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# Original quantitative research

# Recreational screen time and mental health among Canadian children and youth

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## Abstract

**Background:** Higher amounts of recreational screen time have been associated with mental ill-health among children and youth. We examined the association between meeting the 24-Hour Movement Guideline's recreational screen time recommendation of ≤ 2 hours/day and indicators of mental health among children and youth.

**Methods:** Using the 2019 Canadian Health Survey on Children and Youth (N = 26 986), associations were assessed using age- and sex-stratified multivariate logistic regression. A secondary analysis used incremental amounts of screen time to explore dose–response relationships.

**Results:** Female children (5–11 years) who met the recommendation were less likely to be diagnosed with an anxiety disorder (adjusted odds ratio = 0.49; 99% CI: 0.25–0.96) or appear sad/depressed (0.60; 0.37–0.99). Female youth (12–17 years) who met the recommendation were more likely to report excellent or very good mental health, high happiness and high life satisfaction and less likely to report feeling stressed, anxious or depressed or be diagnosed with an anxiety disorder. Male youth who met the recommendation were more likely to report high happiness (1.74; 1.40–2.15) and high life satisfaction (1.64; 1.34–2.01) and less likely to feel stressed (0.74; 0.56–0.99) or experience psychosocial difficulties (0.79; 0.64–0.97). Some dose–response relationships were present among youth.

**Conclusion:** Adherence to the screen time recommendation was associated with several mental health indicators. Understanding these associations can help inform future research and guide strategies to improve mental health.

***Keywords:*** *recreational screen time, mental health, children, youth, anxiety, child functioning, mood disorder*

### *Highlights*

- Youth who met the recreational screen time recommendation of 2 hours or less per day were more likely than those who exceeded it to self-report high levels of positive mental health indicators, that is, excellent or very good mental health, high happiness and high life satisfaction.
- Youth who met the recommendation were less likely to report indicators of mental ill-health, such as often feeling stressed and psychosocial difficulties.
- The likelihood of youth reporting positive mental health indicators decreased as screen time increased.
- Female children, and not male children, who met the recommendation were less likely to often appear sad or depressed or be diagnosed with an anxiety disorder.

## Introduction

Reducing sedentary screen time and increasing physical activity are public health priorities.[1] Among children and youth, high levels of sedentary behaviour, including recreational screen time, are a risk factor for overweight and obesity, lower physical fitness and decreased self-esteem and prosocial behaviour.[2]

The Canadian 24-Hour Movement Guidelines recommend that children and youth aged 5 to 17 years accumulate no more than 2 hours per day of recreational screen time.[3-5] In 2018 to 2019, about 70% of Canadian children aged 5 to 11 years and 30% of youth aged 12 to 17 years met this recommendation.[1] Recreational screen time use, among youth in particular, has increased since about 2000,[6,7] and especially during the COVID-19 pandemic when the proportion of youth meeting the recreational screen time recommendation decreased from 33% in 2018 to 22% in 2021.[8,9]

Studies have found associations between sedentary screen time use and mental ill-health, where children and youth with higher screen time use reported more symptoms of depression, anxiety, hyperactivity

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and inattention.[10-13] Sedentary screen time was also associated with greater severity of depression and anxiety symptoms among Canadian youth.[14,15] Although the relationship between screen time and positive mental health has been less researched, a recent scoping review suggests that less sedentary behaviour is associated with greater mental wellness among children and youth.[16]

There has been little research examining associations between adherence to screen time recommendations and positive mental health indicators, mental ill-health, psychosocial difficulties and diagnosed mental health conditions among children and youth at a national level. This study, with the objective of examining the associations between meeting the recreational screen time recommendation and various indicators of mental health among children and youth in Canada, will help address this evidence gap, especially for younger children.

## Methods

### *Data source*

This study utilized data from the 2019 Canadian Health Survey on Children and Youth (CHSCY), a cross-sectional survey conducted by Statistics Canada. The CHSCY covers a representative sample of children and youth aged 1 to 17 years living in the 10 provinces and the three territories. Excluded from the survey coverage were children and youth living on First Nations reserves and in other Indigenous settlements in the provinces and in foster homes and institutions. The survey sampling frame is based on the Canada Child Benefit File which covers 98% of the population in the provinces and 96% in the territories.[17] The CHSCY is conducted under the authority of the *Statistics Act*, and therefore the use of these data for research purposes does not require research ethics board review.

This study included two age groups: children aged 5 to 11 years and youth aged 12 to 17 years. Children aged 3 to 4 years were excluded due to small sample sizes. For children and youth aged 5 to 17 years, a questionnaire was administered to the "person most knowledgeable" (PMK), who was most often a parent. A separate questionnaire was administered directly to youth; this questionnaire contained some of the same questions asked of children's PMKs.

Surveys were mostly completed online; those who did not complete the online questionnaire by the deadline were contacted by a Statistics Canada interviewer to complete the questionnaire by telephone. Response rates were 57.8% for children and 41.3% for youth. Statistics Canada addressed total nonresponse by using a multistage process of adjusting the weight of the persons who responded to the survey to account for those who did not respond, to reduce any potential nonresponse bias.[17]

Of the 27 771 CHSCY respondents, 26 986 (97.2%) had complete sociodemographic data and were included in the current study. Respondents with missing data for specific mental health indicators were excluded from the respective analyses. There were no significant differences in sociodemographic characteristics of nonrespondents versus the study sample.

### *Recreational screen time independent variable*

Respondents were asked how much time the child (5–11 years) or they (youth aged 12–17 years) spent using any electronic device such as a mobile device, computer, tablet, video game console or television while sitting down in the past 7 days. Response options were "no time," "less than 3 hours," "3 hours to less than 7 hours," "7 hours to less than 14 hours," "14 hours to less than 21 hours" or "21 hours or more." Children and youth were classified as meeting the recommendation if they accumulated less than 14 hours per week of recreational screen time, which corresponds to the Canadian 24-H Movement Guidelines of 2 hours or less per day.[3] The response options were converted from hours per week to hours per day.

### *Positive mental health outcomes*

Positive mental health outcomes were based on how they are defined and measured in the youth Positive Mental Health Surveillance Indicator Framework.[18]

#### Perceived or self-rated mental health

PMKs reported their perception of their child's mental health, while youth self-rated their mental health. The five-point response scale options were dichotomized as "excellent or very good mental health" (versus "good," "fair" or "poor").[18]

#### Life satisfaction

Youth reported their general life satisfaction on a scale from 0 ("very dissatisfied") to 10 ("very satisfied"). Responses of 9 or 10 were classified as high life satisfaction.[18]

#### Happiness

Youth who described themselves as "happy and interested in life" (versus "somewhat happy," "somewhat unhappy," "unhappy with little interest in life" or "so unhappy that life is not worthwhile") were categorized as having high happiness.[18]

### *Mental ill-health*

#### Perceived stress

Youth who reported that most of their days were "extremely" or "quite a bit stressful" (versus "not at all stressful," "not very stressful" or "a bit stressful") were categorized as often feeling stressed.[19]

#### Appearing anxious or sad

PMKs reported how frequently they thought the child or youth in their care appeared anxious, nervous or worried and how frequently they appeared sad or depressed. Participants whose PMK responded "daily" or "weekly" (versus "monthly," "a few times a year" or "never") were classified as often appearing anxious, nervous or worried or as often appearing sad or depressed.[20]

### *Psychosocial difficulties*

PMKs reported whether the child or youth had difficulties with (1) remembering things; (2) concentrating on activities they enjoy doing; (3) accepting changes to their routine; (4) controlling their behaviour; and (5) making friends. Responses of "some difficulty," "a lot of difficulty" or "cannot do at all" for any of these behaviours were classified as having at least some psychosocial difficulties (versus "no difficulty").

These prompts are based on the 2016 Washington Group/UNICEF Child Functioning Module, which was designed to provide an estimate of the proportion of children with functional difficulties and was intended for use on national surveys.[20] Although there are several components of this module, we only included those that were related to psychosocial difficulties.

### *Diagnosed mental disorders and mental health service use*

#### Diagnosed mood, anxiety or attention deficit hyperactivity disorder

PMKs identified (by responding "yes" or "no") whether the child or youth was ever diagnosed with an anxiety disorder, a mood disorder or attention deficit hyperactivity disorder (ADHD). The CHSCY did not include validated screening or diagnostic tools for diagnosing children or youth with these mental disorders; rather, PMKs reported whether the child or youth had ever been diagnosed with any one of these three disorders by a medical professional. Each of these disorders were analyzed as separate indicators.

#### Required or received mental health services

PMKs reported (by responding "yes" or "no") whether the child or youth received care, in the past 12 months, for difficulties focusing or controlling behaviour; for mental health issues; from a psychologist or counsellor; or from a psychiatrist. Participants were categorized as having required or received mental health services if their PMK responded "yes" to any of these four questions.

### *Covariates*

The following potential covariates were identified a priori: age (in years); identifying as Indigenous or as belonging to a racialized group (Arab, Black, Chinese, Filipino, Japanese, Korean, Latin American, South Asian, Southeast Asian, West Asian or Other versus White); immigrant status (landed immigrant, permanent resident or naturalized immigrant versus Canadian born); urban versus rural dwelling; household income adequacy (in quintiles); PMK's self-rated mental health (excellent or very good versus good, fair or poor); and PMK's self-reported stress (extremely or quite a bit stressful versus a bit stressful, not very stressful or not at all stressful).[21-24]

### *Statistical analysis*

Proportions and 99% confidence intervals (CIs) were calculated for recreational screen time and mental health indicators, by age group and sex. We used 99% CIs, rather than 95% CIs, to account for possible spurious associations that can result when examining the relationship between one independent variable and multiple outcomes. Reporting by gender (specifically nonbinary) was not possible due to the small sample sizes. In addition, because the question on gender was PMK-reported for children and self-reported for youth, we chose to report on sex to avoid potential discrepancies between youth self-reports and PMK reports.

Multivariate logistic regression models were fitted to examine the relationship between meeting the recreational screen time recommendation and mental health indicators separately for children and youth. A secondary analysis assessed the association between amounts of daily recreational screen time and mental health indicators to explore dose–response relationships. Results are presented as adjusted odds ratios (aORs) with 99% CIs. Statistically significant results were identified for $p$ values less than 0.01 and where CIs of odds ratios excluded the null (aOR = 1.0).

Estimates were weighted using sampling weights provided by Statistics Canada to account for survey design and nonresponse. Bootstrap weights were used for variance estimation. Analyses were conducted using SAS Enterprise Guide version 7.1 (SAS Institute Inc., Cary, NC, USA).

## Results

The majority of children (83.2%) and youth (56.9%) accumulated an average of less than 2 hours per day of leisure screen time (Table 1).

Most PMKs described their child as having "excellent or very good" mental health (83.0%); however, only 66.2% of youth self-rated their mental health as "excellent or very good." About two-thirds of youth reported high happiness (64.5%); less than half reported high life satisfaction (45.1%); and less than a quarter reported often feeling stressed (20.4%) (Table 1).

PMKs reported that 17.4% of children and 18.9% of youth often appeared anxious, nervous or worried and that 6.1% of children and 7.1% of youth often appeared sad or depressed (Table 1).

PMKs reported psychosocial difficulties for 51.3% of children and 42.9% of youth. The prevalence of PMKs reporting that children and youth had been diagnosed with a mood disorder (0.6% and 3.9%), an anxiety disorder (3.2% and 7.6%) or ADHD (7.6% and 10.2%) or required or received mental health services (15.7% and 18.4%) was relatively low.

### *Associations between meeting the recreational screen time recommendation and indicators of mental health among children (5–11 years)*

Compared with females who exceeded the recreational screen time recommendation, females who met the recommendation were less likely to have a PMK report that they often appeared sad or depressed (aOR = 0.60; 99% CI: 0.37–0.99) or that they had been diagnosed with an anxiety disorder (aOR = 0.49; 99% CI: 0.25–0.96) (Table 2).

### *Associations between meeting the recreational screen time recommendation and indicators of mental health among youth (12–17 years)*

Among both female and male youth, meeting the recreational screen time recommendation was associated with a greater likelihood of reporting high happiness (aORs: 1.84 and 1.74) and high life satisfaction (aORs: 1.80 and 1.64) and a lower likelihood of often feeling stressed (aORs: 0.64 and 0.74) (Table 3). In addition, meeting the recommendation was associated with a greater likelihood of female youth reporting "excellent or very good" mental health (aOR = 1.65; 99% CI: 1.33–2.04) and a lower likelihood of often appearing anxious, nervous or worried (aOR = 0.77; 99% CI: 0.60–0.97), often appearing sad or depressed (aOR = 0.68; 99% CI: 0.49–0.94) and being diagnosed with an anxiety disorder (aOR = 0.65; 99% CI: 0.46–0.92). Among male youth, meeting the recommendation was associated with a lower likelihood of experiencing at least some psychosocial difficulties (aOR = 0.79; 99% CI: 0.64–0.97).

### *Dose–response associations between recreational screen time and indicators of mental health*

Compared to female children who accumulated less than 1 hour per day of recreational screen time, those who exceeded the recommendation of 2 hours per day had a greater likelihood of being diagnosed with an anxiety disorder (aOR = 2.08; 99% CI: 1.02–4.28); no differences were observed between those with less than 1 hour per day and 1 to less than 2 hours per day of screen time (Table 4). Among male children, 2 hours or more per day of

**TABLE 1**
**Descriptive statistics for screen time variables, mental health outcomes and covariates for children and youth, 5–17 years, Canada, 2019**

| | Children (5–11 years) | | | Youth (12–17 years) | | |
|---|---|---|---|---|---|---|
| | Total (n = 16 272) | Females (n = 7886) | Males (n = 8386) | Total (n = 10 714) | Females (n = 5434) | Males (n = 5280) |
| Recreational screen time, % | | | | | | |
| Meeting the recommendation[a,b] | 83.2 | 85.0 | 81.3 | 56.9 | 60.9 | 53.2 |
| Amount of screen time per day[a,b], % | | | | | | |
| No time | 4.5 | 4.7 | 4.3 | 1.0 | 0.9[E] | 1.2 |
| Less than 30 minutes | 19.5 | 20.9 | 18.2 | 9.2 | 9.7 | 8.7 |
| 30 minutes to less than 1 hour | 30.5 | 31.5 | 29.5 | 22.7 | 24.0 | 21.4 |
| 1 hour to less than 2 hours | 28.7 | 28.0 | 29.4 | 24.0 | 26.3 | 21.9 |
| 2 hours to less than 3 hours | 11.5 | 10.5 | 12.4 | 20.8 | 19.8 | 21.7 |
| 3 hours or more | 5.4 | 4.5 | 6.3 | 22.3 | 19.3 | 25.2 |
| Positive mental health, % | | | | | | |
| Excellent or very good mental health[a,b] | 83.0 | 85.2 | 80.9 | 66.2 | 58.3 | 73.7 |
| High happiness[b] | n/a | n/a | n/a | 64.5 | 60.6 | 68.1 |
| High life satisfaction[b] | n/a | n/a | n/a | 45.1 | 41.1 | 48.8 |
| Mental ill-health, % | | | | | | |
| Often feels stressed[b] | n/a | n/a | n/a | 20.4 | 27.6 | 13.5 |
| Often appears anxious, nervous or worried[a] | 17.4 | 16.3 | 18.4 | 18.9 | 23.4 | 14.7 |
| Often appears sad or depressed[a] | 6.1 | 5.3 | 6.8 | 7.1 | 8.8 | 5.4 |
| Psychosocial difficulties, % | | | | | | |
| At least some psychosocial difficulties[a] | 51.3 | 46.1 | 56.2 | 42.9 | 41.3 | 44.4 |
| Diagnosed mental disorders and required or received mental health services, % | | | | | | |
| Diagnosed mood disorder[a] | 0.6 | 0.3[E] | 0.9[E] | 3.9 | 5.4 | 2.4 |
| Diagnosed anxiety disorder[a] | 3.2 | 2.6 | 3.8 | 7.6 | 9.7 | 5.7 |
| Diagnosed ADHD[a] | 7.6 | 4.3 | 10.7 | 10.2 | 6.4 | 13.7 |
| Required or received mental health services[a] | 15.7 | 11.9 | 19.3 | 18.4 | 19.8 | 17.1 |
| Covariates, % | | | | | | |
| Urban dwelling | 82.2 | 82.3 | 82.1 | 81.6 | 82.0 | 81.1 |
| Belonging to a racialized group or identifying as Indigenous | 33.2 | 32.3 | 33.9 | 33.3 | 33.8 | 32.9 |
| Immigrant (not Canadian born) | 8.6 | 8.4 | 8.9 | 14.6 | 15.4 | 13.8 |
| Household income adequacy | | | | | | |
| Q1 (lowest quintile) | 21.2 | 21.8 | 20.6 | 18.3 | 19.3 | 17.3 |
| Q2 | 20.2 | 20.2 | 20.3 | 18.5 | 18.0 | 19.1 |
| Q3 | 19.8 | 19.6 | 20.0 | 20.6 | 20.3 | 20.8 |
| Q4 | 19.2 | 19.2 | 19.2 | 19.8 | 19.8 | 19.8 |
| Q5 (highest quintile) | 19.6 | 19.3 | 19.9 | 22.8 | 22.6 | 22.9 |
| High PMK self-rated stress[a] | 28.4 | 28.6 | 28.2 | 28.7 | 29.4 | 28.1 |
| Excellent or very good PMK self-rated mental health[a] | 72.7 | 72.8 | 72.6 | 70.8 | 71.0 | 70.7 |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** ADHD, attention deficit hyperactivity disorder; n/a, not available; PMK, person most knowledgeable.

[a] Reported by the PMK.

[b] Reported by youth.

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

**TABLE 2**
**Association between adherence to the recreational screen time recommendation and indicators of mental health,[a] children (5–11 years), Canada, 2019**

| | aOR (99% CI) | | |
|---|---|---|---|
| | Total | Females | Males |
| Positive mental health | | | |
| Excellent or very good mental health | 1.14 (0.92–1.43) | 1.18 (0.84–1.65) | 1.13 (0.84–1.52) |
| Mental ill-health | | | |
| Often appears anxious, nervous or worried | 0.85 (0.70–1.04) | 0.80 (0.60–1.07) | 0.88 (0.67–1.17) |
| Often appears sad or depressed | 0.81 (0.58–1.12) | 0.60 (0.37–0.99)* | 1.00 (0.66–1.51) |
| Psychosocial difficulties | | | |
| At least some psychosocial difficulties | 0.84 (0.71–0.99)* | 0.87 (0.68–1.12) | 0.81 (0.65–1.02) |
| Diagnosed mental disorders and required or received mental health services | | | |
| Diagnosed mood disorder | 0.81 (0.34–1.92) | 0.35 (0.07–1.74)[E] | 1.07 (0.38–3.06)[E] |
| Diagnosed anxiety disorder | 0.79 (0.51–1.22) | 0.49 (0.25–0.96)* | 1.07 (0.61–1.91) |
| Diagnosed ADHD | 0.86 (0.64–1.14) | 0.63 (0.37–1.07) | 0.96 (0.69–1.34) |
| Required or received mental health services | 0.83 (0.67–1.03) | 0.80 (0.56–1.14) | 0.85 (0.65–1.11) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** ADHD, attention deficit hyperactivity disorder; aOR, adjusted odds ratio; CI, confidence interval; PMK, person most knowledgeable.

**Notes:** Models have been adjusted for age, identifying as Indigenous or as belonging to a racialized group, immigrant status, urban or rural residence, household income adequacy, PMK-reported mental health and PMK-reported stress. The reference group exceeded the recreational screen time recommendation of < 2 hours/day.

[a] Reported by the PMK.

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

*$p < 0.01$.

**TABLE 3**
**Association between adherence to the recreational screen time recommendation and indicators of mental health, youth aged 12–17 years, Canada, 2019**

| | aOR (99% CI) | | |
|---|---|---|---|
| | Total | Females | Males |
| Positive mental health | | | |
| Excellent or very good mental health[a] | 1.44 (1.23–1.68)* | 1.65 (1.33–2.04)* | 1.25 (0.99–1.57) |
| High happiness[a] | 1.80 (1.54–2.09)* | 1.84 (1.48–2.29)* | 1.74 (1.40–2.15)* |
| High life satisfaction[a] | 1.71 (1.48–1.98)* | 1.80 (1.44–2.23)* | 1.64 (1.34–2.01)* |
| Mental ill-health | | | |
| Often feels stressed[a] | 0.68 (0.56–0.82)* | 0.64 (0.50–0.82)* | 0.74 (0.56–0.99)* |
| Often appears anxious, nervous or worried[b] | 0.85 (0.71–1.03) | 0.77 (0.60–0.97)* | 0.98 (0.75–1.30) |
| Often appears sad or depressed[b] | 0.76 (0.59–0.99)* | 0.68 (0.49–0.94)* | 0.89 (0.58–1.37) |
| Psychosocial difficulties | | | |
| At least some psychosocial difficulties[b] | 0.81 (0.70–0.94)* | 0.84 (0.68–1.04) | 0.79 (0.64–0.97)* |
| Diagnosed mental disorders and mental health services[b] | | | |
| Diagnosed mood disorder | 0.79 (0.55–1.15) | 0.74 (0.48–1.12) | 0.90 (0.48–1.71) |
| Diagnosed anxiety disorder | 0.69 (0.53–0.90)* | 0.65 (0.46–0.92)* | 0.75 (0.49–1.13) |
| Diagnosed ADHD | 0.86 (0.67–1.12) | 0.90 (0.56–1.45) | 0.85 (0.62–1.15) |
| Required or received mental health services | 0.88 (0.72–1.06) | 0.82 (0.62–1.06) | 0.95 (0.72–1.25) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** ADHD, attention deficit hyperactivity disorder; aOR, adjusted odds ratio; CI, confidence interval; PMK, person most knowledgeable.

**Notes:** Models have been adjusted for age, identifying as Indigenous or as belonging to a racialized group, immigrant status, urban or rural residence, household income adequacy, PMK-reported mental health and PMK-reported stress. The reference group did not meet the recreational screen time recommendation of < 2 hours/day.

[a] Reported by youth.

[b] Reported by the PMK.

*$p < 0.01$.

**TABLE 4**
**Odds ratios for mental health by amounts of daily recreational screen time, children (5–11 years), Canada, 2019**

| | Total | | | | | | | Females | | | | | | | Males | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | < 1 h | 1 to < 2 h | | | ≥ 2 h | | | < 1 h | 1 to < 2 h | | | ≥ 2 h | | | < 1 h | 1 to < 2 h | | | ≥ 2 h | | |
| | Ref. | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL | Ref. | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL | Ref. | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL |
| Positive mental health[a] | | | | | | | | | | | | | | | | | | | | | |
| Excellent or very good mental health | Ref. | 0.86 | 0.7 | 1.07 | 0.83 | 0.65 | 1.05 | Ref. | 0.93 | 0.68 | 1.28 | 0.83 | 0.58 | 1.19 | Ref. | 0.81 | 0.61 | 1.09 | 0.81 | 0.59 | 1.11 |
| Mental ill-health[a] | | | | | | | | | | | | | | | | | | | | | |
| Often appears anxious, nervous or worried | Ref. | 1.08 | 0.9 | 1.31 | 1.21 | 0.98 | 1.49 | Ref. | 1.02 | 0.78 | 1.35 | 1.26 | 0.93 | 1.72 | Ref. | 1.13 | 0.87 | 1.47 | 1.19 | 0.89 | 1.59 |
| Often appears sad or depressed | Ref. | 0.99 | 0.75 | 1.31 | 1.23 | 0.87 | 1.74 | Ref. | 0.86 | 0.55 | 1.35 | 1.58 | 0.93 | 2.68 | Ref. | 1.07 | 0.73 | 1.56 | 1.03 | 0.67 | 1.58 |
| Psychosocial difficulties[a] | | | | | | | | | | | | | | | | | | | | | |
| At least some psychosocial difficulties | Ref. | 1.09 | 0.95 | 1.26 | 1.23* | 1.03 | 1.46 | Ref. | 1.05 | 0.86 | 1.29 | 1.17 | 0.90 | 1.52 | Ref. | 1.13 | 0.92 | 1.37 | 1.29* | 1.02 | 1.63 |
| Diagnosed mental disorders and mental health services[a] | | | | | | | | | | | | | | | | | | | | | |
| Diagnosed mood disorder | Ref. | 1.64[E] | 0.66 | 4.08 | 1.56[E] | 0.61 | 3.98 | Ref. | F | F | F | F | F | F | Ref. | 1.54[E] | 0.53 | 4.43 | 1.17[E] | 0.38 | 3.49 |
| Diagnosed anxiety disorder | Ref. | 1.12 | 0.75 | 1.66 | 1.33 | 0.84 | 2.12 | Ref. | 1.04[E] | 0.55 | 1.98 | 2.08*[E] | 1.02 | 4.28 | Ref. | 1.12 | 0.66 | 1.88 | 0.98 | 0.53 | 1.81 |
| Diagnosed ADHD | Ref. | 1.17 | 0.88 | 1.56 | 1.25 | 0.92 | 1.70 | Ref. | 0.96 | 0.55 | 1.68 | 1.56 | 0.88 | 2.77 | Ref. | 1.26 | 0.90 | 1.76 | 1.15 | 0.80 | 1.66 |
| Required or received mental health services | Ref. | 1.22* | 1.00 | 1.49 | 1.30* | 1.03 | 1.64 | Ref. | 1.10 | 0.80 | 1.52 | 1.30 | 0.88 | 1.91 | Ref. | 1.31* | 1.01 | 1.70 | 1.31 | 0.98 | 1.75 |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** ADHD, attention deficit hyperactivity disorder; aOR, adjusted odds ratio; h, hour; LCL, lower confidence limit; PMK, person most knowledgeable; Ref., reference; UCL, upper confidence limit.

**Notes:** Models have been adjusted for age, identifying as Indigenous or as belonging to a racialized group, immigrant status, urban or rural residence, household income adequacy, PMK-reported mental health and PMK-reported stress. The reference group had < 1 hour/day of screen time.

[a] Reported by the PMK.

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

F Too unreliable to be published due to high sampling variability.

* $p < 0.01$.

screen time was associated with a greater likelihood of experiencing psychosocial difficulties (aOR = 1.29; 99% CI: 1.02–1.63). Engaging in 1 to less than 2 hours per day of recreational screen time was associated with a greater likelihood of male children requiring or receiving mental health services (aOR = 1.31; 99% CI: 1.01–1.70).

A dose–response relationship was observed among female youth. As recreational screen time amounts increased, the likelihood of often feeling stressed, often appearing anxious, nervous or worried, experiencing psychosocial difficulties, and requiring or receiving mental health services also increased, whereas the likelihood of reporting high levels of positive mental health indicators decreased (Table 5).

For male youth, increasing screen time to 2 hours or more per day was associated with lower odds of reporting high levels of positive mental health indicators (Table 5). Having higher odds of experiencing psychosocial difficulties was only associated with recreational screen time amounts of more than 3 hours per day. Conversely, males accumulating less than the recommended amount of screen time per day (1 to < 2 hours) had a lower likelihood of appearing anxious, nervous or worried.

## Discussion

In this study we examined the relationship between meeting the 24-H Movement Guidelines' recreational screen time recommendation and various indicators of mental health among children and youth in Canada. We found that adhering to the recommendation was positively associated with positive mental health indicators and negatively associated with indicators of mental ill-health, psychosocial difficulties and diagnosed mental health conditions, with differences in effect size across sex and age groups.

### *Positive mental health*

Our findings suggest that meeting the recreational screen time recommendation was associated with all examined indicators of positive mental health among female youth and with happiness and life satisfaction among male youth. A population-based Canadian study found a similar, albeit inverted, significant association, whereby exceeding 2 hours per day of screen time was associated with worse self-rated mental health (i.e. good, fair or poor self-rated mental health) among youth.[25]

We observed a dose–response relationship between daily screen time amounts and positive mental health among male and female youth. Studies of North American and European youth have also found similar dose–response relationships between screen time amounts, happiness and life satisfaction.[26,27] Twenge et al.[27] found a U-shaped relationship between screen time and unhappiness, with the lowest prevalence of unhappiness reported when using electronic devices between < 1 hour and 1–2 hours per week, with variations by school grade and device type. Among female youth, life satisfaction decreased after 1 hour per day of screen time, whereas among male youth the decrease occurred after 1.5 hours per day of screen time.[26] This aligns with our findings of lower odds of reporting high happiness and life satisfaction with increasing amounts of screen time. Other studies, however, have found no association between recreational screen time and indicators of positive mental health.[13,28] These null associations may be due to differences in screen time and mental health measures, compared to our study, as well as differing population coverage, year of data collection, covariates, and PMK- versus child- or youth-reported data. We did not find a significant relationship between meeting the recreational screen time recommendation and PMK-rated child mental health. Interpreting the absence of significant associations is challenging as very few studies have examined this association in children.

### *Mental ill-health*

We found that meeting the recreational screen time recommendation was associated with a lower likelihood of female children and youth appearing sad or depressed and a lower likelihood of female youth appearing anxious, nervous or worried. The measures of mental ill-health we used in our study rely on questions about usual feelings of anxiety, nervousness or worry as well as sadness or depression, rather than symptoms of anxiety or depression, as commonly reported in the literature.[14,15,29-32] Although symptoms of anxiety or depression may be a proxy to the measures we used, they are not necessarily directly comparable. Some previous studies found positive associations between screen time and symptoms of anxiety or depression while others found none.[29-31] Studies examining gender differences found that female youth who played video games or watched TV for more than 3 hours per day had more symptoms of anxiety and depression than those with less screen time; however, the opposite or no association was found among male youth.[29,31,33] One study suggests that media use may be a protective factor for male youth, as those who spend more time playing video games and watching TV report fewer symptoms of anxiety and depression.[33] Our findings also show no associations between screen time and male youth appearing anxious, nervous or worried or appearing sad or depressed. The types of devices that male and female youth predominantly use could explain this difference[33-37] as screen types have varying associations with mental health.[14,38] For example, social media use can foster social comparison, which can negatively affect mental health, but such comparisons are less common when playing video games or watching TV.[38] However, limited research is available to examine the association between types of screen-based activities and mental health, especially among younger children.

Our findings also suggest that female and male youth who met the recommendation were less likely to often feel stressed. A study of adolescents from across 38 countries in Europe and North America found a positive linear association between the amount of screen time and levels of school-related stress with no apparent gender differences,[39] whereas a study of Ontario adolescents found no significant association.[40] Overall, our findings suggest that adherence to the screen time recommendation is associated with lower likelihoods of indicators of mental ill-health, especially among female youth.

### *Psychosocial difficulties*

Male youth who met the screen time recommendation were less likely to experience psychosocial difficulties, but we found no significant association with children or female youth. The literature examining associations between screen time and psychosocial difficulties is inconsistent. Large studies of children and youth from Australia and the United States found linear and U-shaped relationships between screen time and different psychosocial difficulties.[41,42]

**TABLE 5**
**Odds ratios for mental health by hours of daily recreational screen time, youth 12–17 years, Canada, 2019**

| | Total | | | | | | | | | | Females | | | | | | | | | | Males | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | < 1 h | 1 to < 2 h | | | 2 to < 3 h | | | ≥ 3 h | | | < 1 h | 1 to < 2 h | | | 2 to < 3 h | | | ≥ 3 h | | | < 1 h | 1 to < 2 h | | | 2 to < 3 h | | | ≥ 3 h | | |
| | Ref. | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL | Ref. | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL | Ref. | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL | aOR | 99% LCL | 99% UCL |
| Positive mental health[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Excellent or very good mental health | Ref. | 0.81* | 0.66 | 0.99 | 0.70* | 0.57 | 0.88 | 0.57* | 0.46 | 0.71 | Ref. | 0.76 | 0.57 | 1.00 | 0.61* | 0.46 | 0.82 | 0.47* | 0.34 | 0.63 | Ref. | 0.89 | 0.65 | 1.21 | 0.84 | 0.60 | 1.16 | 0.71* | 0.53 | 0.95 |
| High happiness | Ref. | 0.82 | 0.67 | 1.00 | 0.60* | 0.48 | 0.75 | 0.44* | 0.36 | 0.54 | Ref. | 0.66* | 0.50 | 0.87 | 0.55* | 0.40 | 0.74 | 0.37* | 0.27 | 0.50 | Ref. | 1.06 | 0.78 | 1.43 | 0.68* | 0.50 | 0.92 | 0.53* | 0.40 | 0.70 |
| High life satisfaction | Ref. | 0.75* | 0.62 | 0.91 | 0.59* | 0.48 | 0.72 | 0.45* | 0.37 | 0.56 | Ref. | 0.68* | 0.52 | 0.90 | 0.60* | 0.45 | 0.81 | 0.36* | 0.26 | 0.50 | Ref. | 0.82 | 0.62 | 1.08 | 0.59* | 0.45 | 0.78 | 0.54* | 0.41 | 0.71 |
| Mental ill-health | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Often feels stressed[a] | Ref. | 1.19 | 0.93 | 1.51 | 1.41* | 1.09 | 1.82 | 1.78* | 1.38 | 2.29 | Ref. | 1.24 | 0.91 | 1.68 | 1.42* | 1.02 | 1.99 | 2.10* | 1.51 | 2.92 | Ref. | 1.06 | 0.70 | 1.61 | 1.34 | 0.90 | 1.99 | 1.42 | 0.97 | 2.07 |
| Often appears anxious, nervous or worried[b] | Ref. | 0.94 | 0.74 | 1.19 | 1.04 | 0.81 | 1.33 | 1.24 | 0.96 | 1.59 | Ref. | 1.20 | 0.88 | 1.65 | 1.31 | 0.94 | 1.81 | 1.54* | 1.10 | 2.17 | Ref. | 0.62* | 0.41 | 0.92 | 0.74 | 0.50 | 1.09 | 0.94 | 0.66 | 1.34 |
| Often appears sad or depressed[b] | Ref. | 0.99 | 0.69 | 1.41 | 1.23 | 0.83 | 1.80 | 1.37 | 0.96 | 1.96 | Ref. | 1.17 | 0.73 | 1.86 | 1.50 | 0.92 | 2.45 | 1.67* | 1.06 | 2.63 | Ref. | 0.72 | 0.42 | 1.25 | 0.91[E] | 0.48 | 1.73 | 1.06 | 0.61 | 1.85 |
| Psychosocial difficulties[b] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| At least some psychosocial difficulties | Ref. | 1.08 | 0.90 | 1.30 | 1.17 | 0.96 | 1.44 | 1.38* | 1.13 | 1.68 | Ref. | 1.21 | 0.93 | 1.58 | 1.23 | 0.92 | 1.64 | 1.38* | 1.03 | 1.84 | Ref. | 0.95 | 0.73 | 1.24 | 1.11 | 0.84 | 1.48 | 1.36* | 1.03 | 1.79 |
| Diagnosed mental disorders and mental health services[b] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Diagnosed mood disorder | Ref. | 1.23 | 0.74 | 2.04 | 1.45 | 0.86 | 2.45 | 1.33 | 0.80 | 2.22 | Ref. | 1.50 | 0.81 | 2.77 | 1.71 | 0.93 | 3.15 | 1.63 | 0.88 | 3.02 | Ref. | 0.70[E] | 0.25 | 1.93 | 1.04[E] | 0.41 | 2.68 | 0.93[E] | 0.41 | 2.09 |
| Diagnosed anxiety disorder | Ref. | 1.18 | 0.83 | 1.67 | 1.43 | 0.99 | 2.06 | 1.69* | 1.17 | 2.44 | Ref. | 1.38 | 0.87 | 2.17 | 1.83* | 1.15 | 2.91 | 1.77* | 1.08 | 2.88 | Ref. | 0.87 | 0.49 | 1.53 | 0.95 | 0.52 | 1.74 | 1.53 | 0.89 | 2.61 |
| Diagnosed ADHD | Ref. | 1.31 | 0.92 | 1.87 | 1.06 | 0.73 | 1.55 | 1.53* | 1.07 | 2.20 | Ref. | 1.46 | 0.80 | 2.67 | 1.00[E] | 0.52 | 1.91 | 1.68 | 0.87 | 3.26 | Ref. | 1.22 | 0.79 | 1.89 | 1.08 | 0.69 | 1.71 | 1.47 | 0.98 | 2.21 |
| Required or received mental health services | Ref. | 1.10 | 0.85 | 1.42 | 1.06 | 0.81 | 1.39 | 1.32* | 1.01 | 1.72 | Ref. | 1.51* | 1.08 | 2.11 | 1.37 | 0.96 | 1.95 | 1.62* | 1.12 | 2.35 | Ref. | 0.75 | 0.51 | 1.10 | 0.81 | 0.54 | 1.20 | 1.06 | 0.73 | 1.54 |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** ADHD, attention deficit hyperactivity disorder; aOR, adjusted odds ratio; LCL, lower confidence limit; PMK, person most knowledgeable; Ref., reference; UCL, upper confidence limit.

**Notes:** Models have been adjusted for age, identifying as Indigenous or as belonging to a racialized group, immigrant status, urban or rural residence, household income adequacy, PMK-reported mental health and PMK-reported stress. The reference group has < 1 hour/day of screen time.

[a] Reported by youth.

[b] Reported by the PMK.

[E] Use with caution due to high sampling variability.

* $p < 0.01$.

The data we used in our study came from asking PMKs to report on their young or adolescent child's psychosocial difficulties, which may have led to discrepancies in the perceived difficulties. One study found that parents of boys reported more psychosocial difficulties than did the parents of girls, and that children tended to report more symptoms than their parents.[43]

### *Diagnosed mental disorders and mental health services*

We found that female children and youth who met the screen time recommendation were less likely to be diagnosed with an anxiety disorder. In addition, female youth who accumulated 1 to less than 2 hours or 3 or more hours per day of recreational screen time were more likely to require or receive mental health services than those with less than 1 hour of daily screen time. Previous research suggests that youth who used screens for 4 to 7 hours per day were more likely to be diagnosed with depression or anxiety and seek mental health care than their peers who used screens for 1 hour per day.[32,44] Poor mental health literacy, lack of emotional competence and fewer intimate relationships have been identified as barriers in seeking mental health care, particularly among male youth.[45,46] This may explain in part why we only observed the association between screen time and mental health service use among female youth in our study.

Overall, we found several significant associations between adherence to the recreational screen time recommendation and indicators of mental health among youth, with notable sex differences. However, very few statistically significant associations were found among children, which may be due to insufficient power to detect associations. While the available research shows that accumulating excess screen time in early childhood is associated with mental ill-health outcomes, it is possible that these outcomes may not be as apparent until adolescence.[11,47-49] In addition, the literature suggests that certain screen-based devices are more harmful to mental health compared to others, and the types of devices that children and youth predominantly use are different.[7,38]

### *Strengths and limitations*

Strengths of this study include the representative sample, and the comprehensive range of mental health indicators examined. In addition, in recognition of sex differences in screen time and mental health indicators, we explored sex-specific associations. Lastly, our study includes children as young as 5 years, which helps address the evidence gap in the literature for this population group.

However, this study does have several limitations. This work does not encompass the full spectrum of mental disorders and symptoms because data were not collected or sample sizes were too small to report. The survey question about recreational screen time included categorical response options across a 7-day period, which did not directly align with the recommended threshold of 2 hours per day or less. In addition, some of the survey questions used to assess the mental health outcomes in this study are not from validated mental health scales. The data were also collected retrospectively and were primarily based on self-report and report by the PMK, and may therefore be prone to recall, social desirability and informant biases.[43,50,51] Lastly, the CHSCY's cross-sectional design prevents inferences on causality and directionality. There is some evidence to suggest a bidirectional relationship; while screen time may be a predictor of mental health, pre-existing mental health problems or stressors may also predict screen time use.[48,52]

### *Future research and public health implications*

Other than this present study, there has been no research examining the associations between recreational screen time and mental health of children and youth by gender or sex; future studies examining gender and sex are needed to validate our findings. Given the cross-sectional nature of the present study and the potential for a bidirectional relationship, future longitudinal studies are needed to confirm the direction of effect. In addition, future work is needed to explore the association between recreational screen time and positive mental health among younger children, and the types of screens and programs being used by children and youth.

Understanding the dose–response of recreational screen time associations with the mental health among children and youth is important for public health intervention design. Previous work that supported the development of the 24-H Movement Guidelines suggested that engaging in recreational screen time for more than 2 hours per day is associated with a multitude of health problems.[2,5] Most previous research had been among youth, with limited evidence among younger children. Our findings support the 2-hour-per-day limit, but also suggest that in some cases, shorter amounts of screen time are associated with lower life satisfaction and happiness and greater anxiety, and higher doses are associated with poorer mental health. Promotion of the current limit of 2 hours per day remains an important intervention.

## Conclusion

Female children who meet the 24-H Movement Guidelines' screen time recommendation are less likely to appear sad or depressed and be diagnosed with an anxiety disorder. Youth who meet the screen time recommendation may have better mental health than those exceed the recommendation. Findings also suggest a dose–response relationship, where higher screen time amounts are associated with a reduced likelihood of reporting high levels of positive mental health indicators, among youth. As screen-based devices continue to be a part of everyday life for children and youth, it is important to monitor how their use affects both their mental and physical health, and to encourage healthy screen time habits. Future work is needed to examine if the association between recreational screen time and mental health has changed as a result of the COVID-19 pandemic and to explore longitudinal trends and associations.

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The authors have no conflicts of interests to disclose.

## Authors' contributions and statement

ST – Conceptualization, methodology, formal analysis, writing – original draft.

CW – Conceptualization, methodology, writing – review & editing.

SPW – Conceptualization, methodology, writing – review & editing.

MV – Conceptualization, methodology, writing – review & editing.

KCR – Conceptualization, methodology, writing – review & editing.

MTB – Conceptualization, methodology, writing – review & editing.

All authors have reviewed and approved the final manuscript.

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# Original quantitative research

# Outdoor physical activity, mental health, life satisfaction, happiness and life stress among Canadian adolescents

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## Abstract

**Introduction:** The objective of this article is to examine the association between outdoor physical activity (OPA) and mental health, life satisfaction, happiness and life stress among Canadian adolescents aged 12 to 17 years.

**Methods:** This cross-sectional and nationally representative study used self-reported data from the 2019 Canadian Health Survey on Children and Youth (n = 10 413). The survey categorized OPA into six groups (from 0 to ≥ 14 hours/week). Logistic regression analyses examined the associations between OPA levels and outcomes, with adjustments for relevant covariates.

**Results:** In adjusted models, OPA was not significantly associated with anxiety or depressive symptoms. Compared to adolescents with no OPA, those who engaged in ≥ 14 hours/week had higher odds of positive mental health (odds ratio [OR] = 1.64; 95% confidence interval [CI]: 1.13–2.38), high life satisfaction (OR = 1.75; 95% CI: 1.24–2.46) and high happiness (OR = 2.36; 95% CI: 1.59–3.50), independent of covariates including indoor physical activity. A positive dose–response relationship was observed between higher levels of OPA and life satisfaction and happiness.

**Conclusion:** Independent of indoor physical activity and other covariates, OPA was associated with positive mental health, high life satisfaction and high happiness, with levels of OPA of ≥ 14 hours/week (highest category) showing the strongest associations. Further studies are needed to elucidate the mechanisms linking OPA with higher life satisfaction and happiness.

***Keywords:*** *physical activity, outdoor time, youth, lifestyle, psychological health, public health, adolescence*

### *Highlights*

- Adolescence is an age when mental health may decline. Many adolescents in Canada are also insufficiently physically active.
- Outdoor physical activity (OPA) may provide added health benefits compared to indoor physical activity, but adolescents are spending less time outdoors.
- Independent of indoor physical activity, OPA was associated with positive mental health, high life satisfaction and high happiness among adolescents.
- 14 or more hours per week of OPA had the strongest associations with positive mental health, high life satisfaction and high happiness.
- There was a clear dose–response relationship between higher levels of OPA and life satisfaction and happiness.

## Introduction

Mental health refers to an individual's emotional, psychological and social well-being.[1] According to the Mental Health Commission of Canada, approximately 1.2 million children and adolescents are affected by mental illness, and 70% of adults with mental illness experienced symptoms before they were 18 years old.[2] As such, understanding the factors that contribute to adolescents' mental health is essential. The most common mental health issues among Canadian adolescents are anxiety (e.g. social anxiety disorder, specific phobias, performance anxiety) and depression.[3]

Positive mental health is the capacity to feel, think and act in ways that enhance

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the ability to enjoy life and deal with challenges.[4] Adolescents with high positive mental health are able to function well across different settings, experience happiness, cope well with life stress and enjoy a positive quality of life.[4] Adolescence is also a critical stage for developing behavioural, social and emotional habits—such as regular physical activity—that support long-term mental well-being.[5]

Mental health is complex and multifaceted, and an array of factors contribute to both positive and negative outcomes. For example, positive mental health (e.g. flourishing, resiliency) is associated with a physically active lifestyle and good sleep habits, whereas poor mental health is associated with excessive sedentary behaviour and screen time, physical inactivity, unhealthy diet and poor sleep patterns.[6] Avoiding mental illness and promoting good mental health therefore requires various strategies. Exploring positive mental health indicators can help improve adolescent mental health.

A behaviour that may contribute to adolescents' positive mental health is participation in outdoor physical activity (OPA). Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure.[7] OPA is any form of physical activity that occurs in any open-air, wild, natural or human-made outdoor space.[8] Physical activity is essential for adolescents' healthy development and has been associated with physical, social and mental health benefits.[9] Yet, according to the 2024 ParticipACTION Report Card on Physical Activity for Children and Youth, only 39% of children and youth in Canada are meeting the recommendation of 60 minutes per day of moderate-to-vigorous intensity physical activity.[10] The Canadian 24-Hour Movement Guidelines for Children and Youth[11] recommend that indoor time be replaced with outdoor time, but do not specify the amount of outdoor time because research in this area is scarce. Interacting with nature is positively associated with the mental health of children and youth (although the associations were not found to be consistently significant).[12] Interactions with nature, which can occur during outdoor activities, may also be associated with lower stress levels.[12,13] Compared with previous generations, adolescents spend less time in nature nowadays.[14] In addition, adolescence is a period when time spent outdoors and being physically active typically decrease and mental health also declines.[15]

Although the association between physical activity and mental health of children and adolescents in Canada has been widely investigated, there has been little research on OPA and mental health.[16,17] OPA has been less studied than indoor activity due to the challenges of controlling environmental variables like weather, terrain, air quality and social settings, which can complicate data collection and analysis. Also, few studies have explored the association between adolescent stress levels and interactions with the outdoors; additional research is needed to confirm any benefits.[12,18] Therefore, it is important to better understand the relationship between OPA and various mental health indicators, including anxiety, depressive symptoms, life satisfaction, happiness and life stress in adolescents.

Implementing treatments, interventions and prevention strategies for mental health issues among adolescents requires taking into account the specific problems they face, which are distinct from those experienced by adults. A better understanding of the connection between OPA and adolescents' mental health is important to help understand and develop important targets for intervention strategies and inform public health policies. Further, because various mental health problems begin in adolescence, identifying early life interventions can help prevent problems later in life.[2,19] Thus, this study addresses important knowledge gaps to better inform the development of future interventions.

The objective of this study was to investigate associations between OPA and self-perceived mental health, symptoms of anxiety and depression, life satisfaction, happiness and life stress among Canadian adolescents in a large and nationally representative sample. We hypothesized that greater levels of OPA would be associated with better mental health indicators after adjusting for indoor physical activity and other relevant covariates.

## Methods

### *Study design and participants*

This cross-sectional and nationally representative study used data from the 2019 Canadian Health Survey on Children and Youth (CHSCY). The CHSCY, which was conducted by Statistics Canada, collected data from 11 February to 2 August 2019. Detailed information about the survey methodology is available elsewhere.[20] In brief, the target population for the 2019 CHSCY was children and youth aged 1 to 17 years residing in the 10 provinces and the three territories of Canada. The Canada Child Benefit was used to create the survey frame. Excluded from the survey's coverage were children and youth living on First Nation reserves and other Indigenous settlements and in foster homes and institutions. Approximately 98% of the children and youth aged 1 to 17 years in the provinces and 96% of those in the territories were included in the survey frame. The present study focuses on adolescents aged 12 to 17 years because the OPA question was not used in the survey for children younger than 12 years old.

The adolescent participants answered survey questions directly through an online electronic questionnaire, or through telephone interview for follow-up on nonresponses. The 2019 CHSCY dataset had a total response rate of 52.1%, yielding a sample of 11 077 participants aged 12 to 17 years. For the present analysis, respondents lacking information on OPA (n = 36), outcome measures (n = 167) or covariate information (n = 461) were excluded, resulting in a final sample size of 10 413 participants.

Statistics Canada secured the necessary approvals to conduct the CHSCY. Pursuant to Article 2.2 of the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (https://ethics.gc.ca/eng/policy-politique_tcps2-eptc2_2022.html), Statistics Canada's CHSCY data are considered publicly available information through a mechanism set out by legislation or regulation that is protected by law and therefore their use for research purposes does not require review by a research ethics board, as long as there is no linkage to other datasets. Informed consent from participants was obtained before they participated in the study.

### *Independent variable: outdoor physical activity (OPA)*

Participants were asked about OPA in the past 7 days. Participants responded with either "yes" or "no" to the first question: "In the past 7 days, did you participate in

any outdoor physical activities in your free time, such as biking, skating, gardening, playing ball or sledding?" Those who answered "no" were coded as having no OPA. Those who responded "yes" were then asked, "In the past 7 days, how much time did you spend participating in these outdoor physical activities in your free time?" The five response options (< 1 hour; 1 hour to < 3 hours; 3 hours to < 7 hours; 7 hours to < 14 hours; and ≥ 14 hours) to this question and the "no OPA" response to the first question were used for analysis.

### *Dependent variables: perceived mental health, symptoms of anxiety and depression, life satisfaction, happiness and life stress*

Based on availability in the CHSCY, we included indicators of mental wellness and illness. Self-perceived mental health was assessed with the question "In general, how is your mental health?" The response options were "excellent," "very good," "good," "fair" and "poor." Responses of "excellent" and "very good" were coded as having high (positive) mental health, in accordance with the Positive Mental Health Surveillance Indicator Framework (PMHSIF).[21,22] Self-perceived mental health is a valid and widely used indicator in population health surveys associated with multi-item measures of mental health, self-rated health and health-related problems.[23]

Anxiety and depressive symptoms were assessed using validated questions from the Washington Group/UNICEF Child Functioning Module.[24-27] Anxiety symptoms were assessed using the question "How often do you seem very anxious, nervous or worried?" Depressive symptoms were assessed using the question, "How often do you seem very sad or depressed?" Response options included "daily," "weekly," "monthly," "a few times a year" and "never." Responses of "a few times a year" and "never" were coded as having low anxiety or depressive symptoms.[21]

Life satisfaction was measured with the following item: "Using a scale of 0 to 10, where 0 means 'very dissatisfied' and 10 means 'very satisfied,' how do you feel about your life as a whole right now?" For our study, we dichotomized life satisfaction as "high life satisfaction" (score ≥ 9), based on the PMHSIF.[21] Perceived life satisfaction is routinely used as an indicator of social well-being, and many studies have supported its validity.[28,29] Perceived mental health significantly influences life satisfaction.[30]

Self-perceived happiness was assessed by asking participants whether they would usually describe themselves as "happy and interested in life," "somewhat happy," "somewhat unhappy," "unhappy with little interest in life" or "so unhappy that life is not worthwhile." The response of "happy and interested in life" was coded as high self-perceived happiness. Single-item happiness measures have shown good validity in adolescents, and happiness is associated with positive health and healthier development during adolescence.[31,32]

Finally, self-perceived life stress was assessed by asking participants how they would describe the amount of stress in their life on most days. Response options included "not at all stressful," "not very stressful," "a bit stressful," "quite a bit stressful" and "extremely stressful." Responses of "not at all stressful," "not very stressful" and "a bit stressful" were coded as having low life stress, in line with Skinner et al.'s contextual analysis.[33] Perceived life stress is another important factor affecting population health, and single-item assessments have demonstrated comparability to more extensive questionnaires in gauging perceived general life stress.[34]

### *Covariates*

Age (in years), sex (male or female), highest parental education level (from less than high school to graduate university degree), ethnocultural background (14 options), average sleep duration (hours per night), total recreational screen time (from no recreational screen time to ≥ 21 hours/week), data collection season (winter, spring, summer), urbanicity (urban, rural) and indoor physical activity (from no indoor physical activity to ≥ 14 hours in the past week) were used as covariates in the analyses based on their availability in the dataset and their known associations in the literature with the outcome measures.

### *Statistical analysis*

Comparisons of positive mental health, low anxiety and depressive symptoms, high life satisfaction, high levels of happiness (or "high happiness") and low life stress between sex (male versus female) and age groups (12–14 and 15–17 years) were undertaken through chi-square tests. Logistic regression analyses were conducted to examine the associations between levels of OPA and the outcome measures, with adjustment for covariates. Odds ratios (OR) and 95% confidence intervals (CI) are reported. Statistics Canada–derived sample weights were applied to address the survey's sampling design and potential nonresponse bias to ensure that our findings remain representative of the broader adolescent population in Canada. To account for survey design effects, bootstrap weights were utilized to estimate 95% CI.

All statistical analyses were conducted using statistical package SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, US).

## Results

Of the adolescents in Canada, 36% reported no OPA and only 3% reported 14 or more hours per week (Table 1). The most noticeable difference was in the prevalence of high happiness among adolescents with no OPA (54.4%) and those with 14 or more hours per week of OPA (81.5%). There were several significant within-group differences in OPA for positive mental health, high life satisfaction, high happiness and low life stress. There were also many between-group significant differences by sex and age for most outcome measures.

In the fully adjusted models, OPA was not significantly associated with anxiety or depressive symptoms, and largely showed null associations with life stress (Table 2). However, compared to adolescents with no OPA (the reference group), those who engaged in 14 or more hours per week of OPA had higher odds of positive mental health (adjusted odds ratio [aOR] = 1.64; 95% CI: 1.13–2.38), high life satisfaction (aOR = 1.75; 95% CI: 1.24–2.46) and high happiness (aOR = 2.36; 95% CI: 1.59–3.50), independent of indoor physical activity time and other covariates. There were also clear dose–response associations for high life satisfaction and high happiness.

Subgroup analyses stratified by sex demonstrated similar and stronger overall associations for males versus females and younger versus older adolescents (12–14 years versus 15–17 years) (Tables 3–6).

**TABLE 1**
**Prevalence of perceived mental health, anxiety and depressive symptoms, life satisfaction, happiness and life stress based on levels of OPA among adolescents aged 12–17 years, by sex and age group, Canada, 2019 (n = 10 413)**

| | % (95% CI) | | | | | |
|---|---|---|---|---|---|---|
| | 0 h/wk (n = 3783) | < 1 h/wk (n = 727) | 1 to < 3 h/wk (n = 2700) | 3 to < 7 h/wk (n = 2116) | 7 to < 14 h/wk (n = 787) | ≥ 14 h/wk (n = 300) |
| Positive mental health | | | | | | |
| Total sample | 60.1 (58.0–62.2) | 64.8 (60.0–69.6) | 69.0 (66.6–71.3) | 71.9 (69.4–74.3) | 74.6 (70.4–78.7) | 78.0 (72.2–83.8)* |
| Male | 69.3 (66.3–72.4)[a] | 71.8 (65.3–78.2)[a] | 75.6 (72.6–78.5)[a] | 77.1 (74.1–80.1)[a] | 78.8 (74.2–83.4)[a] | 83.2 (76.4–90.0)[a] |
| Female | 53.0 (50.2–55.8) | 58.7 (51.8–65.6) | 62.1 (58.4–65.8) | 64.3 (60.3–68.4) | 65.4 (57.6–73.2) | 68.2 (56.7–79.6) |
| 12–14 years | 69.9 (67.1–72.8)[b] | 73.5 (68.1–78.9)[b] | 75.2 (72.5–78.0)[b] | 77.5 (74.5–80.5)[b] | 82.1 (78.0–86.2)[b] | 83.5 (77.4–89.6)[b] |
| 15–17 years | 53.4 (50.6–56.2) | 54.1 (46.2–61.9) | 60.4 (56.4–64.5) | 64.3 (60.2–68.4) | 59.8 (51.8–67.9) | 70.4 (59.5–81.3) |
| Low anxiety symptoms | | | | | | |
| Total sample | 67.7 (65.7–69.7) | 67.2 (62.6–71.8) | 70.4 (68.2–72.7) | 72.1 (69.5–74.7) | 69.0 (64.8–73.2) | 68.2 (61.5–74.9) |
| Male | 77.2 (74.5–79.9)[a] | 72.6 (66.3–79.0)[a] | 76.5 (73.4–79.7)[a] | 77.6 (74.5–80.8)[a] | 72.5 (67.5–77.4)[a] | 70.6 (62.3–79.0) |
| Female | 60.4 (57.7–63.2) | 62.5 (55.7–69.3) | 64.1 (60.6–67.6) | 64.2 (60.0–68.4) | 61.4 (53.5–69.4) | 63.7 (52.4–75.0) |
| 12–14 years | 71.3 (68.3–74.3)[b] | 66.4 (60.5–72.4) | 73.1 (70.3–75.9)[b] | 72.5 (69.1–75.9) | 70.6 (65.6–75.6) | 67.8 (59.2–76.4) |
| 15–17 years | 65.2 (62.6–67.9) | 68.2 (61.3–75.0) | 66.9 (63.0–70.7) | 71.6 (67.8–75.3) | 65.8 (58.3–73.4) | 68.8 (58.4–79.3) |
| Low depressive symptoms | | | | | | |
| Total sample | 83.0 (81.4–84.5) | 82.2 (78.2–86.1) | 85.5 (83.7–87.3) | 85.7 (83.8–87.5) | 86.3 (83.0–89.5) | 85.1 (80.2–90.0) |
| Male | 88.1 (86.1–90.1)[a] | 88.4 (84.0–92.8)[a] | 89.1 (86.8–91.5)[a] | 90.2 (88.1–92.4)[a] | 87.5 (83.6–91.3) | 87.2 (81.4–92.9) |
| Female | 79.0 (76.7–81.3) | 76.7 (70.6–82.9) | 81.8 (79.1–84.5) | 79.1 (75.7–82.6) | 83.7 (77.7–89.7) | 81.3 (72.1–90.5) |
| 12–14 years | 87.3 (85.4–89.3)[b] | 83.7 (79.0–88.3) | 87.0 (84.7–89.3) | 86.4 (84.1–88.8) | 85.7 (81.5–89.9) | 88.6 (83.1–94.2) |
| 15–17 years | 80.0 (77.7–82.2) | 80.4 (73.9–86.8) | 83.5 (80.7–86.3) | 84.7 (81.6–87.8) | 87.4 (82.4–92.3) | 80.3 (71.6–88.9) |
| High life satisfaction | | | | | | |
| Total sample | 37.5 (35.3–39.6) | 42.9 (37.9–47.8) | 47.9 (45.4–50.5) | 51.1 (48.2–54.1) | 57.0 (52.4–61.5) | 62.3 (55.4–69.3)* |
| Male | 40.3 (37.0–43.6)[a] | 44.6 (37.6–51.7) | 49.6 (46.2–53.0) | 54.3 (50.5–58.1)[a] | 60.8 (55.5–66.2)[a] | 65.0 (56.7–73.3) |
| Female | 35.3 (32.4–38.1) | 41.3 (34.4–48.2) | 46.2 (42.4–49.9) | 46.5 (41.9–51.2) | 48.6 (40.6–56.5) | 57.4 (45.2–69.6) |
| 12–14 years | 46.0 (42.7–49.4)[b] | 53.2 (46.6–59.8)[b] | 55.2 (52.0–58.4)[b] | 60.0 (56.1–63.9)[b] | 64.4 (59.0–69.7)[b] | 68.4 (60.5–76.3) |
| 15–17 years | 31.6 (28.8–34.4) | 30.2 (23.1–37.2) | 37.9 (34.0–41.9) | 39.2 (35.0–43.3) | 42.5 (34.5–50.5) | 54.0 (41.5–66.5) |
| High happiness | | | | | | |
| Total sample | 54.4 (52.3–56.5) | 62.8 (57.9–67.6) | 68.3 (65.9–70.7) | 73.7 (71.0–76.3) | 76.4 (72.6–80.1) | 81.5 (75.9–87.1)* |
| Male | 57.0 (53.6–60.3)[a] | 67.5 (60.6–74.4) | 70.2 (67.0–73.5) | 75.8 (72.5–79.2) | 77.8 (73.5–82.1) | 85.0 (79.6–90.4) |
| Female | 52.4 (49.5–55.2) | 58.7 (51.8–65.6) | 66.2 (62.7–69.8) | 70.5 (66.3–74.7) | 73.3 (65.9–80.7) | 75.0 (63.1–86.9) |
| 12–14 years | 61.6 (58.5–64.7)[b] | 73.8 (68.6–79.1)[b] | 71.4 (68.4–74.4)[b] | 77.1 (73.8–80.4)[b] | 80.0 (75.7–84.3)[b] | 86.9 (81.7–92.1)[b] |
| 15–17 years | 49.4 (46.6–52.3) | 49.2 (41.3–57.0) | 64.1 (60.1–68.0) | 69.0 (64.9–73.1) | 69.3 (62.0–76.5) | 74.0 (63.3–84.7) |
| Low life stress | | | | | | |
| Total sample | 74.7 (72.9–76.5) | 76.6 (72.3–81.0) | 82.7 (80.7–84.7) | 84.9 (82.8–87.0) | 83.1 (79.4–86.8) | 83.1 (77.0–89.2)* |
| Male | 83.3 (80.9–85.7)[a] | 84.7 (79.7–89.6)[a] | 88.6 (86.3–90.9)[a] | 89.4 (87.0–91.7)[a] | 87.6 (83.9–91.3)[a] | 86.6 (79.8–93.4) |
| Female | 68.1 (65.5–70.7) | 69.7 (63.2–76.1) | 76.5 (73.2–79.8) | 78.5 (74.8–82.2) | 73.2 (65.4–81.0) | 76.6 (64.7–88.5) |
| 12–14 years | 83.6 (81.3–85.8)[b] | 83.8 (79.2–88.4)[b] | 87.1 (84.8–89.3)[b] | 90.1 (87.7–92.5)[b] | 88.6 (84.8–92.5)[b] | 93.9 (90.0–97.8)[b] |
| 15–17 years | 68.6 (66.0–71.3) | 67.8 (60.1–75.5) | 76.6 (73.1–80.1) | 77.9 (74.4–81.5) | 72.2 (64.7–79.7) | 68.3 (56.4–80.3) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** CI, confidence interval; h, hour; OPA, outdoor physical activity; wk, week.

**Notes:** A chi-square test was used to compare proportions between sex and age groups. Positive mental health includes responses of "excellent" and "very good." Low anxiety or depressive symptoms include responses of "a few times a year" and "never." High life satisfaction includes scores ≥ 9. High happiness includes responses of "happy and interested in life." Low life stress includes responses of "not at all stressful," "not very stressful" and "a bit stressful."

[a] Males are significantly different from females ($p < 0.05$).

[b] Youth aged 12–14 years are significantly different from youth aged 15–17 years ($p < 0.05$).

* There is a significant difference within the sample ($p < 0.05$).

**TABLE 2**
**Associations between levels of OPA and mental health, anxiety and depressive symptoms, life satisfaction, happiness and life stress among all adolescents (12–17 years), Canada, 2019 (n = 10 413)**

| OPA level, h/wk | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| Positive mental health | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.22 (0.97–1.55) | 1.01 (0.79–1.30) |
| 1 to < 3 | 1.48 (1.28–1.70) | 1.09 (0.94–1.27) |
| 3 to < 7 | 1.70 (1.46–1.97) | 1.18 (1.00–1.39) |
| 7 to < 14 | 1.95 (1.53–2.48) | 1.19 (0.92–1.53) |
| ≥ 14 | 2.34 (1.65–3.32) | 1.64 (1.13–2.38) |
| Low anxiety symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.98 (0.78–1.22) | 0.97 (0.77–1.23) |
| 1 to < 3 | 1.14 (0.98–1.32) | 1.09 (0.94–1.27) |
| 3 to < 7 | 1.24 (1.06–1.45) | 1.13 (0.95–1.34) |
| 7 to < 14 | 1.06 (0.85–1.31) | 0.92 (0.73–1.16) |
| ≥ 14 | 1.02 (0.75–1.41) | 0.87 (0.62–1.24) |
| Low depressive symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.95 (0.70–1.26) | 0.92 (0.68–1.23) |
| 1 to < 3 | 1.21 (1.01–1.45) | 1.08 (0.89–1.31) |
| 3 to < 7 | 1.23 (1.02–1.48) | 1.04 (0.85–1.28) |
| 7 to < 14 | 1.29 (0.96–1.73) | 1.03 (0.75–1.42) |
| ≥ 14 | 1.17 (0.78–1.76) | 0.97 (0.63–1.48) |
| High life satisfaction | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.25 (1.00–1.57) | 0.99 (0.78–1.25) |
| 1 to < 3 | 1.54 (1.34–1.76) | 1.10 (0.95–1.28) |
| 3 to < 7 | 1.74 (1.51–2.02) | 1.22 (1.04–1.44) |
| 7 to < 14 | 2.21 (1.80–2.71) | 1.41 (1.14–1.75) |
| ≥ 14 | 2.75 (2.01–3.77) | 1.75 (1.24–2.46) |
| High happiness | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.41 (1.13–1.77) | 1.20 (0.95–1.52) |
| 1 to < 3 | 1.81 (1.57–2.08) | 1.36 (1.17–1.58) |
| 3 to < 7 | 2.35 (2.00–2.74) | 1.73 (1.46–2.05) |
| 7 to < 14 | 2.72 (2.16–3.43) | 1.82 (1.43–2.32) |
| ≥ 14 | 3.70 (2.52–5.43) | 2.36 (1.59–3.50) |
| Low life stress | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.11 (0.85–1.45) | 0.89 (0.68–1.17) |
| 1 to < 3 | 1.62 (1.36–1.92) | 1.15 (0.96–1.39) |
| 3 to < 7 | 1.91 (1.58–2.30) | 1.28 (1.04–1.58) |
| 7 to < 14 | 1.66 (1.26–2.20) | 0.92 (0.69–1.22) |
| ≥ 14 | 1.67 (1.05–2.61) | 0.99 (0.64–1.54) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** CI, confidence interval; h, hours; OPA, outdoor physical activity; OR, odds ratio; wk, week.

**Notes:** Logistic regression models were used to examine the associations between OPA and the outcome measures. Models were adjusted for age, sex, highest parental education, ethnocultural background, average sleep duration (hours/night), total recreational screen time (hours/week), season, urbanicity and indoor physical activity (categories from no indoor physical activity to ≥ 14 hours/week).

Positive mental health includes responses of "excellent" and "very good" (vs. "good," "fair" and "poor"). Low anxiety symptoms and low depressive symptoms include responses of "a few times a year" and "never" (vs. "daily," "weekly" and "monthly"). High life satisfaction includes scores ≥ 9 on a scale of 0–10 (vs. scores < 9 for low life satisfaction). High happiness includes responses of "happy and interested in life." Low life stress includes responses of "not at all stressful," "not very stressful" and "a bit stressful" (vs. "quite a bit stressful" and "extremely stressful").

**TABLE 3**
**Associations between levels of OPA and mental health, anxiety and depressive symptoms, life satisfaction, happiness and life stress among male adolescents (12–17 years), Canada, 2019 (n = 5109)**

| OPA level, h/wk | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| Positive mental health | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.12 (0.79–1.60) | 0.99 (0.69–1.43) |
| 1 to < 3 | 1.37 (1.10–1.71) | 1.06 (0.84–1.34) |
| 3 to < 7 | 1.49 (1.18–1.87) | 1.17 (0.92–1.49) |
| 7 to < 14 | 1.64 (1.20–2.24) | 1.24 (0.89–1.73) |
| ≥ 14 | 2.17 (1.29–3.65) | 1.90 (1.12–3.25) |
| Low anxiety symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.78 (0.55–1.13) | 0.85 (0.58–1.24) |
| 1 to < 3 | 0.97 (0.76–1.22) | 1.02 (0.80–1.30) |
| 3 to < 7 | 1.03 (0.81–1.31) | 1.07 (0.83–1.38) |
| 7 to < 14 | 0.78 (0.58–1.04) | 0.86 (0.63–1.17) |
| ≥ 14 | 0.71 (0.46–1.09) | 0.72 (0.46–1.13) |
| Low depressive symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.03 (0.64–1.67) | 1.14 (0.69–1.86) |
| 1 to < 3 | 1.10 (0.81–1.50) | 1.11 (0.82–1.52) |
| 3 to < 7 | 1.25 (0.91–1.72) | 1.27 (0.91–1.77) |
| 7 to < 14 | 0.94 (0.62–1.42) | 1.04 (0.68–1.61) |
| ≥ 14 | 0.92 (0.53–1.61) | 1.00 (0.55–1.82) |
| High life satisfaction | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.19 (0.86–1.64) | 1.01 (0.72–1.43) |
| 1 to < 3 | 1.45 (1.19–1.76) | 1.10 (0.89–1.37) |
| 3 to < 7 | 1.75 (1.43–2.15) | 1.37 (1.09–1.72) |
| 7 to < 14 | 2.29 (1.76–2.98) | 1.69 (1.27–2.25) |
| ≥ 14 | 2.72 (1.84–4.03) | 1.86 (1.20–2.88) |
| High happiness | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.56 (1.11–2.20) | 1.43 (1.00–2.04) |
| 1 to < 3 | 1.77 (1.44–2.19) | 1.45 (1.16–1.81) |
| 3 to < 7 | 2.36 (1.89–2.94) | 1.98 (1.56–2.50) |
| 7 to < 14 | 2.64 (1.99–3.51) | 2.07 (1.52–2.83) |
| ≥ 14 | 4.29 (2.73–6.74) | 3.04 (1.87–4.96) |
| Low life stress | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.10 (0.71–1.71) | 0.98 (0.62–1.56) |
| 1 to < 3 | 1.55 (1.16–2.07) | 1.21 (0.89–1.63) |
| 3 to < 7 | 1.68 (1.24–2.29) | 1.35 (0.97–1.89) |
| 7 to < 14 | 1.41 (0.96–2.09) | 1.05 (0.70–1.59) |
| ≥ 14 | 1.28 (0.68–2.39) | 1.00 (0.53–1.88) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** CI, confidence interval; h, hour; OPA, outdoor physical activity; OR: odds ratio; wk, week.

**Notes:** Logistic regression models were used to examine the associations between OPA and the outcome measures. Models were adjusted for age, highest parental education, ethnocultural background, average sleep duration (hours/night), total recreational screen time (hours/week), season, urbanicity and indoor physical activity (categories from no indoor physical activity to ≥ 14 hours/week).

Positive mental health includes responses of "excellent" and "very good" (vs. "good," "fair" and "poor"). Low anxiety symptoms and low depressive symptoms include responses of "a few times a year" and "never" (vs. "daily," "weekly" and "monthly"). High life satisfaction includes scores ≥ 9 on a scale of 0–10 (vs. scores < 9 for low life satisfaction). High happiness includes responses of "happy and interested in life." Low life stress includes responses of "not at all stressful," "not very stressful" and "a bit stressful" (vs. "quite a bit stressful" and "extremely stressful").

## Discussion

Using a nationally representative sample of adolescents aged 12 to 17 years living in Canada, we found that OPA was strongly associated with high happiness and high life satisfaction in a dose–response manner. The level of OPA most strongly associated with high happiness and high life satisfaction was 14 or more hours per week (or ≥ 2 hours/day), which represented the highest exposure category in our analysis. More importantly, the associations were independent of indoor physical activity, suggesting that OPA may provide added benefits to happiness and life satisfaction that indoor physical activity does not provide.

The null associations for anxiety and depressive symptoms and life stress in our study are typical of research in the field,[11] likely due to the many factors that may contribute to and potentially confound these associations (e.g. quality of OPA, type of outdoor space, interactions with nature, safety of outdoors and so on). However, recent efforts to control for such variables are beginning to show more definitive associations between OPA and health outcomes.[6,18] The cross-sectional nature of previous studies, similar to this study, precludes inferences about causality and temporality.[12] Several studies have found that cortisol levels decrease when participants spend time in nature, a phenomenon associated with reduced perceived stress.[35] However, these studies were performed in adult populations, and specifically explored the impact of natural environments on stress.

Higher levels of life satisfaction among adolescents are associated with adaptive psychological functioning, interpersonal and social relationships, academic success, decreased behavioural problems, healthier behaviours (movement, eating and social) and various school-related variables, such as perceived academic efficacy, competence and self-efficacy.[36] All of these can lead to better mental health outcomes and successful functioning. A scoping review of the health benefits of nature-based physical activity revealed that engaging in OPA, specifically in more natural environments, may have synergistic benefits to mental and physical health compared to physical activity in built environments and indoors.[17] An important finding of our study was the clear dose–response associations between OPA and

**TABLE 4**
**Association between levels of OPA and mental health, anxiety and depressive symptoms, life satisfaction, happiness and life stress among female adolescents (12–17 years), Canada, 2019 (n = 5304)**

| OPA level, h/wk | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| Positive mental health | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.26 (0.92–1.73) | 1.05 (0.75–1.45) |
| 1 to < 3 | 1.45 (1.20–1.76) | 1.11 (0.89–1.37) |
| 3 to < 7 | 1.60 (1.30–1.97) | 1.22 (0.96–1.54) |
| 7 to < 14 | 1.69 (1.16–2.45) | 1.10 (0.75–1.61) |
| ≥ 14 | 1.90 (1.10–3.28) | 1.41 (0.76–2.61) |
| Low anxiety symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.09 (0.79–1.48) | 1.05 (0.76–1.45) |
| 1 to < 3 | 1.17 (0.97–1.42) | 1.17 (0.95–1.43) |
| 3 to < 7 | 1.18 (0.95–1.46) | 1.18 (0.93–1.50) |
| 7 to < 14 | 1.03 (0.72–1.48) | 1.07 (0.74–1.54) |
| ≥ 14 | 1.15 (0.69–1.91) | 1.17 (0.68–2.01) |
| Low depressive symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.86 (0.59–1.26) | 0.80 (0.55–1.16) |
| 1 to < 3 | 1.19 (0.94–1.49) | 1.09 (0.85–1.38) |
| 3 to < 7 | 1.00 (0.78–1.29) | 0.91 (0.69–1.19) |
| 7 to < 14 | 1.36 (0.85–2.17) | 1.19 (0.72–1.97) |
| ≥ 14 | 1.15 (0.61–2.17) | 1.07 (0.55–2.09) |
| High life satisfaction | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.29 (0.94–1.77) | 0.98 (0.71–1.35) |
| 1 to < 3 | 1.58 (1.30–1.91) | 1.10 (0.89–1.36) |
| 3 to < 7 | 1.60 (1.27–2.00) | 1.08 (0.84–1.40) |
| 7 to < 14 | 1.72 (1.21–2.45) | 1.03 (0.71–1.49) |
| ≥ 14 | 2.48 (1.45–4.22) | 1.64 (0.95–2.84) |
| High happiness | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.29 (0.95–1.76) | 1.04 (0.76–1.43) |
| 1 to < 3 | 1.79 (1.47–2.18) | 1.29 (1.04–1.62) |
| 3 to < 7 | 2.18 (1.73–2.75) | 1.57 (1.22–2.03) |
| 7 to < 14 | 2.51 (1.67–3.78) | 1.65 (1.12–2.45) |
| ≥ 14 | 2.73 (1.38–5.43) | 1.83 (0.94–3.56) |
| Low life stress | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.08 (0.77–1.50) | 0.84 (0.60–1.16) |
| 1 to < 3 | 1.52 (1.22–1.89) | 1.14 (0.90–1.43) |
| 3 to < 7 | 1.71 (1.33–2.19) | 1.26 (0.95–1.68) |
| 7 to < 14 | 1.28 (0.85–1.95) | 0.79 (0.51–1.21) |
| ≥ 14 | 1.53 (0.74–3.19) | 1.08 (0.55–2.14) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** CI, confidence interval; h, hour; OPA, outdoor physical activity; OR, odds ratio; wk, week.

**Notes:** Logistic regression models were used to examine the associations between OPA and the outcome measures. Models were adjusted for age, highest parental education, ethnocultural background, average sleep duration (hours/night), total recreational screen time (hours/week), season, urbanicity and indoor physical activity (categories from no indoor physical activity to ≥ 14 hours/week).

Positive mental health includes responses of "excellent" and "very good" (vs. "good," "fair" and "poor"). Low anxiety symptoms and low depressive symptoms include responses of "a few times a year" and "never" (vs. "daily," "weekly" and "monthly"). High life satisfaction includes scores ≥ 9 on a scale of 0–10 (vs. scores < 9 for low life satisfaction). High happiness includes responses of "happy and interested in life." Low life stress includes responses of "not at all stressful," "not very stressful" and "a bit stressful" (vs. "quite a bit stressful" and "extremely stressful").

high life satisfaction and high happiness. The associations were independent of indoor physical activity, suggesting that OPA may provide added or enhanced benefits. That OPA may provide additional benefits for happiness and life satisfaction compared to indoor physical activity is important for public health guidelines.

Understanding the underlying mechanisms linking OPA to adolescents' life satisfaction, mental health and happiness can help promote and support OPA. The features of outdoor environments result in specific stimuli that cannot be replicated indoors.[37] Outdoor environments, with the exposure to sunlight and fresh air, promote a sense of freedom and allow for energetic and exuberant behaviour.[37] Exposure to sunlight facilitates the secretion of serotonin,[38] a hormone involved in mood and feelings of happiness and well-being. Outdoor spaces also play a role in encouraging physical activity and promoting social contact between children and youth.[39] Children and youth prompt each other to be more physically active when they are outdoors, and aspects of outdoor environments (e.g. open spaces, play structures, trees, loose parts) encourage running, walking, climbing, jumping and cycling.[39,40] It is unclear whether the benefits of OPA on mental health can be attributed to physical activity, socialization or some effect of outdoor environments,[41] but it is likely a combination of these and other factors. Flourishing mental health, being outdoors and physical activity are likely interconnected; spending more time outdoors has been associated with higher levels of physical activity levels, which in turn can increase the probability of flourishing mental health.[15]

Other benefits of increased OPA for children and youth include reduced screen time and improved sleep, both of which can lead to better mental health.[6,42] Although physical activity and socialization can occur indoors, outdoor environments provide a sense of connectedness with nature. In a previous Canadian study, a majority of youth reported that having a connection with nature is important to them, and these youth had reduced psychosomatic symptoms (an indicator of poor mental health).[41] Averaging more than 0.5 hours per week in nature was associated with a 24% reduction in psychosomatic symptoms among females (with no significant findings for males).[41] Modelling showed symptom prevalence

**TABLE 5**
**Association between OPA and mental health, anxiety and depressive symptoms, life satisfaction, happiness and life stress among younger adolescents (12–14 years), Canada, 2019 (n = 5482)**

| OPA level, h/wk | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| Positive mental health | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.20 (0.87–1.65) | 1.22 (0.87–1.72) |
| 1 to < 3 | 1.31 (1.07–1.60) | 1.14 (0.92–1.41) |
| 3 to < 7 | 1.48 (1.19–1.84) | 1.22 (0.97–1.54) |
| 7 to < 14 | 1.98 (1.43–2.73) | 1.53 (1.08–2.16) |
| ≥ 14 | 2.16 (1.34–3.48) | 1.66 (1.00–2.76) |
| Low anxiety symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.79 (0.58–1.08) | 0.84 (0.61–1.15) |
| 1 to < 3 | 1.09 (0.89–1.35) | 1.12 (0.90–1.40) |
| 3 to < 7 | 1.06 (0.85–1.33) | 1.06 (0.82–1.35) |
| 7 to < 14 | 0.96 (0.73–1.28) | 0.97 (0.72–1.32) |
| ≥ 14 | 0.85 (0.56–1.29) | 0.79 (0.51–1.24) |
| Low depressive symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.73 (0.50–1.07) | 0.80 (0.53–1.19) |
| 1 to < 3 | 0.97 (0.74–1.27) | 0.95 (0.72–1.26) |
| 3 to < 7 | 0.92 (0.71–1.21) | 0.86 (0.64–1.15) |
| 7 to < 14 | 0.87 (0.59–1.28) | 0.80 (0.53–1.20) |
| ≥ 14 | 1.14 (0.63–2.06) | 1.04 (0.56–1.93) |
| High life satisfaction | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.32 (0.98–1.78) | 1.24 (0.90–1.72) |
| 1 to < 3 | 1.44 (1.20–1.73) | 1.22 (1.00–1.49) |
| 3 to < 7 | 1.75 (1.42–2.16) | 1.44 (1.14–1.82) |
| 7 to < 14 | 2.10 (1.60–2.76) | 1.69 (1.26–2.27) |
| ≥ 14 | 2.50 (1.68–3.72) | 1.74 (1.13–2.68) |
| High happiness | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.74 (1.29–2.36) | 1.70 (1.23–2.36) |
| 1 to < 3 | 1.54 (1.27–1.88) | 1.32 (1.07–1.64) |
| 3 to < 7 | 2.09 (1.66–2.63) | 1.70 (1.32–2.18) |
| 7 to < 14 | 2.49 (1.84–3.38) | 1.90 (1.37–2.62) |
| ≥ 14 | 4.16 (2.54–6.82) | 2.81 (1.71–4.60) |
| Low life stress | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.02 (0.70–1.49) | 1.01 (0.67–1.52) |
| 1 to < 3 | 1.32 (1.02–1.71) | 1.12 (0.85–1.47) |
| 3 to < 7 | 1.79 (1.29–2.46) | 1.41 (0.99–2.00) |
| 7 to < 14 | 1.53 (1.00–2.34) | 1.09 (0.70–1.71) |
| ≥ 14 | 2.91 (1.38–6.14) | 2.08 (0.89–4.82) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** CI, confidence interval; h, hour; OPA, outdoor physical activity; OR, odds ratio; wk, week.

**Notes:** Logistic regression models were used to examine the associations between OPA and the outcome measures. Models were adjusted for age, sex, highest parental education, ethnocultural background, average sleep duration (hours/night), total recreational screen time (hours/week), season, urbanicity and indoor physical activity (categories from no indoor physical activity to ≥ 14 hours/week).

Positive mental health includes responses of "excellent" and "very good" (vs. "good," "fair" and "poor"). Low anxiety symptoms and low depressive symptoms include responses of "a few times a year" and "never" (vs. "daily," "weekly" and "monthly"). High life satisfaction includes scores ≥ 9 on a scale of 0–10 (vs. scores < 9 for low life satisfaction). High happiness includes responses of "happy and interested in life." Low life stress includes responses of "not at all stressful," "not very stressful" and "a bit stressful" (vs. "quite a bit stressful" and "extremely stressful").

continuing to decrease until up to 14 hours of outdoor play per week.[41] A systematic review also found numerous impacts of nature connectedness on children's and youth's psychological well-being including reduced stress, feelings of joy and happiness, experiences of mindfulness or spirituality and a sense of competence, self-esteem or emotional well-being,[43] all of which can help improve mental health and life satisfaction.

As previously mentioned, no current guidelines recommend a minimum time for adolescents' OPA. Our results show that those who spent 14 or more hours per week being active outdoors had the highest prevalence of positive mental health, life satisfaction and happiness. Although 14 hours is by no means a magic number, aiming for this many or more hours of OPA each week (equivalent to 2 hours each day) may be a sensible target given all the potential benefits and the low risk involved. This aligns with the threshold used in the ParticipACTION Report Card.[44] For some people, having a quantifiable goal provides an amount to strive for and makes the recommendation to replace indoor time with outdoor time less subjective.[11]

## *Recommended future research directions*

Future research should aim to clarify the mechanisms by which OPA contributes to higher life satisfaction and happiness among adolescents. Understanding these pathways could inform targeted interventions and mental health strategies. In addition, incorporating objective measures of OPA—such as wearable activity trackers—will improve the accuracy of findings and help validate self-reported data. Longitudinal and intervention studies are needed to establish the directionality of associations and determine whether increasing OPA leads to improved mental health outcomes. Further, research comparing OPA in different settings—urban versus rural and natural versus built environments—could provide valuable insights into how context influences adolescents' well-being. These findings may ultimately support the development of evidence-based guidelines for adolescent OPA to promote optimal mental and emotional health.

## *Strengths and limitations*

Strengths of this study include the large and nationally representative sample, the

**TABLE 6**
**Association between levels of OPA and mental health, anxiety and depressive symptoms, life satisfaction, happiness and life stress among older adolescents (15–17 years), Canada, 2019 (n = 4931)**

| OPA level, h/wk | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| Positive mental health | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.03 (0.73–1.45) | 0.87 (0.60–1.27) |
| 1 to < 3 | 1.33 (1.08–1.64) | 1.09 (0.87–1.37) |
| 3 to < 7 | 1.57 (1.27–1.94) | 1.21 (0.95–1.54) |
| 7 to < 14 | 1.30 (0.91–1.86) | 0.94 (0.64–1.38) |
| ≥ 14 | 2.07 (1.20–3.59) | 1.79 (1.00–3.18) |
| Low anxiety symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.14 (0.82–1.60) | 1.15 (0.80–1.66) |
| 1 to < 3 | 1.08 (0.87–1.33) | 1.06 (0.85–1.33) |
| 3 to < 7 | 1.35 (1.08–1.68) | 1.23 (0.95–1.58) |
| 7 to < 14 | 1.03 (0.72–1.47) | 0.83 (0.56–1.23) |
| ≥ 14 | 1.18 (0.71–1.95) | 1.04 (0.60–1.80) |
| Low depressive symptoms | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 1.02 (0.66–1.58) | 0.99 (0.65–1.52) |
| 1 to < 3 | 1.26 (0.98–1.62) | 1.17 (0.90–1.52) |
| 3 to < 7 | 1.38 (1.05–1.82) | 1.23 (0.91–1.66) |
| 7 to < 14 | 1.72 (1.07–2.77) | 1.45 (0.84–2.51) |
| ≥ 14 | 1.01 (0.57–1.80) | 0.90 (0.47–1.71) |
| High life satisfaction | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.94 (0.65–1.35) | 0.79 (0.54–1.15) |
| 1 to < 3 | 1.33 (1.07–1.64) | 1.05 (0.83–1.33) |
| 3 to < 7 | 1.39 (1.13–1.72) | 1.06 (0.84–1.35) |
| 7 to < 14 | 1.60 (1.13–2.28) | 1.23 (0.85–1.78) |
| ≥ 14 | 2.55 (1.50–4.33) | 1.87 (1.05–3.31) |
| High happiness | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.99 (0.71–1.38) | 0.87 (0.61–1.22) |
| 1 to < 3 | 1.83 (1.48–2.25) | 1.47 (1.17–1.84) |
| 3 to < 7 | 2.28 (1.83–2.85) | 1.82 (1.42–2.33) |
| 7 to < 14 | 2.31 (1.60–3.34) | 1.83 (1.25–2.67) |
| ≥ 14 | 2.92 (1.62–5.26) | 2.14 (1.13–4.05) |
| Low life stress | | |
| 0 | 1.00 [Reference] | 1.00 [Reference] |
| < 1 | 0.96 (0.66–1.40) | 0.85 (0.59–1.24) |
| 1 to < 3 | 1.50 (1.18–1.90) | 1.25 (0.98–1.61) |
| 3 to < 7 | 1.61 (1.27–2.05) | 1.25 (0.96–1.63) |
| 7 to < 14 | 1.19 (0.80–1.77) | 0.85 (0.57–1.28) |
| ≥ 14 | 0.98 (0.55–1.76) | 0.70 (0.39–1.24) |

**Source:** Canadian Health Survey on Children and Youth, 2019.

**Abbreviations:** CI, confidence interval; h, hour; OPA, outdoor physical activity; OR, odds ratio; wk, week.

**Notes:** Logistic regression models were used to examine the associations between OPA and the outcome measures. Models were adjusted for age, sex, highest parental education, ethnocultural background, average sleep duration (hours/night), total recreational screen time (hours/week), season, urbanicity and indoor physical activity (categories from no indoor physical activity to ≥ 14 hours/week).

Positive mental health includes responses of "excellent" and "very good" (vs. "good," "fair" and "poor"). Low anxiety symptoms and low depressive symptoms include responses of "a few times a year" and "never" (vs. "daily," "weekly" and "monthly"). High life satisfaction includes scores ≥ 9 on a scale of 0–10 (vs. scores < 9 for low life satisfaction). High happiness includes responses of "happy and interested in life." Low life stress includes responses of "not at all stressful," "not very stressful" and "a bit stressful" (vs. "quite a bit stressful" and "extremely stressful" for high life stress).

inclusion of psychometrically valid questions for the dependent variables and noting the significance of these findings for informing future OPA-related strategies. Also, we controlled for indoor physical activity in addition to other covariates, strengthening internal validity and allowing the examination of the added value of OPA on mental health indicators.

The limitations include the subjective nature of the collected variables, the lack of contextual factors (e.g. the quality of OPA, the types of outdoor spaces or their relative safety, interactions with nature, whether the time outdoors is spent alone or with others, and others) and the cross-sectional design, which limits inferences about causality and directionality. Further, residual confounding by unmeasured factors (e.g. pre-existing mental health conditions, chronic illnesses, medication use, social support) is always a possibility in epidemiology. The relatively low response rate (52.1%) could lead to selection bias, where the estimated association between OPA and mental health in the study sample would differ from the estimate had the entire target population agreed to participate. In addition, misclassification of categorical variables is possible, potentially leading to biased estimates of associations or attenuated relationships between exposure and outcome. However, we used the original OPA categories and relied on previously established classifications for the outcome measures.

## Conclusion

OPA was associated with positive mental health, high life satisfaction and high happiness among Canadian adolescents, with levels of OPA of 14 or more hours per week showing the strongest associations. The associations were independent of indoor physical activity and other covariates, suggesting added benefits of OPA on those mental health indicators. Intervention studies that aim to increase OPA are needed to better determine cause-and-effect relationships with various outcomes in the pediatric population.

## Conflicts of interest

Justin Lang is one of this journal's Associate Scientific Editors and Mark Tremblay is an Editorial Board Member. Both have recused themselves from the review process for this article.

The authors have declared no conflicts of interest.

## Authors' contributions and statement

JPC: Conceptualization, validation, writing – original draft.

JJL: Formal analysis, validation, writing – review & editing.

SAP: Validation, writing – review & editing.

GSG: Validation, writing – review & editing.

LL: Validation, writing – review & editing.

MST: Validation, writing – review & editing.

TB: Validation, writing – original draft.

All authors gave final approval for the final version and agreed to be accountable for all aspects of the work.

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

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# Original quantitative research

# Changes in chronic disease prevention resources and activities in Canada during the COVID-19 pandemic

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## Abstract

**Background:** The COVID-19 pandemic disrupted public health efforts for chronic disease prevention (CDP) in Canada and elsewhere. We describe COVID-19–related disruptions in CDP resources and activities among Canadian public health organizations.

**Methods:** We surveyed all organizations in Canada with mandates for primary CDP, including "resource organizations" that develop or transfer CDP initiatives and "user organizations" that deliver these CDP initiatives to target populations. Key informants most knowledgeable about CDP activities and resources within each organization reported pandemic-related changes in CDP resources and activities. User organizations also reported on the status of 18 specific CDP activities and rated whether pandemic containment measures were barriers to or facilitators of CDP activities.

**Results:** Of the 298 participating organizations (88% response), 129 were resource organizations (37% formally mandated organizations [FMOs]; 63% non-governmental organizations [NGOs]) and 169 were user organizations (48% FMOs; 52% NGOs). Overall, 36% reported decreases in CDP funding (24% major, 12% minor), 30%–41% reported decreases in full-time, volunteer and managerial staff (19%–27% major, 11%–14% minor) and 32% reported decreases in CDP activities (23% major, 9% minor). User FMOs were most affected by decreases. Among user organizations, 16%–39% decreased, suspended or discontinued specific CDP activities. Still, 8%–39% increased their activities, particularly those targeting mental health, marginalized populations, racialized communities and specific gender groups. Half (53%) of user organizations perceived COVID-19 contagion restrictions as barriers to CDP activities.

**Conclusion:** Continued monitoring of CDP resources and activities can inform emergency preparedness and ensure that CDP remains a priority during public health crises.

***Keywords:*** *chronic disease prevention, resources, activities, Canada, COVID-19, pandemic, survey, noncommunicable disease, NCD*

### *Highlights*

- At least one-third (30%–41%) of public health organizations reported decreases in chronic disease prevention (CDP) funding, personnel and activities during the COVID-19 pandemic.
- Formally mandated public health user organizations had particularly high decreases in CDP resources and activities.
- There were marked decreases in tobacco control, healthy eating and healthy weight activities.
- Activities targeting mental health, marginalized populations, racialized communities and specific gender groups increased.
- More than half of user organizations viewed COVID-19 public health measures as barriers to CDP activities.

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## Introduction

The COVID-19 pandemic placed unprecedented strain on Canada's health care and public health systems and radically affected delivery of prevention programs and services for chronic diseases. According to a World Health Organization survey, 75% of countries reported disruptions in chronic disease services, including hypertension management, diabetes management and cancer treatment.[1] Other studies reported notable declines in cancer screening test volumes, including in Canada, at the start of the pandemic,[2,3] leading to delayed diagnoses and treatments.

Although less apparent or documented, the COVID-19 pandemic also disrupted preventive efforts in the public health system. In Canada and elsewhere, public health system capacity (i.e. skills and resources) dedicated to chronic disease prevention (CDP) was diverted to combat the spread of COVID-19. Globally, 20% of countries reported reassignment and deployment of full-time CDP staff to support COVID-19 efforts, leading to reductions in the capacity of public health systems to undertake usual CDP activities.[1]

The development and delivery of programs, policies and practices with the aim of preventing chronic (or noncommunicable) diseases such as cancer, cardiovascular disease, diabetes, chronic respiratory illness, mental illness are critical components of Canada's public health systems.[4-6] Public health systems and, more specifically, organizations within public health systems with mandates for CDP are vital to reducing the chronic disease burden, but are chronically underfunded and underprioritized and frequently undergo restructuring and reform.[7-10]

CDP organizations have diverse mandates, missions, structures, target populations and funding. This research team previously characterized CDP organizations as either "resource organizations," which develop CDP programs, policies and practices and then transfer these initiatives to other organizations, or "user organizations," which deliver CDP initiatives to the general population or to specific population groups.[11,12] These organizations can vary from formally mandated organizations (FMOs) to non-governmental or nonprofit organizations (NGOs). FMOs are governmental and arms-length governmental organizations with a formally mandated, legislated role in CDP, for example, health authorities and public health units. NGOs include non-governmental, nonprofit organizations, health charities, professional associations, research centres and resource centres.[13] While FMOs generally have more stable resources, including funding and personnel, NGOs rely heavily on volunteer support and report more challenges with adequate funding and stability.[11]

Improved understanding of the extent to which the COVID-19 pandemic disrupted the functioning of public health organizations engaged in CDP would help to build (or rebuild) resilient public health systems capable of withstanding future health crises and natural disasters. Further, to ensure a coordinated response to CDP, we must understand whether different types of organizations (resource versus user, FMO versus NGO) were impacted differently. No studies to date have investigated changes in public health organizations' CDP resources (funding or personnel) or activities (programs, policies or practices) during the COVID-19 pandemic at the national, provincial or regional levels in Canada. In this study, we sought to describe (1) changes in CDP resources (funding and personnel) and activities (programs, policies and practices) in resource and user FMOs and NGOs; (2) changes in 18 specific CDP activities targeting lifestyle risk factors, chronic disease diagnoses, mental health and specific population groups in user FMOs and NGOs; and (3) whether user FMOs and NGOs perceived public health measures to curtail the spread of COVID-19 as barriers or facilitators to CDP activities.

## Methods

### *Ethics approval*

The study was approved by the Ethics Review Boards at St. Michael's Hospital, Unity Health Toronto (REB #21-240) and Centre hospitalier de l'Université de Montréal (CRCHUM) (F9H-86805).

### *Study population*

The Public Health ORganizational CApacity STudy (PHORCAST) is a repeat national census of all public health organizations in Canada engaged in CDP at the national, provincial or territorial, or regional levels. The organizations in PHORCAST have been characterized as resource and user organizations.[11,12] Organizations that have both resource and user mandates or functions are considered as unique, separate entities.

Data were collected in 2004, 2010 and 2023 from all resource and user organizations with mandates for population-level CDP identified through extensive online searches and consultation with key informants with wide-ranging knowledge of the public health landscape in Canada.[11-13] This current study uses data drawn from the 2023 data collection cycle.

New organizations identified in 2023 included those that were established after the 2010 data collection wave; pre-existing organizations with new CDP activities or with newly formed CDP divisions; and organizations formed through the amalgamation of two or more previously participating organizations. Excluded were local-level organizations; grouped organizations (i.e. coalitions, partnerships, alliances); organizations primarily engaged in secondary or tertiary prevention, advocacy, allocation of funds, fundraising and facilitating joint interorganizational efforts; and organizations exclusively engaged in research or knowledge transfer.

### *Procedures*

All resource and user organizations identified in 2023 (n = 321) were screened for eligibility. We sent an introductory email to a senior manager in each organization to solicit participation, confirm eligibility and establish whether the organization was a resource or user organization or both. The senior manager was then asked to identify a key informant for data collection, that is, the individual who was most knowledgeable about CDP activities and resources within the organization. Senior managers could suggest themselves as the key informant. We contacted key informants via email to introduce the study, notify them of their senior manager's consent and confirm their suitability as the key informant; we followed up with non-respondents through repeat emails and telephone calls.

Key informants were emailed a copy of the relevant questionnaire (to share with colleagues if they needed help with responses to any questions) and a personalized link to the 45- to 60-minute-long English or French questionnaire, available online on the LimeSurvey platform

(LimeSurvey GmbH, Hamburg, DE). To facilitate survey completion and accommodate their schedules, the key informants (henceforth referred to as participants) could complete the questionnaire in an interview with the study coordinator or investigators over Zoom (Zoom Communications, San Jose, CA, US) or by telephone. After completing the questionnaire, the key informants were asked for any open-ended comments.

### *Measures*

#### Changes in CDP funding, personnel and activities during the COVID-19 pandemic

Participants in both resource and user organizations reported the extent of perceived changes (major decreases, minor decreases, no change, minor increases, major increases) in funds spent on CDP during the COVID-19 pandemic; the number of full-time employees, volunteers (including Board members) and managers involved in CDP; and CDP activities (programs, policies and practices).

#### Changes in 18 specific CDP activities during the COVID-19 pandemic

Participants in user organizations only (i.e. those organizations that deliver CDP activities to populations) were asked to report any changes in 18 CDP activities during the COVID-19 pandemic: lifestyle risk factors, including tobacco control, healthy eating, physical activity, healthy lifestyle, and prevention of high blood pressure and of high cholesterol; chronic disease diagnoses, including chronic obstructive pulmonary disease (COPD), diabetes, cancer, heart disease, healthy weights; stress and mental health; and marginalized populations, racialized groups or communities and specific gender groups (i.e. women, men or gender-diverse people) as well as rural communities and urban communities. Specifically, participants were asked whether each of these CDP activities had changed in the past 3 years and, if so, whether these changes occurred before or during the COVID-19 pandemic. We determined whether each of the 18 activities remained stable, had increased, had decreased, was temporarily suspended or was permanently discontinued during the COVID-19 pandemic.

#### The COVID-19 pandemic as a barrier or facilitator to CDP activities

The participants in user organizations reported the extent to which public health measures to restrict COVID-19 contagion were barriers or facilitators to organizational CDP activities. Responses were recorded on a seven-point Likert scale with the following labels: "very strong barrier," "strong barrier," "somewhat strong barrier," "neither barrier nor facilitator," "very strong facilitator," "strong facilitator" and "somewhat strong facilitator."

#### Organization type

Organizations were categorized as FMOs or NGOs. FMOs include federal, provincial or territorial government departments; regional, provincial or territorial administrative health authorities; public health agencies and units; and para-governmental health organizations (i.e. arms-length organizations funded by the government but acting independently). NGOs include non-governmental, nonprofit organizations, health charities, professional associations, research centres and resource centres.

#### Open-ended question

Upon completing the questionnaire, participants could provide any other comments.

Detailed descriptions of study variables, including questionnaire item(s) and response choices, are provided in Supplemental Tables 1 and 2. These tables and other information, including recoding of responses for analysis, and the number and percentage of participants with missing data for each study variable, are available on request from the authors.

### *Data analyses*

Descriptive statistics were used to characterize organizations and report changes in CDP funding, personnel and activities during the COVID-19 pandemic. We computed the proportion of all CDP organizations reporting major decreases, minor decreases, no change, minor increases and major increases in CDP funding, personnel and activities. We then stratified resource and user organizations according to FMO or NGO status and reported these proportions in each of the resulting four groups. Organizations that were both resource and user organizations were considered separately as unique entities in these analyses (i.e. once in the user group and once in the resource group).

Next, we computed the proportions of user organizations reporting that delivery of each of 18 specific CDP activities had remained stable, had increased, had decreased, was temporarily suspended or was permanently discontinued during the COVID-19 pandemic. We used as the denominator the total number of organizations that reported undertaking the specific CDP activity in the last 3 years.

Finally, we computed the proportion of user organizations that selected each of the ratings on the seven-point Likert scale (from "very strong barrier" to "very strong facilitator") describing how the COVID-19 contagion measures may have affected CDP activities.

Statistical significance was not relevant in these descriptive analyses of the census of CDP organizations in Canada.

Analyses were conducted using Stata version 17 (Stata Corp, College Station, TX, US). No formal qualitative analysis of these free-text responses was conducted. Excerpts from participants' open-ended comments are included in this article to provide context and illustrate quantitative findings. Quotes are reproduced verbatim.

## Results

In 2023, PHORCAST surveyed 298 public health organizations with CDP mandates, which represented 88% of the eligible organizations. Of the 129 resource organizations, 37% were FMOs and 63% were NGOs. Of the 169 user organizations, 48% were FMOs and 52% were NGOs. The median organizational age was 49 years. These organizations served subregions (8%), regions (28%) or provinces or territories (44%) or were national in scope (15%). More than half (59%) served geographical areas with populations of 500000 or more people. The median number of full-time staff and volunteers was 35 and 20, respectively (Table 1).

### *Changes in CDP resources and activities during the COVID-19 pandemic*

More than one-third (36%) of organizations reported decreases in CDP funding, with 24% reporting these as major (Table 2). Between 30% and 41% of all public health organizations across Canada reported decreases in dedicated full-time, volunteer and managerial staff during the first 3 years of the COVID-19 pandemic, with between 19% and 27% of the decreases characterized as major. Most notable were the decreases in the number of full-time employees involved in CDP

**TABLE 1**
**Characteristics of resource and user FMOs and NGOs engaged in CDP, PHORCAST, Canada, 2023**

| Characteristics | Total (n = 298) | User organization (n = 169) | | Resource organization (n = 129) | |
|---|---|---|---|---|---|
| | | FMO (n = 81) | NGO (n = 88) | FMO (n = 48) | NGO (n = 81) |
| Median age of organization (IQR), years | 49 (22–75) | 50 (22–76) | 50 (29–86) | 40 (18–75) | 39 (19–60) |
| Geographic area served, % | | | | | |
| Subregion | 8 | 17 | 7 | 6 | 3 |
| Region | 28 | 48 | 19 | 27 | 19 |
| Province/territory | 44 | 32 | 48 | 58 | 44 |
| Multiple provinces/ territories | 4 | 1 | 6 | 0 | 9 |
| Canada | 15 | 1 | 21 | 8 | 26 |
| Population size, % | | | | | |
| < 50 000 | 8 | 10 | 8 | 4 | 10 |
| 50 000–99 999 | 3 | 4 | 2 | 4 | 1 |
| 100 000–199 999 | 16 | 25 | 13 | 15 | 12 |
| 200 000–499 999 | 14 | 22 | 10 | 10 | 12 |
| 500 000–1 000 000 | 13 | 10 | 16 | 13 | 14 |
| > 1 000 000 | 46 | 30 | 51 | 54 | 51 |
| No. of full-time CDP staff, median (IQR) | 35 (9–200) | 250 (130–3750) | 15 (6–54) | 200 (100–6000) | 11 (6–30) |
| No. of volunteers, median (IQR) | 20 (7–60) | 11 (0–50) | 35 (10–80) | 0 (0–18) | 23 (9–58) |

**Abbreviations:** CDP, chronic disease prevention; FMO, formally mandated organization; IQR, interquartile range; NGO, non-governmental organization; No., number.

**Notes:** Resource organizations develop CDP programs, policies and practices and then transfer these initiatives to other organizations. User organizations deliver CDP programs, policies and practices to the general population or to underserved population groups. FMOs include federal, provincial or territorial government departments; regional, provincial or territorial administrative health authorities; public health agencies and units; and para-governmental health organizations (i.e. arms-length organizations funded by the government but acting independently). NGOs include non-governmental, nonprofit organizations, health charities, professional associations, research centres and resource centres.

(41%), with 27% of organizations reporting these decreases as major. About one-third (32%) of organizations reported decreases in CDP activities, with 23% characterized as major. Of note, 25% of organizations reported increases in CDP funding, 20% reported increases in the number of full-time employees involved in CDP, and 30% reported increases in CDP activities. However, most of these increases were characterized as minor.

Decreases in CDP funding, personnel and activities were more prevalent among FMOs than NGOs, and most markedly among user FMOs (Table 3). Among resource organizations, 38% of FMOs reported decreases in CDP funding, 52% in the number of full-time employees involved in CDP and 41% in CDP activities. These proportions were even higher among user FMOs, with 60% reporting decreases in funds spent on CDP, 71% in the number of full-time employees involved in CDP, 58% in the number of managers involved in CDP and 71% in CDP activities. On the other hand, a higher proportion of NGOs than of FMOs reported increases in CDP funding, personnel and activities during the pandemic, with differences between user NGOs and user FMOs the most striking.

A participant at an FMO made this insightful comment:

> The vast majority of our health promotion staff were redeployed to the COVID-19 response during the pandemic. We needed every available person to work on case and contact management and left health promotion with a skeleton staff for over 18 months. Public health was swamped and did what was needed to survive. We had limited resources that were negligible during COVID. Prior to COVID we did not have resources for internal evaluation, but lacking that, we did have an incredibly knowledgeable and dedicated team who research best practice both in terms of intervention but also process.

Compared to FMOs, markedly lower proportions of NGOs reported decreases in CDP funding, personnel and activities during the COVID-19 pandemic, with decreases in the number of volunteers most common among resource and user NGOs (27% and 37%, respectively). Less than one-third of resource and user NGOs

**TABLE 2**
**Percentage of resource and user organizations with CDP mandates, by reported change in CDP funding, personnel and activities during the COVID-19 pandemic, PHORCAST, Canada, 2023 (n = 298)**

| Area of change | Reported change | | | | |
|---|---|---|---|---|---|
| | Major decreases, % | Minor decreases, % | No change, % | Minor increases, % | Major increases, % |
| Funds spent on CDP | 24 | 12 | 39 | 19 | 6 |
| No. of full-time staff involved in CDP | 27 | 14 | 39 | 14 | 6 |
| No. of volunteers involved in CDP | 19 | 12 | 63 | 5 | 1 |
| No. of managers involved in CDP | 19 | 11 | 58 | 9 | 3 |
| No. of CDP activities | 23 | 9 | 32 | 22 | 8 |

**Abbreviations:** CDP, chronic disease prevention; No., number.

**Note:** The sum of percentages is calculated across rows, for each area of change.

**TABLE 3**
**Percentage of resource and user FMOs and NGOs with CDP mandates, by reported change in CDP resources and activities during the COVID-19 pandemic, PHORCAST, Canada, 2023**

| Type of organization and area of change | Reported change | | | | | |
|---|---|---|---|---|---|---|
| | Major/minor decreases, % | No change, % | Major/minor increases, % | Major/minor decreases, % | No change, % | Major/minor increases, % |
| **Resource organizations (n = 129)** | **FMO (n = 48)** | | | **NGO (n = 81)** | | |
| Funds spent on CDP | 38 | 40 | 23 | 22 | 44 | 34 |
| No. of full-time staff involved in CDP | 52 | 27 | 21 | 22 | 53 | 24 |
| No. of volunteers involved in CDP | 19 | 79 | 2 | 27 | 64 | 9 |
| No. of managers involved in CDP | 29 | 58 | 13 | 13 | 68 | 18 |
| No. of CDP activities | 41 | 38 | 22 | 14 | 53 | 34 |
| **User organizations (n = 169)** | **FMO (n = 81)** | | | **NGO (n = 88)** | | |
| Funds spent on CDP | 60 | 27 | 14 | 27 | 46 | 27 |
| No. of full-time staff involved in CDP | 71 | 17 | 12 | 26 | 53 | 22 |
| No. of volunteers involved in CDP | 34 | 61 | 5 | 37 | 56 | 7 |
| No. of managers involved in CDP | 58 | 36 | 5 | 19 | 71 | 12 |
| No. of CDP activities | 71 | 11 | 18 | 14 | 36 | 50 |

**Abbreviations:** CDP, chronic disease prevention; FMO, formally mandated organization; NGO, non-governmental organization; No., number.

**Note:** The sum of percentages is calculated across rows, for each area of change.

reported decreases in CDP funding (22% and 27%, respectively), in full-time CDP staff (22% and 26%, respectively), in the number of managers (13% and 19%, respectively) and in CDP activities (14% each). Compared to FMOs, higher proportions of NGOs reported increases in CDP funding, personnel and activities during the pandemic. Notably, CDP activities in resource and user NGOs intensified (34% and 50%, respectively) as did CDP funding (34% and 27%, respectively).

### *Changes in specific CDP activities during the COVID-19 pandemic*

Of the user organizations that delivered one or more of 18 specific CDP activities in the past 3 years, 16% to 39% reported that the activities had decreased, were temporarily suspended or were permanently discontinued during the COVID-19 pandemic (Table 4). Relatively high proportions of organizations with activities that targeted tobacco control (39%), healthy eating (35%), physical activity (33%) and healthy weights (37%) in the past 3 years reported decreases, suspensions or discontinuations. Only 16% of organizations that undertook activities targeting elevated cholesterol reported decreased, suspended or discontinued activities. Organizations reported increases in programming that targeted mental health (39%), stress (30%), marginalized populations (32%), racialized groups or communities (33%) and specific gender groups (32%).

A comment by a study participant at an NGO underscores the growing emphasis on broader social determinants of health as evidenced by the increases in programs specifically targeting marginalized and racialized populations as a driver for program change:

> We focus on the community as a client, not individuals, and are focusing away from modifiable risk factors to equity, racial equity, built environment, etc. We are learning and growing and challenging ourselves with modest resources to try to create greatest positive health impact while challenging ourselves to better understand unintended consequences and to be humble and open to two-eyed seeing and new ways of knowing. That [is] balanced within a system and organization that is fundamentally focused on individuals and illness. We are doing our best...

Decreases in CDP activities were more prevalent among FMOs than NGOs (Table 5). More than 50% of FMOs reported that activities targeting physical activity, healthy eating, healthy lifestyle and healthy weights had either decreased or been suspended. Less than 20% of NGOs reported such decreases. Higher proportions of NGOs than of FMOs reported increases in CDP activities.

### *Perception of pandemic-related restrictions as a barrier to or facilitator of CDP activities*

Half (53%) of user organizations overall (67% of user FMOs and 43% of user NGOs) perceived the public health measures to stop the spread of COVID-19 as a barrier to CDP activities (Figure 1). One-third (32%) reported that the public health measures were neither a facilitator nor a barrier (20% of NGOs and 43% of FMOs). Of note, 15% overall viewed the measures as a facilitator, and this view was consistent across FMOs and NGOs (13% and 14%).

The following participant comment exemplifies how the COVID-19 pandemic served as a barrier to sustaining CDP activities by diverting staff and resources away from established CDP efforts:

> As a smaller public health unit, nearly all [our] resources were deployed to the COVID-19 pandemic response. Currently, we are in the recovery phase and are in the process of planning and prioritization, within a new organizational structure. At this time [2023], we have not resumed most CDP activities. Prior to the COVID-19 pandemic, we had a dedicated CDP

**TABLE 4**
**Percentage of user organizations that undertook specific CDP activities in the past 3 years, by status of each activity during the COVID-19 pandemic, PHORCAST, Canada, 2023 (n = 169)**

| | Organizations that offered activity in past 3 years, n | Status of activity during the COVID-19 pandemic | | | |
|---|---|---|---|---|---|
| | | Suspended/ discontinued, % | Decreased, % | Remained stable, % | Increased, % |
| **Lifestyle risk factors** | | | | | |
| Tobacco control | 99 | 21 | 18 | 48 | 13 |
| Healthy eating | 124 | 21 | 14 | 52 | 13 |
| Physical activity | 142 | 21 | 12 | 55 | 12 |
| Healthy lifestyle | 136 | 17 | 13 | 57 | 14 |
| High blood pressure | 38 | 16 | 8 | 58 | 18 |
| Elevated cholesterol | 25 | 8 | 8 | 64 | 20 |
| **Chronic disease diagnoses** | | | | | |
| COPD | 45 | 14 | 16 | 53 | 18 |
| Diabetes | 55 | 16 | 11 | 56 | 16 |
| Cancer | 54 | 13 | 11 | 48 | 28 |
| Heart disease | 47 | 15 | 13 | 64 | 8 |
| Healthy weights | 85 | 21 | 16 | 54 | 8 |
| **Mental health** | | | | | |
| Stress | 104 | 14 | 15 | 43 | 30 |
| Mental health | 134 | 11 | 14 | 38 | 39 |
| **Population groups** | | | | | |
| Marginalized populations | 142 | 8 | 17 | 43 | 32 |
| Racialized groups/communities | 118 | 9 | 16 | 42 | 33 |
| Specific gender groups | 94 | 10 | 14 | 45 | 32 |
| Rural communities | 132 | 10 | 18 | 54 | 18 |
| Urban communities | 120 | 9 | 19 | 56 | 16 |

**Abbreviations:** CDP, chronic disease prevention; COPD, chronic obstructive pulmonary disease.

team which focused on multilevel activities. We hope to get back to this level of service delivery.

## Discussion

In this study, our aim was to describe the impact of the COVID-19 pandemic on the resources and activities of public health organizations across Canada with mandates for CDP. A sizable proportion of these public health organizations reported major or minor pandemic-related decreases in CDP funding, personnel and activities. Changes were generally similar across resource and user NGOs, but were more pronounced among FMOs, and especially user FMOs. Relatively high proportions of organizations reported reductions in tobacco control, healthy eating, physical activity and healthy weights activities; activities for mental health and stress and targeting underserved groups (i.e. marginalized populations, racialized groups and specific gender groups) increased. Further, more than half of user organizations perceived the public health measures implemented to restrict the spread of COVID-19 as a barrier to CDP activities.

Although re-allocation of resources during public health emergencies may be inevitable, there should be widespread recognition across public health and health services jurisdictions that the burden of chronic disease will be affected by these re-allocations.[14-16] Individuals with chronic diseases[17-20] and those with risk factors for chronic disease (i.e. tobacco use, unhealthy diets, physical inactivity)[21-23] were more vulnerable to severe COVID-19 outcomes and increased mortality. Reinforcing CDP capacity should be considered a key component of pandemic preparedness and response.

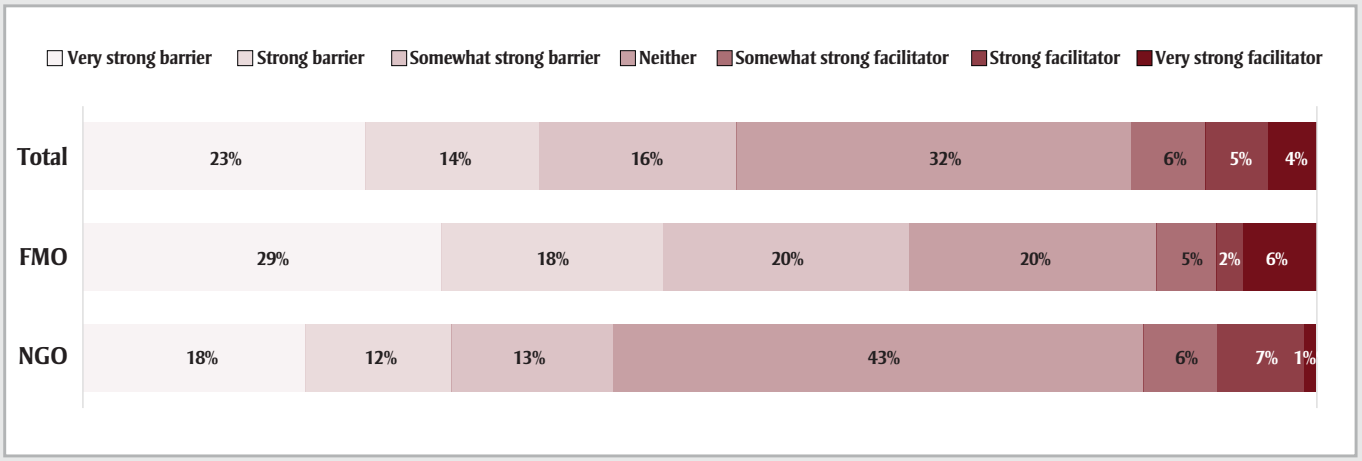
Fewer resource organizations than user organizations reported pandemic-related changes. This could be because resource organizations do not rely as heavily on in-person interactions in their day-to-day activities, which would have facilitated operational continuity during lockdowns and when physical distancing measures were in place. These organizations may have been able to shift more easily to online and digital platforms. A 2020 systematic review highlights the limited evidence for the effectiveness of mobile health (or mHealth) interventions and tools (e.g. mobile apps, text messaging) in managing conditions such as diabetes and obesity.[24] Research on digital interventions in weight management and healthy lifestyle behaviours emphasizes the importance of behavioural theories, user-centred design, personalization, timely feedback and motivation, addressing access barriers and collaboration between developers, health care professionals and users.[25] However, further study is needed to assess the feasibility and impact of digital strategies in the Canadian public health context.

**TABLE 5**
**Percentage of user FMOs and NGOs undertaking specific CDP activities, according to the status of each activity during the COVID-19 pandemic, PHORCAST, Canada, 2023 (n = 169)**

| | FMO | | | | | NGO | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Organizations that offered activity in past 3 years, n | Suspended/ discontinued, % | Decreased, % | Remained stable, % | Increased, % | Organizations that offered activity in past 3 years, n | Suspended/ discontinued, % | Decreased, % | Remained stable, % | Increased, % |
| **Lifestyle risk factors** | | | | | | | | | | |
| Tobacco control | 70 | 26 | 23 | 40 | 11 | 29 | 10 | 7 | 66 | 17 |
| Healthy eating | 67 | 31 | 21 | 39 | 9 | 57 | 9 | 5 | 68 | 18 |
| Physical activity | 67 | 39 | 16 | 40 | 4 | 75 | 4 | 8 | 69 | 19 |
| Healthy lifestyle | 64 | 31 | 20 | 38 | 11 | 72 | 4 | 6 | 74 | 17 |
| High blood pressure | 20 | 20 | 10 | 55 | 15 | 18 | 11 | 6 | 61 | 22 |
| Elevated cholesterol | 15 | 13 | 7 | 67 | 13 | 10 | 0 | 10 | 60 | 30 |
| **Chronic disease diagnoses** | | | | | | | | | | |
| COPD | 23 | 22 | 22 | 48 | 9 | 22 | 5 | 9 | 59 | 27 |
| Diabetes | 29 | 24 | 14 | 48 | 14 | 26 | 8 | 8 | 65 | 19 |
| Cancer | 28 | 14 | 18 | 43 | 25 | 26 | 12 | 4 | 54 | 31 |
| Heart disease | 24 | 21 | 21 | 54 | 4 | 23 | 9 | 4 | 74 | 13 |
| Healthy weights | 47 | 34 | 19 | 40 | 6 | 38 | 5 | 13 | 71 | 11 |
| **Mental health** | | | | | | | | | | |
| Stress | 52 | 23 | 25 | 29 | 23 | 52 | 4 | 4 | 56 | 37 |
| Mental health | 69 | 19 | 22 | 22 | 38 | 65 | 2 | 5 | 54 | 40 |
| **Population groups** | | | | | | | | | | |
| Marginalized populations | 75 | 12 | 26 | 31 | 31 | 67 | 3 | 6 | 57 | 34 |
| Racialized groups/communities | 67 | 13 | 24 | 36 | 27 | 51 | 4 | 6 | 49 | 41 |
| Specific gender groups | 55 | 15 | 20 | 40 | 25 | 39 | 3 | 5 | 51 | 41 |
| Rural communities | 72 | 15 | 26 | 44 | 14 | 60 | 3 | 8 | 65 | 23 |
| Urban communities | 63 | 14 | 29 | 44 | 13 | 57 | 4 | 7 | 70 | 19 |

**Abbreviations:** CDP, chronic disease prevention; COPD, chronic obstructive pulmonary disease; FMO, formally mandated organization; NGO, non-governmental organization.

**FIGURE 1**
**Percentage of user organizations overall and FMOs and NGOs, by perception of pandemic-related public health contagion measures as a barrier or facilitator to CDP activities, PHORCAST, Canada, 2023**




**Abbreviations:** CDP, chronic disease prevention; FMO, formally mandated organization; NGO, non-governmental organization.

The most pronounced decreases in CDP resources and activities occurred among user FMOs. While NGOs showed some stability and even increases in certain areas, FMOs more often reported decreases. This difference likely reflects the inherent organizational structures and funding mechanisms that distinguish these types of organizations. Namely, inflexibility in FMO processes, structures or practices may affect their ability to adapt quickly to crises or natural disasters without significant bureaucratic changes.[26] In contrast, NGOs might have more flexible operational structures that allow them to create interdepartmental task forces and rapidly revise emergency response protocols, and diversified funding sources, such as private donations and grants,[27] which may better position them to maintain or swiftly adapt their services and continue their engagement with underserved populations. It is also worth noting that user FMOs are often staffed with individuals who operate under a dual mandate to address both infectious and chronic (or noncommunicable) diseases, which may have resulted in staff transfers from CDP to infectious disease programs during crises.

Despite these challenges, both FMOs and NGOs demonstrated similar activity levels in CDP domains over the past 3 years, with FMOs more active in the areas of lifestyle risk factors, such as tobacco control and healthy eating, and addressing the CDP needs of marginalized and racialized populations. However, decreases in and suspensions of CDP activities were reported across all types of activities, reflecting the widespread impact of the pandemic. Compared to NGOs, FMOs generally experienced more decreases and suspensions, suggesting the need for tailored strategies and pre-pandemic planning to help FMOs maintain key CDP activities during public health crises. Future research should explore the potential for enhanced FMO–NGO collaboration[28] during crises. Understanding how these organizations might synergize resources and activities may provide actionable strategies to foster resilient public health responses. Moeenian et al.[29] found that factors such as investing in NGO collaboration, management ability and cultural and educational infrastructure are critical to the success of such initiatives. Exploring these collaborative strategies in Canada could provide valuable insights that help foster resilient public health responses.

We drew measures of CDP resources and activities from an empirically supported integrative conceptual model of organizational capacity for CDP.[12] This model identifies several critical elements—organizational capacity, determinants, facilitators, outcomes and the broader social determinants of health—that are thought to influence the effectiveness of CDP activities. According to this model, resources, skills and infrastructure are essential for effective CDP efforts. However, our observations suggest depletions in resources during the pandemic. While not measured directly in this study, organizational determinants such as commitment, technical expertise and leadership may have also been strained due to priorities shifting toward urgent pandemic responses. In addition, changes in facilitators such as governmental and public priorities, which are considered mediators between organizational capacity and outcomes,[12] might have influenced the level of engagement in CDP activities. Further research could be valuable in quantifying these impacts and exploring strategies to maintain organizational capacity during such shifts.

### *Limitations*

Limitations of this study include that data were collected from one participant within each organization, although each of these individuals was carefully selected as the most knowledgeable about CDP. Organizational characteristics should ideally be assessed using objective measures (e.g. data from health records, registries or databases that track implementation of CDP activities) to the extent possible. Self-report data are subject to misclassification error. However, because of feasibility and cost, self-report is the most common data collection method in organizational research.[30]

## Conclusion

This work offers novel insight into changes in CDP resources and activities during the COVID-19 pandemic that may affect the burden of chronic disease in Canada. We documented important declines

in funding, personnel and CDP activities across public health organizations. Although efforts targeting mental health and underserved populations increased, many traditional CDP activities were suspended. These findings underscore the necessity for building and maintaining resilient public health systems capable of sustaining prioritization of CDP efforts during public health crises. Continued monitoring of CDP resources and activities is essential to ensure that it remains a top public health priority. Using the lessons learned from the early years of the COVID-19 pandemic, it is essential to prioritize and rebuild CDP infrastructure to ensure that public health systems are resilient and capable of addressing both ongoing and future health challenges effectively.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## Conflicts of interest

Jennifer O'Loughlin is one of this journal's Editorial Board Members, but was not involved in the editorial decision-making associated with this manuscript.

The authors have no competing interests.

## Authors' contributions and statement

KM: Supervision, conceptualization, funding acquisition, project administration, resources, writing – review and editing.

MM: Analysis, writing – original draft, writing – review and editing.

EH: Conceptualization, writing – review and editing.

DM: Conceptualization, writing – review and editing.

GP: Conceptualization, writing – review and editing.

GP: Conceptualization, writing – review and editing.

JLM: Conceptualization, methodology, supervision, writing – review and editing.

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

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**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 2025:**

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