, diary, and self-reported habitual sleep in a community sample. Sleep Health. 2018; 4(1):96-103. https://doi.org/10.1016/j.sleh.2017.10.011

58. Wainberg M, Jones SE, Beaupre LM, et al. Association of accelerometer-derived sleep measures with lifetime psychiatric diagnoses: a cross-sectional study of 89,205 participants from the UK Biobank. PLoS Med. 2021;18(10):e1003782. https://doi.org/10.1371/journal.pmed.1003782

59. Baribeau B. Could nonresponse be biasing trends of health estimates? In: JSM Proceedings. Alexandria (VA): American Statistical Association; 2014: 4285-93.

60. Weatherson K, Gierc M, Patte K, Qian W, Leatherdale S, Faulkner G. Complete mental health status and associations with physical activity, screen time, and sleep in youth. Ment Health Phys Act. 2020;19:100354. https://doi.org/10.1016/j.mhpa.2020.100354

61. Gellis LA, Park A, Stotsky MT, Taylor DJ. Associations between sleep hygiene and insomnia severity in college students: cross-sectional and prospective analyses. Behav Ther. 2014;45(6):806-16. https://doi.org/10.1016/j.beth.2014.05.002

62. Kredlow MA, Capozzoli MC, Hearon BA, Calkins AW, Otto MW. The effects of physical activity on sleep: a meta-analytic review. J Behav Med. 2015; 38(3):427-49. https://doi.org/10.1007/s10865-015-9617-6

https://doi.org/10.24095/hpcdp.43.5.05

# At-a-glance

# Suicidal ideation among young adults in Canada during the COVID-19 pandemic: evidence from a population-based cross-sectional study

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## Abstract

Using data from the 2020 and 2021 cycles of the Survey on COVID-19 and Mental Health, we examined suicidal ideation among adults in Canada aged 18 to 34 years. The prevalence of suicidal ideation among adults aged 18 to 34 years was 4.2% in fall 2020 and 8.0% in spring 2021. The subgroup of adults aged 18 to 24 years had the highest prevalence of suicidal ideation, 10.7%, in spring 2021. Prevalence varied by sociodemographic characteristics and tended to be higher among people living in materially deprived areas. Suicidal ideation was strongly associated with pandemic-related stressors respondents experienced.

***Keywords:*** *surveillance, material deprivation, social deprivation, substance use, pandemic impacts, loneliness, anxiety, mental illness, coronavirus*

### *Highlights*

- In spring 2021, the prevalence of suicidal ideation among young adults aged 18 to 34 years was 8.0%.
- At 10.7%, the prevalence of suicidal ideation was highest in the subgroup of young adults aged 18 to 24 years, in spring 2021.
- The odds of suicidal ideation were higher among young adults who were White versus racialized, born in Canada versus immigrated to Canada, living with low or middle income, with high school education or less, or living in a materially deprived area.
- Pandemic-related experiences, stressful events and mental illness were strongly associated with suicidal ideation.

## Introduction

As early as April 2020, mental health professionals were raising concerns about the impact of the COVID-19 pandemic on suicidality.[1] Global suicide mortality rates remained unchanged or decreased fduring the first 9 to 15 months of the pandemic,[2] but suicidal ideation, suicide attempts and self-harm have increased in some populations and contexts.[3] In Canada, the prevalence of recent suicidal ideation among adults was 2.7% in 2019[4,5] and 2.4% in fall 2020,[4] increasing significantly to 4.2% in spring 2021.[5]

Studies suggest that young adults may have been more likely than older people to experience mental health problems such as anxiety and depressive symptoms,[6] loneliness,[7] psychological distress[8] and suicidality[4,5,9] since the start of the pandemic. In Canada in 2019, the odds of young adults aged 18 to 34 years reporting suicidal ideation were 5.4 times that of adults aged 65 years or older; these comparative odds increased to 8.2 by fall 2020 and to 9.7 by spring 2021.[4,5]

Systematic reviews and meta-analyses identified pandemic-specific risk factors for suicidal ideation.[3,10,11] Several reviews found that university students were at high risk for suicide-related behaviours, and associated risk factors included social isolation and mental illness.[11-13] As the long-term mental health effects of the COVID-19 pandemic are unclear, continued surveillance is needed to inform comprehensive and effective responses to suicide risks, including among young adults.

The objectives of this paper were to (1) estimate the prevalence of suicidal ideation during the COVID-19 pandemic among young adults aged 18 to 34 years, by age subgroup; and (2) identify sociodemographic characteristics and pandemic-related stressors that may be associated with an increased risk of suicidal ideation in this population.

## Methods

### *Data source*

We analyzed cross-sectional data from the 2020 and 2021 cycles of the nationally representative, population-based Survey on COVID-19 and Mental Health (SCMH).[14,15] Conducted by Statistics Canada with the Public Health Agency of Canada (PHAC), the SCMH was designed to collect data to assess the impacts of COVID-19 on adults' mental health and well-being. The 2020 cycle was conducted from 11 September through 4 December 2020 ("fall 2020"), and the 2021 cycle from 1 February through 7 May 2021 ("spring 2021").

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The two SCMH cycles had nearly identical methodologies. The target population was individuals aged 18 years or older in the ten provinces and the three territorial capitals. A simple random sample of dwellings from each province and territorial capital was selected from the Dwelling Universe File, and a household member was sampled in each dwelling. Excluded from the survey were residents of institutions; of collective, unmailable, inactive or vacant dwellings; and of First Nations reserves; together, these groups represented less than 2% of the population of interest.

Respondents completed the SCMH voluntarily through an electronic questionnaire or a computer-assisted telephone interview. The response rate was 53.3% (14689 responses) for the 2020 cycle and 49.3% (8032 responses) for the 2021 cycle. A total of 18936 respondents (83.3%) agreed to share their information with PHAC. Of these respondents, 3265 were aged 18 to 34 years. After excluding 10 respondents who did not answer the question about suicidal ideation, we analyzed data from the remaining 3255 respondents.

### *Measures*

Suicidal ideation was determined with the question, "Have you seriously contemplated suicide since the COVID-19 pandemic began?" Sociodemographic factors examined were gender, age group, racialized group member, immigrant status, income tertile, area of residence, education, living alone, and social and material deprivation. The social and material deprivation index developed by the Institut national de santé publique du Québec is a measure of social and material inequalities at the neighbourhood level, based on census dissemination areas.[16,17] The material deprivation component includes measures of area-level income, education and employment; the social deprivation component refers to social ties, that is, marital status, living alone and lone-parent family status.[16,17] Our analysis used the deprivation index based on the 2016 Census.

The variables for COVID-19 stressors were pandemic-related experiences; alcohol and cannabis use; concerns about violence in people's own homes; symptoms of mental illness; ever experienced stressful events in lifetime; and work status. These variables, and the surveys, have been described in detail elsewhere.[18]

### *Analysis*

We estimated the prevalence of suicidal ideation in the 2020 and 2021 SCMH separately, by gender and by age group. We then estimated the prevalence of suicidal ideation using combined data from the two cycles, by sociodemographic characteristics and pandemic-related stressors, and used logistic regressions to examine disparities of reporting suicidal ideation. We computed crude odds ratio (OR) and adjusted odds ratios (aOR) for gender, age group and survey year. All estimates were adjusted with sampling weights provided by Statistics Canada; 95% modified Clopper–Pearson confidence intervals (CI)[19] were estimated using the bootstrap technique. We conducted the analyses using SAS Enterprise Guide version 7.1 (SAS Institute, Cary, NC, USA).

## Results

Table 1 shows the prevalence of suicidal ideation, by gender and age group, in 2020 and 2021. For both cycles, this prevalence tended to be higher in younger age groups. In 2021, the prevalence of suicidal ideation among those aged 18 to 34 was 8.0%, with the highest prevalence (10.7%) among those aged 18 to 24. The prevalence of suicidal ideation was similar for women and men (7.8% versus 7.6%) in 2021. The seemingly higher prevalence among women in 2020 (5.2% versus 2.9% among men) was not statistically significant.

Table 2 shows the prevalence of and odds ratios for suicidal ideation among people aged 18 to 34 years, by sociodemographic characteristics and pandemic-related stressors, based on combined data from the 2020 and 2021 SCMH. The odds of suicidal ideation were significantly higher among people aged 18 to 24 years, those with low and middle income, those with lower educational attainment or those living in materially deprived areas. In contrast, the odds were significantly lower among racialized adults and immigrants to Canada. Young adults in the most materially deprived areas had almost double the

**TABLE 1**
**Prevalence of suicidal ideation during the COVID-19 pandemic,[a] by gender and age group, population aged 18–34 years, Canada**

| Variable | 2020[a] | | | 2021[a] | | |
|---|---|---|---|---|---|---|
| | n | Prevalence, % (95% CL) | OR (95% CL) | n | Prevalence, % (95% CL) | OR (95% CL) |
| Overall | 2096 | 4.2 (3.1, 5.6) | — | 1159 | 8.0 (5.7, 10.9) | — |
| Gender[b] | | | | | | |
| Female | 1210 | 5.2 (3.7, 7.1) | 1.8 (0.9, 3.7) | 705 | 7.8 (4.8, 11.8) | 1.0 (0.5, 2.1) |
| Male | 869 | 2.9 (1.5, 5.1) | (Ref.) | 448 | 7.6 (4.4, 12.1) | (Ref.) |
| Age group, years | | | | | | |
| 18–24 | 500 | 5.2 (2.9, 8.5) | 1.7 (0.9, 3.4) | 273 | 10.7 (6.0, 17.2) | 1.8 (0.8, 4.0) |
| 25–29 | 640 | 4.6 (2.7, 7.4) | 1.5 (0.8, 3.0) | 369 | 7.1 (3.3, 12.9) | 1.2 (0.5, 2.9) |
| 30–34 | 956 | 3.1 (2.0, 4.6) | (Ref.) | 517 | 6.2 (3.6, 9.7) | (Ref.) |

**Sources:** 2020 Survey on COVID-19 and Mental Health; 2021 Survey on COVID-19 and Mental Health.

**Abbreviations:** CL, confidence limit; OR, odds ratio; Ref., reference group in logistic regression.

[a] Data for the 2020 cycle of the Survey on COVID-19 and Mental Health were collected between 11 September and 4 December 2020, and for the 2021 cycle of the Survey on COVID-19 and Mental Health were collected between 1 February through 7 May 2021.

[b] Owing to the small number of samples, gender-diverse respondents were excluded from gender-stratified analyses, but were included in other analyses.

**TABLE 2**
**Prevalence and odds ratios of suicidal ideation during the COVID-19 pandemic,[a] by sociodemographic characteristics and pandemic-related stressors, population aged 18–34 years, Canada**

| Variable | n (%) | Prevalence, % (95% CL) | OR (95% CL) | aOR[b] (95% CL) |
|---|---|---|---|---|
| **Overall** | 3255 (100.0) | 6.0 (4.8, 7.5) | — | — |
| **Sociodemographic characteristics** | | | | |
| Gender[c] | | | | |
| Female | 1915 (50.5) | 6.4 (4.8, 8.5) | 1.3 (0.8, 2.2) | 1.3 (0.8, 2.2) |
| Male | 1317 (49.5) | 5.1 (3.3, 7.3) | (Ref.) | (Ref.) |
| Age group, years | | | | |
| 18–24 | 773 (34.4) | 7.9 (5.2, 11.3) | 1.8 (1.1, 3.1)* | 1.8 (1.0, 3.2)* |
| 25–29 | 1009 (28.8) | 5.8 (3.6, 8.8) | 1.3 (0.7, 2.4) | 1.2 (0.7, 2.2) |
| 30–34 | 1473 (36.8) | 4.5 (3.1, 6.2) | (Ref.) | (Ref.) |
| Racialized group member[d] | | | | |
| Yes | 935 (36.8) | 3.9 (2.4, 6.0) | 0.6 (0.3, 0.9)* | 0.6 (0.3, 1.0)* |
| No | 2293 (63.2) | 6.9 (5.2, 9.0) | (Ref.) | (Ref.) |
| Immigrant status | | | | |
| Yes | 661 (25.7) | 2.7 (1.1, 5.4) | 0.4 (0.2, 0.8)* | 0.4 (0.2, 0.9)* |
| No | 2588 (74.3) | 7.2 (5.6, 9.0) | (Ref.) | (Ref.) |
| Income tertile[e] | | | | |
| Low | 960 (30.8) | 6.6 (4.5, 9.3) | 2.0 (1.1, 3.9)* | 1.9 (1.0, 3.7) |
| Middle | 1006 (35.1) | 6.8 (4.5, 9.8) | 2.1 (1.1, 4.5)* | 2.0 (1.1, 4.0)* |
| High | 982 (34.1) | 3.3 (1.9, 5.5) | (Ref.) | (Ref.) |
| Area of residence | | | | |
| Population centre | 2625 (87.2) | 6.3 (4.9, 7.9) | 1.3 (0.6, 2.8) | 1.3 (0.6, 2.9) |
| Rural area | 580 (12.8) | 4.9 (2.3, 8.9) | (Ref.) | (Ref.) |
| Educational attainment | | | | |
| High school or less | 887 (32.8) | 10.1 (7.2, 13.8) | 2.7 (1.7, 4.3)*** | 3.0 (1.8, 5.2)*** |
| Postsecondary | 2362 (67.2) | 4.0 (2.9, 5.3) | (Ref.) | (Ref.) |
| Living alone | | | | |
| Yes | 524 (7.9) | 7.5 (5.0, 10.7) | 1.3 (0.8, 2.1) | 1.3 (0.8, 2.2) |
| No | 2723 (92.1) | 5.9 (4.6, 7.5) | (Ref.) | (Ref.) |
| Have children <18 years old at home | | | | |
| Yes | 873 (21.1) | 3.5 (2.2, 5.3) | 0.5 (0.3, 0.9)* | 0.6 (0.4, 1.2) |
| No | 2379 (78.9) | 6.7 (5.1, 8.5) | (Ref.) | (Ref.) |
| Material deprivation[f] | | | | |
| Least deprived area | 1542 (42.5) | 4.4 (3.1, 6.0) | (Ref.) | (Ref.) |
| Moderately deprived area | 566 (18.1) | 7.0 (4.0, 11.2) | 1.6 (0.9, 3.1) | 1.7 (0.9, 3.4) |
| Most deprived area | 950 (39.4) | 7.7 (5.2, 10.9) | 1.8 (1.1, 3.0)* | 1.8 (1.1, 3.0)* |
| Social deprivation[f] | | | | |
| Least deprived area | 909 (35.6) | 5.5 (3.2, 8.7) | (Ref.) | (Ref.) |
| Moderately deprived area | 549 (16.5) | 7.3 (4.0, 11.9) | 1.4 (0.6, 3.0) | 1.4 (0.6, 3.1) |
| Most deprived area | 1600 (48.0) | 6.3 (4.6, 8.3) | 1.2 (0.6, 2.1) | 1.2 (0.6, 2.1) |
| **Pandemic-related experience** | | | | |
| Loss of job/income | | | | |
| Yes | 990 (35.5) | 7.6 (5.4, 10.4) | 1.5 (0.9, 2.4) | 1.5 (0.9, 2.4) |
| No | 2248 (64.5) | 5.2 (3.7, 7.0) | (Ref.) | (Ref.) |

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**TABLE 2 (continued)**
**Prevalence and odds ratios of suicidal ideation during the COVID-19 pandemic,[a] by sociodemographic characteristics and pandemic-related stressors, population aged 18–34 years, Canada**

| Variable | n (%) | Prevalence, % (95% CL) | OR (95% CL) | aOR[b] (95% CL) |
|---|---|---|---|---|
| Difficulty meeting financial obligations/essentials | | | | |
| Yes | 648 (22.0) | 9.3 (6.3, 13.0) | 1.9 (1.2, 3.1)* | 1.9 (1.2, 3.2)* |
| No | 2607 (78.0) | 5.1 (3.8, 6.7) | (Ref.) | (Ref.) |
| Death of family/friend/colleague | | | | |
| Yes | 248 (8.6) | 7.5 (4.1, 12.3) | 1.3 (0.7, 2.4) | 1.2 (0.6, 2.4) |
| No | 2990 (91.4) | 5.9 (4.6, 7.5) | (Ref.) | (Ref.) |
| Feelings of loneliness/isolation | | | | |
| Yes | 1846 (56.7) | 10.0 (7.8, 12.5) | 12.4 (6.9, 22.0)*** | 11.1 (6.1, 20.2)*** |
| No | 1392 (43.3) | 0.9 (0.5, 1.5) | (Ref.) | (Ref.) |
| Emotional distress | | | | |
| Yes | 1727 (51.2) | 10.4 (8.1, 13.1) | 7.8 (4.0, 15.1)*** | 7.7 (3.7, 16.2)*** |
| No | 1511 (48.8) | 1.5 (0.8, 2.6) | (Ref.) | (Ref.) |
| Physical health problem | | | | |
| Yes | 1059 (34.3) | 11.1 (8.3, 14.5) | 3.6 (2.1, 6.0)*** | 3.1 (1.8, 5.5)*** |
| No | 2179 (65.7) | 3.4 (2.2, 5.0) | (Ref.) | (Ref.) |
| Challenges in personal relationship | | | | |
| Yes | 848 (26.7) | 9.7 (7.0, 12.9) | 2.2 (1.3, 3.5)** | 2.1 (1.3, 3.5)** |
| No | 2390 (73.3) | 4.7 (3.3, 6.5) | (Ref.) | (Ref.) |
| Number of COVID-19-related impacts experienced | | | | |
| 0 or 1 | 1203 (37.3) | 1.2 (0.4, 2.7) | (Ref.) | (Ref.) |
| 2 | 691 (20.0) | 5.1 (2.5, 9.3) | 4.4 (1.4, 13.9)* | 4.3 (1.3, 13.9)* |
| 3 | 545 (15.4) | 7.1 (3.7, 12.0) | 6.2 (2.1, 18.2)*** | 5.2 (1.7, 16.2)** |
| 4 | 423 (13.2) | 10.0 (6.3, 14.9) | 9.0 (3.3, 25.0)*** | 8.3 (2.9, 23.7)*** |
| 5+ | 376 (14.0) | 15.3 (10.4, 21.5) | 14.8 (5.5, 40.2)*** | 14.1 (4.8, 41.6)*** |
| **Substance use** | | | | |
| Increased alcohol consumption | | | | |
| Yes | 643 (16.6) | 8.6 (5.6, 12.4) | 1.6 (1.0, 2.7) | 1.7 (1.0, 2.9) |
| No | 2608 (83.4) | 5.5 (4.1, 7.1) | (Ref.) | (Ref.) |
| Ever used cannabis | | | | |
| Yes | 1503 (41.4) | 8.6 (6.5, 11.2) | 2.1 (1.3, 3.6)** | 2.1 (1.2, 3.5)** |
| No | 1748 (58.6) | 4.2 (2.7, 6.2) | (Ref.) | (Ref.) |
| Increased cannabis use | | | | |
| Yes | 377 (27.2) | 11.7 (7.2, 17.6) | 1.7 (0.9, 3.1) | 1.6 (0.8, 2.9) |
| No | 1129 (72.8) | 7.4 (5.1, 10.3) | (Ref.) | (Ref.) |
| **Moderate or severe symptoms of mental illness** | | | | |
| Generalized anxiety disorder | | | | |
| Yes | 687 (21.4) | 15.4 (11.5, 19.9) | 5.0 (3.0, 8.3)*** | 4.7 (2.7, 8.1)*** |
| No | 2527 (78.6) | 3.5 (2.3, 5.0) | (Ref.) | (Ref.) |
| Major depressive disorder | | | | |
| Yes | 833 (26.9) | 17.1 (13.2, 21.6) | 9.4 (5.4, 16.3)*** | 8.5 (4.8, 15.2)*** |
| No | 2342 (73.1) | 2.1 (1.3, 3.3) | (Ref.) | (Ref.) |
| Post-traumatic stress disorder | | | | |
| Yes | 331 (9.8) | 19.7 (14.2, 26.1) | 5.3 (3.2, 8.7)*** | 4.6 (2.6, 8.2)*** |
| No | 2836 (90.2) | 4.4 (3.2, 6.0) | (Ref.) | (Ref.) |

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**TABLE 2 (continued)**
**Prevalence and odds ratios of suicidal ideation during the COVID-19 pandemic,[a] by sociodemographic characteristics and pandemic-related stressors, population aged 18–34 years, Canada**

| Variable | n (%) | Prevalence, % (95% CL) | OR (95% CL) | aOR[b] (95% CL) |
|---|---|---|---|---|
| **Other factors** | | | | |
| Experienced stressful/traumatic event during life | | | | |
| Yes | 1860 (54.4) | 8.5 (6.6, 10.8) | 2.9 (1.5, 5.6)** | 2.9 (1.5, 5.6)** |
| No | 1392 (45.6) | 3.1 (1.6, 5.2) | (Ref.) | (Ref.) |
| Concern about violence in respondent's home | | | | |
| Yes | 125 (4.6) | 11.4 (3.3, 26.2) | 2.1 (0.6, 7.7) | 2.1 (0.5, 7.9) |
| No | 3124 (95.4) | 5.8 (4.5, 7.2) | (Ref.) | (Ref.) |
| Work status | | | | |
| Frontline worker | 338 (7.9) | 4.1 (1.9, 7.6) | 0.6 (0.3, 1.3) | 0.6 (0.3, 1.4) |
| Essential non-frontline worker | 830 (25.2) | 4.6 (2.7, 7.3) | 0.7 (0.4, 1.2) | 0.6 (0.4, 1.1) |
| Other[g] | 2081 (67.0) | 6.8 (5.1, 8.8) | (Ref.) | (Ref.) |

**Sources:** 2020 Survey on COVID-19 and Mental Health; 2021 Survey on COVID-19 and Mental Health.

**Abbreviations:** CL, confidence limit; OR, odds ratio; aOR, adjusted odds ratio; SCMH, Survey on COVID-19 and Mental Health; Ref., reference group in logistic regression.

**Note:** Missing data are 9% for income, 6% for social or material deprivation and <3% for others.

[a] Data from the 2020 SCMH cycle, collected between 11 September and 4 December 2020, and from the 2021 SCMH, collected between 1 February and 7 May 2021, were combined.

[b] Logistic regression adjusted for age and survey year in analysis by gender; adjusted for gender and survey year in analysis by age group; adjusted for gender, age group and survey year in analyses for other characteristics.

[c] Owing to the small number of samples, gender-diverse respondents were excluded from gender-stratified analysis, but were included in other analyses.

[d] Racialized group members include people classified as visible minorities or who identified as Indigenous; people who identified as White were coded as non-racialized.

[e] Income tertile was computed based on all populations in the survey aged 18 years or over.

[f] Least deprived areas are those in first and second quintiles of the deprivation index; moderately deprived areas are those in the third quintile; and most deprived areas are those in fourth and fifth quintile.

[g] All other respondents who were not frontline or essential workers, including those who were not employed.

* $p < 0.05$.

** $p < 0.005$.

*** $p < 0.001$.

odds of suicidal ideation compared with those in the least deprived areas. No significant differences were observed across levels of social deprivation.

Most of the pandemic-related experiences examined were associated with higher odds of suicidal ideation, and particularly feelings of loneliness (aOR = 11.1; 95% CI: 6.1–20.2) and emotional distress (aOR = 7.7; 95% CI: 3.7–16.2). A dose–response relationship was evident; the odds of young adults with 5 or more pandemic-related experiences reporting suicidal ideation were 14 times that of the odds reported by those with 0 or 1 of these experiences.

## Discussion

Using data from the 2020 and 2021 SCMH, we analyzed suicidal ideation among young adults aged 18 to 34 years in Canada. The prevalence of suicidal ideation tended to be higher in younger age groups and some sociodemographic subgroups. Pandemic-related stressors were associated with a higher prevalence of suicidal ideation.

In 2021 in Canada, the prevalence of suicidal ideation was 10.7% for young adults 18 to 24 years old; this was more than double the prevalence of suicidal ideation for adults overall, 4.2%.[5] Our findings on disparities in suicidal ideation between sociodemographic groups and associations with pandemic-related stressors experienced by young adults aged 18 to 34 are consistent with those of a recent study of adults 18 years and older.[18] The results also align with the findings of a United States study that reported the prevalence of seriously considering suicide in the past 30 days in June 2020 as higher among respondents aged 18 to 24 years than among older age groups, with prevalence decreasing with age.[9]

During the pandemic, young adults were more likely than older adults to develop anxiety and depressive symptoms[6,20-22] and experience loneliness;[7,23] they also had the largest increase in psychological distress over time.[8] School and university closures may have played a role by restricting opportunities to form and maintain social relationships.[24] Surveys conducted in Germany found a high prevalence of suicidal ideation among university students compared with before or during the early months of the pandemic.[25,26] A national survey of students aged 18 to 35 years in Norway found a negative correlation between time spent in person on campus and suicidal ideation.[27] Job loss could also be a factor; 15- to 24-year-olds experienced unemployment more than other age groups during the pandemic.[28,29] Those living in the most deprived areas had high prevalence of suicidal ideation, which supports previous findings that the rise in suicidal ideation is most likely to occur among young people living in poverty.[30]

Our analysis used data derived from survey cycles with modest sample sizes,

which limits the statistical power needed to detect significant differences between subgroups. In addition, the cross-sectional design does not allow for examination of causal relationships. Nevertheless, the results of this study indicate that young adults in Canada had a higher risk of suicidal ideation than older adults, and that modifiable factors, including loneliness, emotional distress and symptoms of mental illness, played important roles in increasing this risk. These findings suggest that age-specific clinical and population interventions that target key risk factors may help decrease suicidal thinking among young adults during the COVID-19 pandemic.

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## Conflicts of interest

The authors have no conflicts of interest.

## Authors' contributions and statement

All authors conceived the project. LL and GC drafted the article, and all authors contributed to its revisions. LL conducted the statistical analyses and all authors interpreted the results. All authors critically reviewed every draft of the article and approved the final submission.

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

## References

1. Gunnell D, Appleby L, Arensman E, et al.; COVID-19 Suicide Prevention Research Collaboration. Suicide risk and prevention during the COVID-19 pandemic. Lancet Psychiatry. 2020; 7(6):468-71. https://doi.org/10.1016/S2215-0366(20)30171-1

2. Pirkis J, Gunnell D, Shin S, et al. Suicide numbers during the first 9-15 months of the COVID-19 pandemic compared with pre-existing trends: an interrupted time series analysis in 33 countries. EClinicalMedicine. 2022;51: 101573. https://doi.org/10.1016/j.eclinm.2022.101573

3. Dubé JP, Smith MM, Sherry SB, Hewitt PL, Stewart SH. Suicide behaviors during the COVID-19 pandemic: a meta-analysis of 54 studies. Psychiatry Res. 2021;301:113998. https://doi.org/10.1016/j.psychres.2021.113998

4. Liu L, Capaldi CA, Dopko RL. Suicide ideation in Canada during the COVID-19 pandemic. Health Promot Chronic Dis Prev Can. 2021;41(11):378-91. https://doi.org/10.24095/hpcdp.41.11.06

5. Liu L, Pollock NJ, Contreras G, Tonmyr L, Thompson W. Prevalence of suicidal ideation among adults in Canada: results of the second Survey on COVID-19 and mental health. Health Rep. 2022;33(5):13-21. https://doi.org/10.25318/82-003-x202200500002-eng

6. Nwachukwu I, Nkire N, Shalaby R, et al. COVID-19 pandemic: age-related differences in measures of stress, anxiety and depression in Canada. Int J Environ Res Public Health. 2020; 17(17):6366. https://doi.org/10.3390/ijerph17176366

7. Wickens CM, McDonald AJ, Elton-Marshall T, et al. Loneliness in the COVID-19 pandemic: associations with age, gender and their interaction. J Psychiatr Res. 2021;136:103-8. https://doi.org/10.1016/j.jpsychires.2021.01.047

8. Duarte F, Jiménez-Molina Á. A longitudinal nationwide study of psychological distress during the COVID-19 pandemic in Chile. Front Psychiatry. 2022;13:744204. https://doi.org/10.3389/fpsyt.2022.744204

9. Czeisler ME, Lane RI, Petrosky E, et al. Mental health, substance use, and suicidal ideation during the COVID-19 pandemic – United States, June 24-30, 2020. MMWR Morb Mortal Wkly Rep. 2020;69(32):1049-57. https://doi.org/10.15585/mmwr.mm6932a1

10. Farooq S, Tunmore J, Wajid Ali M, Ayub M. Suicide, self-harm and suicidal ideation during COVID-19: a systematic review. Psychiatry Res. 2021;306:114228. https://doi.org/10.1016/j.psychres.2021.114228

11. Martinez-Líbano J, Cabrera MM. Suicidal ideation and suicidal thoughts in university students during the COVID-19 pandemic: a systematic review. Rev Argentina de Clin Psicol. 2021;30(2):390-405. https://www.revistaclinicapsicologica.com/archivesarticle.php?id=470

12. Shobhana SS, Raviraj KG. Global trends of suicidal thought, suicidal ideation, and self-harm during COVID-19 pandemic: a systematic review. Egypt J Forensic Sci. 2022;12(1):28. https://doi.org/10.1186/s41935-022-00286-2

13. Teixeira K, Lisboa JL, Dias BM, Ferreira RC, Zarzar PM, Sampaio AA. Suicidal ideation among university students during the COVID-19 pandemic: a rapid systematic review with meta-analysis. Res Soc Dev. 2022; 11(4):e2211426426. https://doi.org/10.33448/rsd-v11i4.26426

14. Statistics Canada. Survey on COVID-19 and Mental Health (SCMH): detailed information for September to December 2020 [Internet]. Ottawa (ON): Statistics Canada; 2020 [modified 2020 Sep 10; cited 2022 Oct 20]. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=1283036

15. Statistics Canada. Survey on COVID-19 and Mental Health (SCMH): detailed information for February to May 2021 [Internet]. Ottawa (ON): Statistics Canada; 2021 [cited 2022 Oct 20]. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=1295371

16. Gamache P, Hamel D, Blaser C. Material and social deprivation index: a summary [Internet]. Quebec (QC): Institut national de santé publique du Québec; 2019 [cited 2022 Oct 20]. Available from: http://www.inspq.qc.ca/en/publications/2639

17. Pampalon R, Hamel D, Gamache P, Simpson A, Philibert MD. Validation of a deprivation index for public health: a complex exercise illustrated by the Quebec index. Chronic Dis Inj Can. 2014;34(1):12-22. https://doi.org/10.24095/hpcdp.34.1.03

18. Liu L, Pollock NJ, Contreras G, Tonmyr L, Thompson W. Pandemic-related impacts and suicidal ideation among adults in Canada: a population-based cross-sectional study. Health Promot Chronic Dis Prev Can. 2022; 43(3):1-14. https://doi.org/10.24095/hpcdp.43.3.01

19. Clopper CJ, Pearson ES. The use of confidence or fiducial limits illustrated in the case of the binomial. Biometrika. 1934;26(4):404-13. https://doi.org/10.2307/2331986

20. Kučera D, Stuchlíková I, Mrhálek T. Impacts of COVID-19 pandemic on the mental health of working adults in the Czech Republic: analysis of self-report psychological data in a one year perspective. Eur J Investig Health Psychol Educ. 2021;11(3):1061-72. https://doi.org/10.3390/ejihpe11030079

21. Niedzwiedz CL, Green MJ, Benzeval M, et al. Mental health and health behaviours before and during the initial phase of the COVID-19 lockdown: longitudinal analyses of the UK Household Longitudinal Study. J Epidemiol Community Health. 2021; 75(3):224-31. https://doi.org/10.1136/jech-2020-215060

22. Jia R, Ayling K, Chalder T, et al. The prevalence, incidence, prognosis and risk factors for symptoms of depression and anxiety in a UK cohort during the COVID-19 pandemic. BJPsych Open. 2022;8(2):e64. https://doi.org/10.1192/bjo.2022.34

23. Loades ME, Chatburn E, Higson-Sweeney N, et al. Rapid systematic review: the impact of social isolation and loneliness on the mental health of children and adolescents in the context of COVID-19. J Am Acad Child Adolesc Psychiatry. 2020;59(11): 1218-39.e3. https://doi.org/10.1016/j.jaac.2020.05.009

24. Viner RM, Russell SJ, Croker H, et al. School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. Lancet Child Adolesc Health. 2020;4(5):397-404. https://doi.org/10.1016/S2352-4642(20)30095-X

25. Brailovskaia J, Teismann T, Friedrich S, Schneider S, Margrafa J. Suicide ideation during the COVID-19 outbreak in German university students: comparison with pre-COVID 19 rates. J Affect Disord Rep. 2021;6:100228. https://doi.org/10.1016/j.jadr.2021.100228

26. Dogan-Sander E, Kohls E, Baldofski S, Rummel-Kluge1 C. More depressive symptoms, alcohol and drug consumption: increase in mental health symptoms among university students after one year of the COVID-19 pandemic. Front Psychiatry. 2021; 12:790974. https://doi.org/10.3389/fpsyt.2021.790974

27. Sivertsen B, Knapstad M, Petrie K, O'Connor R, Lønning KJ, Hysing M. Changes in mental health problems and suicidal behaviour in students and their associations with COVID-19-related restrictions in Norway: a national repeated cross-sectional analysis. BMJ Open. 2022.12(2):e057492. https://doi.org/10.1136/bmjopen-2021-057492

28. OECD. Unemployment Rates, OECD - Updated: May 2020. Paris (FR): Organisation for Economic Co-operation and Development; 2020 [cited 2022 Oct 20]. Available from: http://www.oecd.org/employment/unemployment-rates-oecd-update-may-2020.htm

29. Statistics Canada. Labour force characteristics by age group, monthly, seasonally adjusted. Frequency: monthly. Table 14-10-0287-02 [Internet]. Ottawa (ON): Statistics Canada; 2022 [cited 2022 Oct 20]. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410028701

30. Barzilay S, Apter A. Recent research advances in identification and prevention of youth suicide risk. Curr Opin Psychiatry. 2022;35(6):395-400. https://doi.org/10.1097/YCO.0000000000000816

https://doi.org/10.24095/hpcdp.43.5.06

# World Non-Communicable Diseases Congress 2023




The third World Non-Communicable Diseases Congress (WNCD 2023) will cover major NCDs (for example, cardiovascular, cancer, diabetes, respiratory, and mental illness) and their risk factors through key lenses including:

1. Basic research, clinical sciences, public health, epidemiology, and behavioural sciences;
2. Health policy, promotion, and economics;
3. Use of modern application tools, such as Big Data analytics, machine learning, artificial intelligence, wearable technologies, and more.

WNCD 2023 will feature preconference symposiums and workshops, plenary sessions, concurrent paper sessions, poster presentations, exhibits, and valuable networking time. WNCD 2023 takes place June 25 to 30, 2023 in-person at the Metro Toronto Convention Centre. This is the first time the World Congress on NCDs is taking place in person in North America and is an excellent opportunity for researchers and policy makers to participate, present their research and hear from leading experts in the field.

The World Health Organization, Canadian Institutes of Health Research (CIHR), the U.S. National Institutes of Health (NIH), the World Bank, UNICEF and governments of Canada and India will be presenting sessions and have representatives at Congress.

On behalf of the Public Health Agency of Canada, we invite you to attend to represent Canadian science on the world stage. For those who are interested, additional information is available on the WNCD 2023 website.

Please feel free to share this information with interested colleagues and relevant networks.

https://doi.org/10.24095/hpcdp.43.5.07

# Call for Papers: Social Prescribing in Canada



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

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

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

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

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

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

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

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

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

**Submission deadline:** July 31, 2023.

## References

1. Bhatti S, Rayner J, Pinto AD, Mulligan K, Cole DC. Using self-determination theory to understand the social prescribing process: a qualitative study. BJGP Open. 2021;5(2):BJGPO.2020.0153. https://doi.org/10.3399/bjgpo.2020.0153

2. Morse DF, Sandhu S, Mulligan K, et al. Global developments in social prescribing. BMJ Global Health. 2022;7:e008524. https://doi.org/10.1136/bmjgh-2022-008524

3. Canadian Institute for Social Prescribing. What matters to you [Internet]. Toronto (ON): CISP; 2022 [cited 2022 Nov 16]. Available from: http://www.socialprescribing.ca/

# Other PHAC publications

**Researchers from the Public Health Agency of Canada also contribute to work published in other journals and books. Look for the following articles published in 2022 and 2023:**

Chaput J-P, Janssen I, **Lang JJ**, et al. Economic burden of excessive sedentary behaviour in Canada. Can J Public Health. 2023;1-10. https://doi.org/10.17269/s41997-022-00729-2

Chaput J-P, Janssen I, Sampasa-Kanyinga H, […] **Lang JJ**. Economic burden of low cardiorespiratory fitness in Canada. Prev Med. 2023;168:107424. https://doi.org/10.1016/j.ypmed.2023.107424

Charide R, Stallwood L, Munan M, […] **Stevens A**, et al. Knowledge mobilization activities to support decision-making by youth, parents, and adults using a systematic and living map of evidence and recommendations on COVID-19: protocol for three randomized controlled trials and qualitative user-experience studies. Trials. 2023;24(1):27. https://doi.org/10.1186/s13063-023-07067-9

**De Rubeis V**, Gonzalez A, **de Groh M, Jiang Y**, et al. Obesity and adverse childhood experiences in relation to stress during the COVID-19 pandemic: an analysis of the Canadian Longitudinal Study on Aging. Int J Obes. 2023;47(3):197-206. https://doi.org/10.1038/s41366-023-01258-9

Decker KM, Lambert P, Bravo J, **Demers A**, et al. Time trends in colorectal cancer incidence from 1992 to 2016 and colorectal cancer mortality from 1980 to 2018 by age group and geography in Canada. Am J Gastroenterol. 2023;118(2):338-44. https://doi.org/10.14309/ajg.0000000000002058

**Graham E**, Zhao B, **Flynn M**, […] **Orpana H, Kuo M, MacDougall L**. Using linked data to identify pathways of reporting overdose events in British Columbia, 2015–2017. Int J Popul Data Sci. 2022;7(1):1708. https://doi.org/10.23889/IJPDS.V7I1.1708

Kidokoro T, Tomkinson GR, **Lang JJ**, et al. Physical fitness before and during the COVID-19 pandemic: results of annual national physical fitness surveillance among 16,647,699 Japanese children and adolescents between 2013 and 2021. J Sport Health Sci. 2022; S2095-2546(22)00108-9. https://doi.org/10.1016/j.jshs.2022.11.002

Lim S, McDougall ARA, Goldstein M, […] **Ricci C**, et al. Analysis of a maternal health medicines pipeline database 2000–2021: new candidates for the prevention and treatment of fetal growth restriction. BJOG. 2023. https://doi.org/10.1111/1471-0528.17392

**Ricci C, Otterman V, Bennett T-L, Metcalfe S**, […] Dzakpasu S. Rates of and factors associated with exclusive and any breastfeeding at six months in Canada: an analysis of population-based cross-sectional data. BMC Pregnancy Childbirth. 2023;23(1):56. https://doi.org/10.1186/s12884-023-05382-2

**Seale E, de Groh M, Greene-Finestone L.** Fast food consumption in adults living in Canada: alternative measurement methods, consumption choices, and correlates. Appl Physiol Nutr Metab. 2023;48(2):163-71. https://doi.org/10.1139/apnm-2022-0252

**Srugo SA**, Fernandes da Silva D, **Menard LM, Shukla N, Lang JJ**. Recent patterns of physical activity and sedentary behaviour among pregnant adults in Canada. J Obstet Gynaecol Can. 2023;45(2):141-9. https://doi.org/10.1016/j.jogc.2022.11.011

Yong SJ, Halim A, Halim M, **Liu S**, et al. Inflammatory and vascular biomarkers in post-COVID-19 syndrome: a systematic review and meta-analysis of over 20 biomarkers. Rev Med Virol. 2023;33(2):e2424. https://doi.org/10.1002/rmv.2424