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Original quantitative research

Associations between meteorological factors and emergency department visits for unintentional falls during Ontario winters

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Abstract

Introduction: Unintentional falls are a leading cause of injury-related hospital visits among Canadians, especially seniors. While certain meteorological conditions are suspected risk factors for fall-related injuries, few studies have quantified these associations across a wider range of age groups and with population-based datasets.

Methods: We applied a time-stratified case-crossover study design to characterize associations of highly-spatially-resolved meteorological factors and emergency department (ED) visits for falls, in Ontario, among those aged 5 years and older during the winter months (November to March) between 2011 and 2015. Conditional logistic models were used to estimate the odds ratios (ORs) and their 95% confidence intervals (CIs) for these visits in relation to daily snowfall accumulation, including single-day lags of up to one week before the visit, and daily mean temperature on the day of the visit. Analyses were stratified by age and sex.

Results: We identified 761 853 fall-related ED visits. The odds for these visits was increased for most days up to a week after a snowfall of 0.2 cm or greater (OR = 1.05–1.08) compared to days with no snowfall. This association was strongest among adults aged 30 to 64 years (OR = 1.16–1.19). The OR for fall-related ED visits on cold days (less than −9.4 °C) was reduced by 0.05 relative to days with an average daily temperature of 3.0 °C or higher (OR = 0.95; 95% CI: 0.94, 0.96), and this pattern was evident across all ages. There were no substantive differences in the strength of this association by sex.

Conclusion: Snowfall and warmer winter temperatures were associated with an increased risk of fall-related ED visits during Ontario winters. These findings are relevant for developing falls prevention strategies and ensuring timely treatment.

Keywords: *case-crossover, unintentional falls, accidental falls, injuries, weather, snow, ambient temperature, winter*

Highlights

- A snowfall accumulation of 0.2 cm or greater was associated with an increased number of fall-related emergency department (ED) visits.
- Colder days (temperatures lower than −9.4 °C) were associated with a decrease in fall-related ED visits compared to days with an average daily temperature of 3.0 °C or higher.
- Adults between 30 and 44 years old had the highest likelihood of a fall-related ED visit after snowfall or at low temperature.
- Our findings suggest that snowfall increases the risks of falls and provide some support for policies that reduce these risks.

Introduction

About 37.3 million falls that require medical attention occur globally every year.[1] In Canada, falls are the leading cause of injury among older adults, accounting for 85% of injury-related hospitalizations in this demographic.[2,3] The number of fall-related deaths and self-reported injuries in older adults increased by 65% from 2003 to 2008 and by 43% from 2003 to 2009/2010.[2] This trend is worrying as the likelihood of experiencing a fall increases with age and Canada's population is aging.[3] Nevertheless, the public health concern for older adults should span across all ages given that those younger than 65 years made up about 70% of emergency department (ED) visits for falls in 2017/2018.[4] Furthermore, there are differences by sex, with females accounting for 54% of fall-related ED visits compared to 46% for males in 2017/2018.[4] This is especially important considering that the prevalence of osteoporosis is more than two times greater among women,[5] and this health condition leaves women more

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vulnerable to injuries from falls. As falls can result in mortality and significant morbidity (e.g. injuries, chronic pain, functional decline, mental health issues, reduced quality of life, etc.),[2,3,6] there is a public health benefit to an improved understanding of the factors contributing to falls.

Slippery conditions due to ice and snow have been implicated as one of the primary causes of outdoor falls,[7,8] indicating that falls are more likely to occur during winter. Although Chow et al.[9] found conflicting findings in the literature on the seasonality of falls, most of the studies they examined found an increased incidence in falls during winter among older adults, and the authors suggested that cold temperatures and slippery conditions during winter likely contributed to this increase.[9-11] Given these findings and that over half of falls reported among those aged 18 to 44 years[7] and about half of the falls among community-dwelling older adults occurred outdoors,[12] weather is likely an important risk factor. Despite these findings, most messaging to do with preventing falls relates to modifications in ergonomics, built environments and modifiable health behaviours rather than weather.[13-15]

Previous studies have shown snowfall was 13.4 times more likely to occur before days with excess ED visits for falls than before periods without excess visits.[16] Others found a 38% increase in falls involving ice and snow compared with risks on dry weather days[17] and an 18% increase in fall-related hospitalizations within 6 days of a snowfall.[18] In addition, fall-related injuries were 31% higher among men and 15% higher among women on days where freezing rain alerts were issued,[19] and the number of outdoor falls doubled a few days following freezing rain compared to days without excess falls during the month of December.[20] Past research also found that these increases typically have a lag period, beginning a few days after a winter meteorological event (e.g. ice storm, snowstorm, and freezing rain) and persisting for up to a week after its occurrence.[8,16,18,20-22] Furthermore, it has been suggested that falls and hospitalizations for fall-related injuries among seniors increase as average daily temperature decreases.[11,23] More specifically, Luukinen et al.[11] found that the incidence rate of outdoor falls among the elderly was about 4.5 times greater on days with an average daily temperature less than −20 °C compared to days of at least 10 °C.

Although these studies provide some insight into how meteorological events may increase the risk for a fall and related hospital care, their generalizability is limited. Firstly, almost all studies investigating relationships between meteorological factors and hospital care for falls focussed exclusively on older adults.[8-11,23,24] Secondly, the Canadian studies that have explored these associations have largely focussed on the impacts of major storms and freezing rain.[8,20,22] Thus, previous studies have not reported associations between more frequent winter meteorological events (e.g. everyday snowfall and cold temperatures) and falls; nor have they consistently explored variations by age. By understanding the relationships between meteorological factors and fall-related hospital care among residents of Ontario, we are better able to anticipate the health care resources required to treat these events and target injury prevention.

To address research gaps in this topic area, the aim of this study was to examine the influence of snowfall and temperature on fall-related ED visits during winter months in Ontario and investigate whether these associations differed by sex and age.

Methods

Study design

We used a time-stratified case-crossover study design to evaluate associations between meteorological factors (e.g. daily snowfall accumulation and daily average temperature) and the occurrence of ED visits for unintentional falls during winter months. This design is effective for evaluating associations between short-term environmental exposures and adverse health events[25] (e.g. snowfall and myocardial infarction,[26] temperature and myocardial infarction,[27] air pollution and asthma,[28] etc.). The effectiveness of this study design at evaluating these associations lies in its method of controlling confounders (e.g. age, sex, etc.) by having cases essentially match to themselves.[29] This study design controls for the influence of individual-level factors by contrasting the individual's exposure on the event date to their exposure during control periods. We chose the time-stratified bi-directional approach to certain control periods by selecting other days of the month that fall on the same day of the week as the event date; this provides the additional benefit of controlling day-of-week effects.[25]

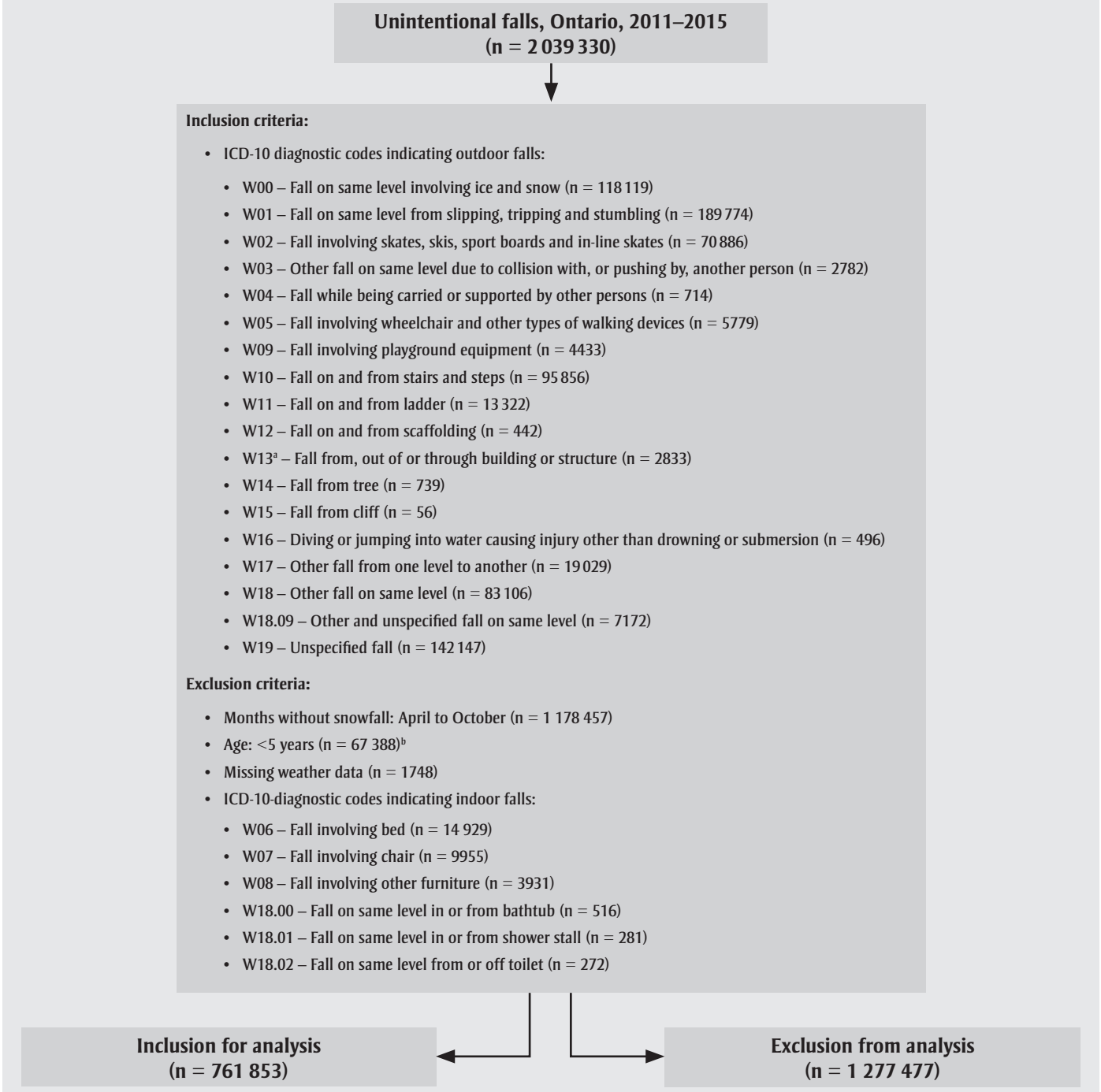
Study population

The National Ambulatory Care Reporting Systems (NACRS) captures individual-level demographic (e.g. age, sex, postal code) and administrative information (e.g. registration date and diagnostic codes) for all hospital-based and community-based ambulatory care from participating facilities and ministries of health.[30] Unintentional falls are defined by records containing International Classification of Disease 10th edition (ICD-10-CA) codes W00 to W19 as the primary reason for these ED visits. As we were most interested in quantifying the associations between meteorological factors and ED visits for outdoor unintentional falls, we removed records with ICD-10-CA codes indicating a fall that was unlikely to occur outdoors. (For a list of included and excluded ICD-10-CA codes, see Figure 1.) We excluded children aged under 5 years because unintentional falls in this age range predominantly occur indoors.[31] Furthermore, given that performing these analyses nationally requires considerable computational resources and that Ontario's NACRS data provides ample sample size and has near complete coverage,[30] we restricted our analyses to Ontario ED visits.

Weather data

While meteorological stations are often used to assess spatial associations between weather events and health outcomes, their use is limited to health outcomes that occur near these stations.[32,33] The Canadian Forest Service of Natural Resources Canada works to overcome this issue by using thin-plate smoothing splines through ANUSPLIN climate modelling software to create spatial climate models.[32,34] While these models have largely had applications in the forestry industry, they can be used in environmental health research.[32,33] These climate models can estimate daily values for temperature extremes (minimum and maximum) and total precipitation at a postal code level.[33,34] However, the lowest geographical unit level available from our NACRS dataset for place of residence is the forward sortation area (FSA; regions defined by the first three digits of a postal code). Thus, the mean

FIGURE 1
Algorithm used to determine emergency department visits for outdoor unintentional falls included in study population, November to March, 2011–2015, Ontario



Sources: Canadian Urban Environmental Health Research Consortium (meteorology data); National Ambulatory Care Reporting System (emergency department visit data).

[a] The ICD-10-CA code W13 was included as it also codes for outdoor falls on balconies, bridges, flag poles and rooftops.

[b] Falls that occur among those aged less than 5 years mostly occur indoors.

daily average temperature, temperature extremes and total precipitation were calculated for each FSA by averaging these values for all six-character postal codes within an FSA. The meteorological data for all fall and control event dates were linked spatiotemporally by the Canadian Urban Environmental Health Research Consortium (CANUE).[35,36]

As our measure of total precipitation was not able to distinguish rain from snow, we defined snowfall as precipitation occurring on days with an average temperature at or below 0 °C. Furthermore, as increases in ED visits for unintentional falls occur up to one week after winter meteorological events,[8,16,18,20-22] we examined lag days up to one week before the fall-related ED visit. We analyzed single-day snowfall accumulation rather than multi-day snowfall accumulation because snowfall removal is likely to occur within 24 hours of its occurrence.[17] We also categorized our main meteorological variables because we sought to examine how the associations between meteorological variables and fall-related ED visits varied at different levels. Furthermore, there may be some error in the values for environmental factors within an FSA due to factors such as buildings, topography, vegetation cover and wind. In the context of snowfall, individuals tend to stay indoors when greater snowfall accumulation occurs,[22] reducing their risk for a fall. We categorized snowfall using the definitions for trace and non-trace snowfall accumulation (> 0 to < 0.2 cm and ≥0.2 cm, respectively) from Environment and Climate Change Canada.[37] Trace snowfall accumulation was used to represent modest snowfall amounts that exceed 0 cm and accumulation of at least 0.2 cm represented more significant snowfall.

For average daily temperature, the temperature range in our data crossed 0 °C, where more slippery conditions may occur due to freezing rain and ice formation. In turn, these conditions may be more likely to precipitate a fall, unlike at temperatures considerably above or below 0 °C. Consequently, we used a quintile approach to categorize our average daily temperature ranges.[11] As there was only recorded snowfall between the months of November and March, we defined these months as winter and restricted the records for analysis to these months. Furthermore, we removed 1748 fall-related ED visit records (0.2%) with missing weather data on the registration date from analysis (Figure 1).

Statistical analysis

We summarized individual-level characteristics by demographic and meteorological factor of individuals who had an ED visit for an unintentional fall during the months of November to March for the calendar years of 2011 to 2015, inclusively. We used conditional logistic regression to compute the odds ratio (OR) and its 95% confidence interval (CI) for ED visits for unintentional falls on days with total daily snowfall accumulation (> 0 to < 0.2 cm, ≥0.2 cm) compared to days with no snowfall, including lag days up to one week before the fall-related ED visit.

Furthermore, we conducted regression analyses for fall-related ED visits on days corresponding to average daily temperature ranges of less than −9.4 °C, −9.4 to less than −4.1 °C, −4.1 to less than −0.3 °C and −0.3 to less than 3.0 °C compared to days with an average temperature of at least 3.0 °C. We stratified the analyses by age group (5–17, 18–29, 30–44, 45–64 and 65 + years) and sex.

We also modelled the association between fall-related ED visits and both exposure factors to assess the stability of our primary results. All analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, US). Carleton University's Research Ethics Board approved the study (Project #113345).

Results

Demographic and weather characteristics

We identified 761 853 fall-related ED visits during the study period (Table 1). Fall-related ED visits occurred most frequently on days without snowfall (63.2%; n = 481 273), followed by days with trace snowfall accumulation (24.1%; n = 183 831) and days with non-trace snowfall accumulation (12.7%; n = 96 749). The distribution of fall-related ED visits by temperature was similar across the temperature ranges. Demographically, there were more fall-related ED visits among females (55.3%; n = 420 978) than males and among adults aged 65 and older (29.6%; n = 225 733) than the other age groups. There were also more fall-related ED visits among those living in urban areas (82.5%; n = 628 650) than in rural areas and in central Ontario (34.7%; n = 264 692) than other regions in Ontario.

Daily snowfall accumulation

For days with trace snowfall accumulation, the highest increase in the odds for fall-related ED visits occurred on the day this accumulation occurred (OR = 1.05; 95% CI: 1.04, 1.06) compared to days with no snowfall (Figure 2; data table available on request from the authors). This pattern was consistent across all groups of analysis (e.g. overall, by sex and by age group). By age group, adults (individuals 30–44 and 45–64 years) presented with the largest increase in odds for a fall-related ED visits (adults 30–44 years: OR = 1.07, 95% CI: 1.05, 1.09; adults 45–64 years, OR = 1.08, 95% CI: 1.06, 1.09). We also observed elevated odds 5 to 7 days afterwards across most groups analyzed.

These observed patterns differed from those seen on days with non-trace snowfall accumulation (Figure 3; data table available on request from the authors). Overall, the increased odds persisted for most of the week after non-trace snowfall accumulation occurred (OR = 1.05–1.08), with a slight reduction 5 days afterwards. While this relationship did not differ by sex, there were differences by age. A modest reduction in the odds for fall-related ED visits occurred on the case day to 2 days afterwards (OR = 0.92–0.97) among school-aged children (5–17 years). While there was a peak in the odds for fall-related ED visits one day following non-trace snowfall accumulation across most age groups, this association was most pronounced among adults (OR = 1.16–1.19). Individuals aged 18 to 29 years and 65 years and older presented with similar increases in odds ratios for fall-related ED visits 1 to 4 days following non-trace snowfall (OR = 1.03–1.09). When adjusted for temperature (Table 2), the risk estimates were similar (OR on lag day 0 for trace snowfall accumulation = 1.06, 95% CI: 1.06, 1.07) to the unadjusted values (OR = 1.05, 95% CI: 1.04, 1.06). This was also the case for our stratified analyses (data available on request from the authors).

Daily average temperature

The odds for fall-related ED visits was elevated across most temperature ranges analyzed (Figure 4). Overall, the increase

TABLE 1
Distribution of ED visits for unintentional falls according to meteorological factors and patient characteristics, November to March, 2011–2015, Ontario

Variable	Number of emergency department visits	
	n = 761 853	%[a]
Snowfall accumulation on the day of the ED visit, cm		
0	481 273	63.2
>0 to <0.2	183 831	24.1
≥0.2	96 749	12.7
Daily average temperature, °C		
≥3.0 (warmest)	147 996	19.4
−0.3 to <3.0	148 645	19.5
−4.1 to <−0.3	160 298	21.0
−9.4 to <−4.1	158 765	20.8
<−9.4 (coldest)	146 149	19.2
Rurality[b]		
Rural	133 203	17.5
Urban	628 650	82.5
Region of residence in Ontario[c]		
Eastern Ontario	140 251	18.4
Central Ontario	264 692	34.7
Metropolitan Toronto	129 532	17.0
Southwestern Ontario	157 315	20.6
Northern Ontario	70 063	9.2
Sex		
Female	420 978	55.3
Male	340 875	44.7
Age group, years		
5–17	138 707	18.2
18–29	94 185	12.4
30–44	105 067	13.8
45–64	198 161	26.0
65+	225 733	29.6
Year		
2011	144 068	18.9
2012	144 305	18.9
2013	157 564	20.7
2014	165 496	21.7
2015	150 420	19.7

Sources: Canadian Urban Environmental Health Research Consortium (meteorology data); National Ambulatory Care Reporting System (emergency department visit data)

[a] Percentages may not add up to 100% due to rounding.

[b] Defined by the second digit of forward sortation areas (rural [0] and urban [1–9]).

[c] Defined by first letter of forward sortation areas (eastern Ontario [K], central Ontario [L], metropolitan Toronto [M], southwestern Ontario [N] and northern Ontario [P]).

in the OR on days with an average daily temperature between −0.3 and less than 3.0 °C (OR = 1.04; 95% CI: 1.03, 1.05) was less than the increase seen on days with an average daily temperature of between −4.1 and less than −0.3 °C (1.09; 1.08, 1.10) or between −9.2 and less than −4.1 °C (1.08; 1.07, 1.09). Conversely, there was a modest reduction in the odds on days colder than −9.4 °C (0.95; 0.94, 0.96).

There were no substantive differences by sex (Figure 4). By age group, the association between average daily temperature and fall-related ED visits was weakest among older adults and most pronounced among adults. The reduction in the odds for fall-related ED visits on days with an average daily temperature of less than −9.4 °C was similar among school-aged children, those 45 to 64 years of age and older adults (OR: 0.92–0.95). Meanwhile, adults aged 18 to 29 years and 30 to 44 years demonstrated no reduction in the odds on these days (OR: 1.00). Conversely, on days with an average daily temperature of −4.1 to less than −0.3 °C, adults had the greatest increase in the odds for a fall-related ED visit (OR: 1.15–1.18) compared to other age groups (OR: 1.04–1.06).

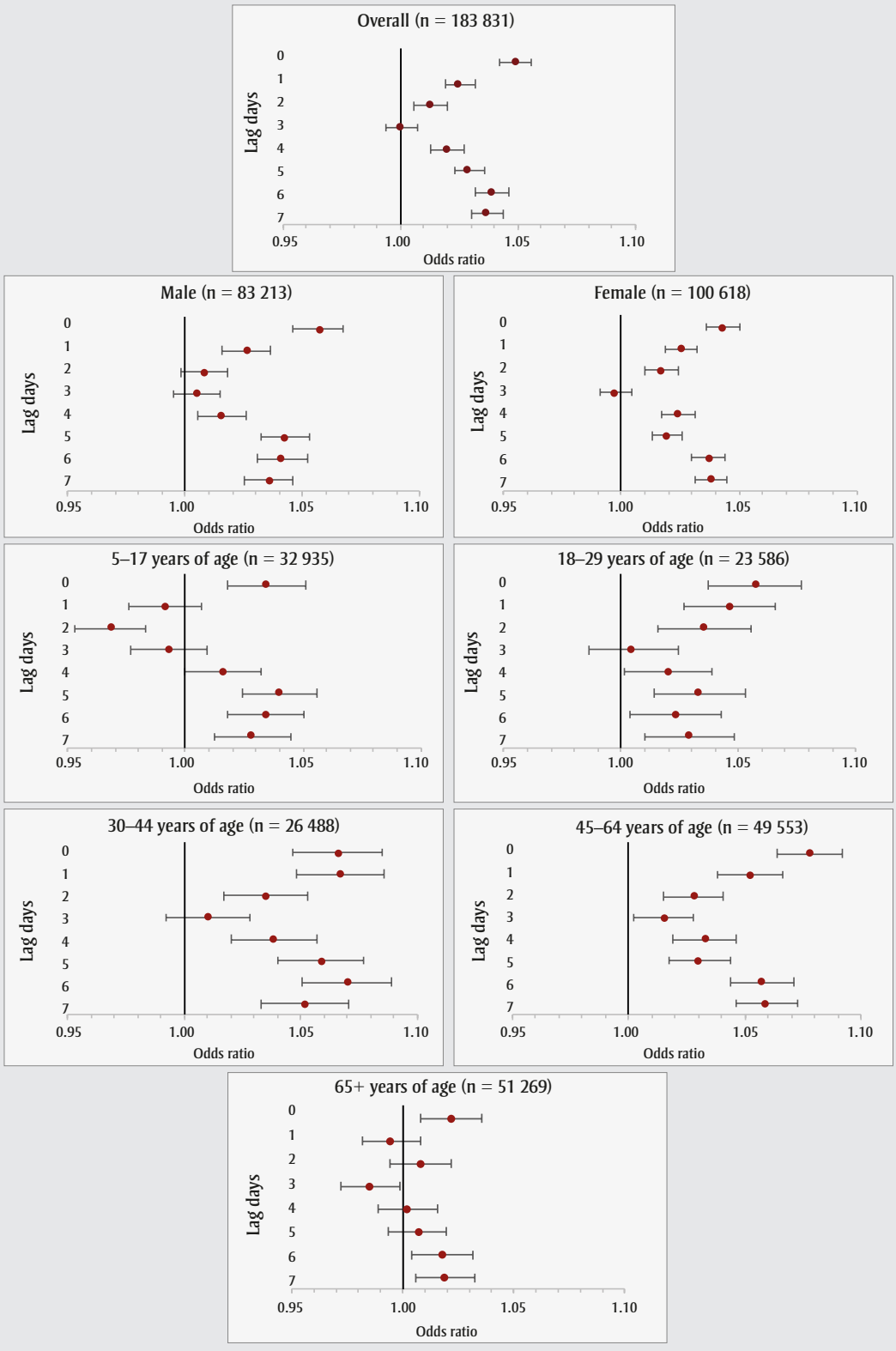
The risk estimates from our sensitivity analysis examining the association between average daily temperature and fall-related ED visits when adjusted for snowfall (data available on request from the authors) were similar to unadjusted values for all groups analyzed. For example, the adjusted OR for the −4.1 to less than −0.3 °C average daily temperature range was 1.10 (95% CI: 1.09, 1.11), while the unadjusted OR was 1.09 (95% CI: 1.08, 1.10).

Discussion

In this study, we evaluated associations between select meteorological factors (i.e. daily snowfall accumulation and temperature) and ED visits for unintentional falls among those aged 5 years and over, in Ontario, for the months of November to March between 2011 and 2015. We found positive associations between snowfall and fall-related ED visits relative to days with no snowfall. We also found decreased odds for these events on days with an average temperature of colder than −9.4 °C compared to days with an average temperature of at least 3.0 °C.

We observed a 5% increase in the odds for fall-related ED visits on days with trace snowfall accumulation and 5 to 7 days after this accumulation. Furthermore, we observed a 5% to 8% elevation on days with non-trace snowfall accumulation up to a week afterwards. Our findings are consistent with past research that found an increase in fall-related ED visits after winter precipitation (i.e. snowfall and ice storms), with greater lags in these increases as the severity of these weather events increased.[9,16,17,19-22] The delay in increased ED visits may be due to lags in

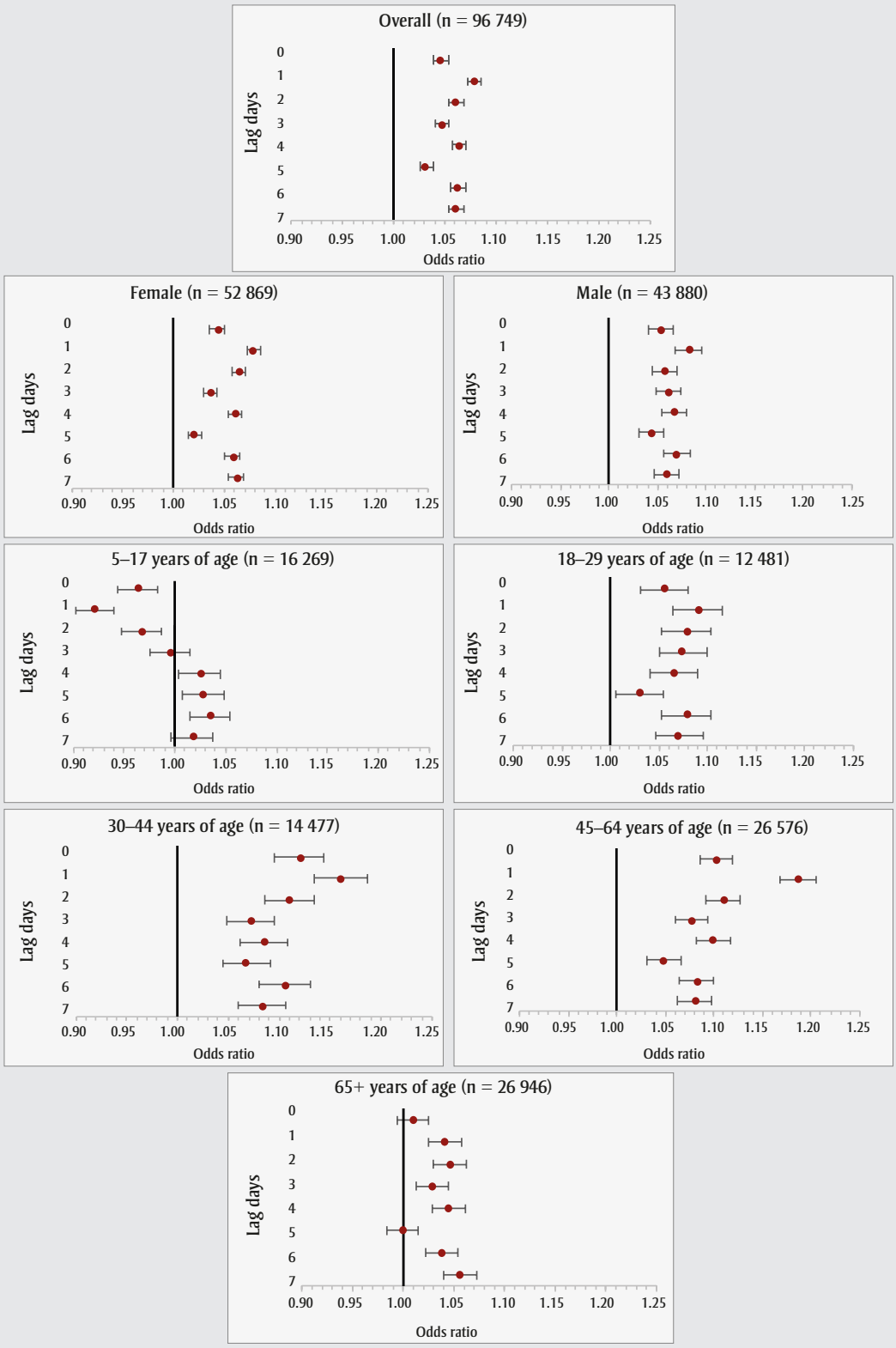
FIGURE 2
Associations between snowfall (>0 to <0.2 cm) and emergency department visits for unintentional falls (≥5 years of age) compared to days with no snowfall, November to March, 2011–2015, Ontario



Sources: Canadian Urban Environmental Health Research Consortium (meteorology data); National Ambulatory Care Reporting System (emergency department visit data).

Note: Lag days represent the number of days before the emergency department visit.

FIGURE 3
Associations between snowfall (≥0.2 cm) and emergency department visits for unintentional falls (≥5 years of age) compared to days with no snowfall, November to March, 2011–2015, Ontario



Sources: Canadian Urban Environmental Health Research Consortium (meteorology data); National Ambulatory Care Reporting System (emergency department visit data).

Note: Lag days represent the number of days before the emergency department visit.

TABLE 2
Association between snowfall accumulation and emergency department visits for unintentional falls (≥5 years of age) adjusted for average daily temperature compared to days with no snowfall, November to March, 2011–2015, Ontario

Lag day	Snowfall accumulation, cm			
	>0 to 0.2		≥0.2	
	OR	95% CI	OR	95% CI
0	1.06	1.06, 1.07	1.06	1.05, 1.07
1	1.04	1.04, 1.05	1.09	1.09, 1.10
2	1.03	1.02, 1.03	1.07	1.06, 1.08
3	1.01	1.00, 1.01	1.05	1.04, 1.06
4	1.02	1.01, 1.02	1.06	1.05, 1.07
5	1.02	1.02, 1.03	1.03	1.02, 1.03
6	1.03	1.02, 1.04	1.06	1.05, 1.07
7	1.03	1.02, 1.03	1.05	1.04, 1.06

Sources: Canadian Urban Environmental Health Research Consortium (meteorology data); National Ambulatory Care Reporting System (emergency department visit data).

Abbreviations: CI, confidence interval; OR, odds ratio.

Note: Lag day refers to the number of days before the fall-related emergency department visit.

the development of slippery conditions from thawing and refreezing of precipitation[20,21] or individuals delaying care by staying indoors during inclement weather.[22] While our associations were more attenuated compared to past studies, the findings from our population-based study suggest that snowfall is an important predictor of unintentional falls treated in Ontario hospitals.

We found no substantial differences in the strength of the association between meteorological characteristic and ED visits for unintentional falls between men and women. This differs from past research that found that men had a greater risk of falling following freezing rain alerts.[8] This finding was somewhat surprising given that multiple biological and behavioural factors have previously been identified that could contribute to sex differences in these associations. For example, females may be more predisposed to falling due to age-related decreases in bone mineral density, increased depressive symptoms and gait variability.[38-41] Females may also be at a greater risk of fracture from a fall due to the loss in bone density.[2] Meanwhile, males may be at greater risk for falling due to poorer balance, increased comorbidities and greater risk-taking behaviour.[38-40] However, we were unable to look at these specific influences directly given limitations of the data.

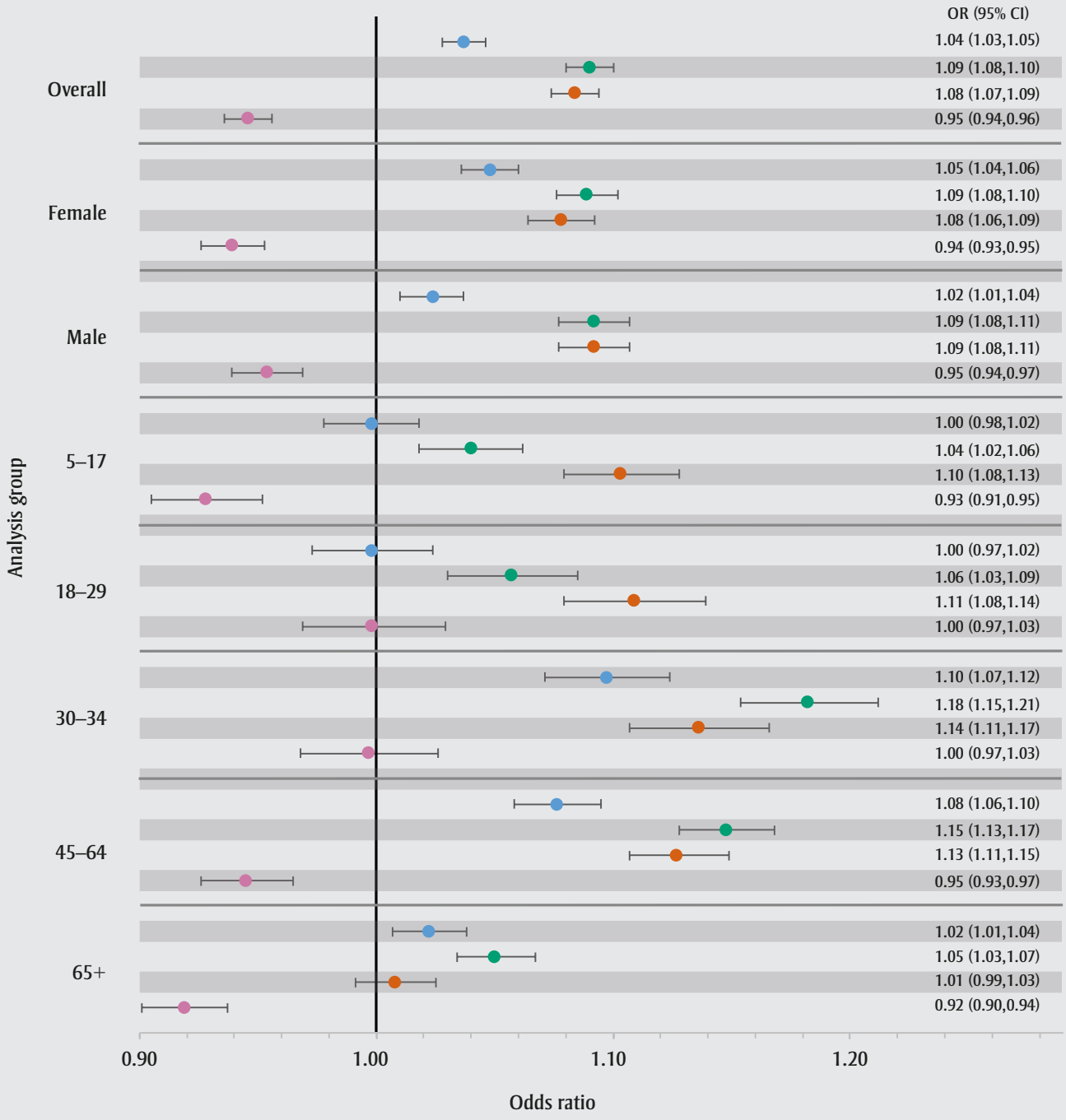
In contrast, we did find that there were differences in the strength of the association across age groups. Specifically, we observed that school-aged children had reduced risks for fall-related ED visit following snowfalls relative to older age groups. We also noted that adults had the greatest positive association, even when compared to older adults, which corroborates with findings from other studies.[16,19] Given this increased risk, it is important to identify factors that may put adults at greater risk. Past research found that older adults (65+) spend less time outdoors during winter than younger adults[42]; other studies posited that exposure to winter weather during work-related commutes was responsible for this elevated risk in the younger age group.[16,19] This rationale could be extended to explain the reduced risk of fall-related ED visits among school-aged children, as schools, parents and caregivers may restrict their outdoor activities on days with inclement weather. However, it is also important to note that we did not find a reduction in risk among older adults even though they also spend less time outdoors than younger adults. This may be explained by differences in the nature in which children and older adults fall, as interactions between weather and other factors (e.g. mobility issues) may put older adults at greater risk for weather-related falls compared to children.[2] However, additional research is needed to confirm these hypotheses.

With respect to temperature, we observed a 4% to 9% increase in the odds of fall-related ED visits on days with average daily temperature ranging from −9.4 to 3.0 °C and a 5% decrease on days when the average daily temperature was colder than −9.4 °C compared to days with an average daily temperature of at least 3.0 °C. By age group, we noted school-aged children and older adults had the lowest increases in risk for temperature ranges at least −4.1 °C and modest decreases in odds on days colder than −9.4 °C. Conversely, we found that adults had the greatest elevated risk on days within the daily temperature ranges of −4.1 to less than −0.3 °C and −9.4 to less than −4.1 °C. These findings partly contradict previous studies that found an inverse association between lower average daily temperature and the incidence of falls and hip fractures.[11,23]

The relationships we found between temperature and fall-related ED visits could be explained by two factors. The elevated risk on days with an average daily temperature of at least −9.4 °C may be due to increased slipperiness of walking surfaces caused by either freezing rain and ice formation from thawing and refreezing of ice and snow as temperatures fluctuate throughout the day. Meanwhile, the decreased risk on colder days (< −9.4 °C) may be attributable to individuals reducing their exposure to weather by staying indoors. Older adults may be dissuaded from going and being active outdoors during colder temperatures due to decreases in perceived walkability.[43,44] In addition, school-aged children may be at a lower risk due to the greater care taken to protect them from colder temperatures. For example, school boards have policies actively encouraging schools to keep school-aged children indoors during the school day (e.g. recess) on days of extreme cold.[45,46] While thresholds differ across different school boards and such policies also consider wind chill, unlike our analysis, such wind chills are more likely to be achieved as temperature decreases.[47] This may partly explain why these groups have a reduction in falls—unlike among young adults or adults 30 to 44 years of age where such policies are less likely to be in place. Future studies should consider evaluating the impact of these factors.

In Canada, unintentional falls are highly prevalent and the accompanying health impacts are substantial. While past research has focussed on older adults, our study suggests that other age groups can also be at increased risk for weather-related falls, especially adults aged 30 to 64 years.

FIGURE 4
Associations between ranges of average daily temperature[a] and emergency department visits for unintentional falls (≥5 years of age) compared to days with an average daily temperature of ≥3.0 °C, November to March, 2011–2015, Ontario



Sources: Canadian Urban Environmental Health Research Consortium (meteorology data); National Ambulatory Care Reporting System (emergency department visit data).

Abbreviations: CI, confidence interval; OR, odds ratio.

Note: A quintile approach was used to select daily average temperature ranges, as follows: blue (−0.3 to <3.0 °C), green (−4.1 to <−0.3 °C), orange (−9.4 to <−4.1 °C) and pink (<−9.4 °C).

[a] Ranges of average daily temperature: <−9.4 °C, −9.4 to <−4.1 °C, −4.1 to <−0.3 °C, −0.3 to <3.0 °C.

Thus, measures aimed at reducing weather-related falls or mitigating the resultant health impacts should also consider targeting younger demographic groups.

Our findings provide support for the development of falls prevention strategies in several areas. As part of regional planning, municipalities can consider these findings when developing service standards (e.g. priorities, snowfall thresholds, timeliness, etc.) for their ice and snow removal policies. Our findings can also inform the content, target audience and timing of weather-related risk communications. Furthermore, for some occupations, employers may be able to implement flexible work arrangement policies (e.g. remote work, variable starting and ending times) due to inclement weather to help reduce the risk of weather-related falls among employees.[16,19] Finally, these findings may be able to help hospitals better anticipate changes in the number of patient contacts and determine appropriate ED staffing levels.

Strengths and limitations

While our study has a wider scope than past Canadian studies, there are several important considerations to note in interpreting these results. First, we matched meteorological factors by place of residence. While it is possible for individuals to have fallen outside the FSA associated with their place of residence, individuals spend most of their time at home. Thus, they are most likely to be exposed to these factors at their place of residence.

Second, some falls may have occurred indoors. We attempted to remove indoor falls from our analysis by excluding NACRS records encoded with ICD-10-CA codes with indoor locations in their description (e.g. W18.00 [Fall on same level in or from bathtub]). However, some ICD-10-CA codes lack location specificity (e.g. W10 [Fall on and from stairs and steps]), which meant that we could only remove about 5% of records. However, as up to 50% of falls could occur indoors,[7,8] our risk estimates for the relationships we analyzed may be conservative. Future studies could consider using other datasets where the distinction between outdoor and indoor falls is collected, such as the Canadian Hospitals Injury Reporting and Prevention Program.

Third, our province-wide analyses do not consider more localized factors, like neighbourhood walkability. A more local analysis can provide additional insights for developing more tailored recommendations.

Nonetheless, unlike previous studies, our study can support falls prevention and mitigation efforts for across a wider range of age groups.

Conclusion

ED visits for unintentional falls are more likely to occur on days with snowfall compared to days without snowfall. This increased risk persists over several days when greater snowfall accumulation occurs. Meanwhile, the risk for fall-related ED visits decreases on days with daily average temperatures of less than −9.4 °C compared to days of at least 3.0 °C. Adults are generally at greatest risk with respect to these relationships. These findings provide insight for the development of strategies to prevent and mitigate the harms due to falls.

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Conflicts of interest

All authors declare no conflicts of interest.

Authors' contributions and statement

DH, CT and PJV were involved in the conceptualization of the work and study design.

DH and PJV led the conceptualization of the analysis.

SRM and FB analyzed and provided the ED visit data. JC analyzed and provided the weather data.

DH conducted the analysis.

DH and CT led the drafting of the manuscript and preparation of the manuscript for submission.

DH, CT, WT, FB, SRM, JC and PJV were all involved in the interpretation of the data and revision of the manuscript.

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

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Original quantitative research

Characteristics of vulnerable women and their association with participation in a Canada Prenatal Nutrition Program site in Toronto, Canada

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Abstract

Introduction: The Canada Prenatal Nutrition Program (CPNP) supports community organizations to provide maternal–infant health services for socially/economically vulnerable women. As part of our research program exploring opportunities to provide postnatal breastfeeding support through the CPNP, we investigated the sociodemographic and psychosocial characteristics of clients enrolled in a Toronto CPNP site and explored associations with participation.

Methods: Data were collected retrospectively from the charts of 339 women registered in one southwest Toronto CPNP site from 2013 to 2016. Multivariable regression analyses were used to assess associations between 10 maternal characteristics and three dimensions of prenatal program participation: initiation (gestational age at enrolment in weeks), intensity (number of times one-on-one supports were received) and duration (number of visits).

Results: The mean (SD) age of clients was 31 (5.7) years; 80% were born outside of Canada; 29% were single; and 65% had household incomes below the Statistics Canada family size-adjusted low-income cut-offs. Income was the only characteristic associated with all dimensions of participation. Compared to clients living above the low-income cut-off, those living below the low-income cut-off enrolled in the program 2.85 weeks earlier (95% CI: −5.55 to −0.16), had 1.29 times higher number of one-on-one supports (95% CI: 1.03 to 1.61) and had 1.29 times higher number of program visits (95% CI: 1.02 to 1.63).

Conclusion: Our findings show that this CPNP site serves vulnerable women, with few differences in participation based on maternal characteristics. This evidence can guide service provision and monitoring decisions at this program site. Further research is needed to explore new program delivery models to enhance perinatal services for vulnerable women.

Keywords: *vulnerable populations, prenatal program, program evaluation, Canada Prenatal Nutrition Program, CPNP, pregnant women*

Highlights

- Clients registered at one Canada Prenatal Nutrition Program (CPNP) site in Toronto reported a variety of vulnerabilities. For example, 80% were not born in Canada and 65% were living in low-income households.
- Of 10 maternal characteristics investigated, household income was the only one associated with all three prenatal participation measures; women living in low-income households enrolled in the program earlier in pregnancy, had a higher number of one-on-one contacts with program staff and a higher number of visits to the program.
- Integrating additional supports at this program site could be explored as a way to extend perinatal services to vulnerable women.

Introduction

The federally funded Canada Prenatal Nutrition Program (CPNP) was established in 1995 to support community-based organizations in developing or expanding health interventions for vulnerable pregnant women across the country.[1]

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The CPNP specifically aims to increase healthy birth weights and promote and support breastfeeding among socially and/or economically vulnerable women, including those with lower income and education and/or who are substance users, newcomers, lone parents and adolescents.

There are over 240 CPNP sites serving about 45 000 women annually across Canada.[2] All the sites are unique as the range of services they provide depend on local needs, but all the services are implemented based on the overarching CPNP guiding principles, program objectives and core services. Core services include group education on nutrition and health; provision of food/grocery gift cards; one-on-one support; and community referrals.

The only national CPNP impact evaluation was based on 48 184 participants between 2002 and 2006. The evaluation utilized an exposure index created by combining three dimensions of participation: gestational age at program enrolment (initiation); number of contacts with program staff (intensity); and number of program visits (duration).[3] Each dimension was split at the median to create a "high" and "low" category (i.e. participants who enrolled at an earlier gestational age versus a later one; had a higher number of contacts with staff versus a lower number of contacts; and had a higher number of visits versus a lower number of visits). CPNP participants in the "high" category for at least two dimensions were considered to have high CPNP exposure.

This evaluation found that, compared with low CPNP exposure, high exposure improved maternal health behaviours, including breastfeeding initiation and duration to 6 weeks, and prenatal supplement use.[3] High CPNP exposure was also associated with a reduction in preterm, low-birth-weight and small-for-gestational-age infants.[3]

Although these data suggest benefits of CPNP participation, breastfeeding remains an ongoing public health issue. According to the 2017/2018 Canadian Community Health Survey, 91% of mothers start breastfeeding, but only 34% exclusively breastfeed for the recommended six months.[4] Breastfeeding practices (initiation, duration, exclusivity) are influenced by a range of determinants (e.g. individual factors, such as age, education, income; the health system; sociocultural attitudes) and are lowest among vulnerable women.[5-8] As an example, national data indicate that women with lower income and education are less likely to breastfeed exclusively for 6 months.[7,8] These data suggest there remains unmet potential for the CPNP to support vulnerable women to breastfeed, and thereby, contribute more to reducing disparities in breastfeeding practices. Currently, the CPNP does not have a formal framework or funding for sites to provide postnatal lactation support.

Our research program aims to evaluate opportunities to improve breastfeeding practices among vulnerable women in Canada by strengthening the delivery of skilled postnatal lactation support (e.g. emotional, practical, informational and social support provided by trained individuals) through the CPNP, primarily through in-home visits by International Board Certified Lactation Consultants.[9] Although high CPNP exposure has been associated with improved perinatal health behaviours and outcomes,[3] little is known on the vulnerability profile of clients at specific sites or how maternal characteristics may affect program participation. A better understanding of who is participating in CPNPs, and how engaged they are, is a necessary step towards strengthening the program, including the delivery of proactive postnatal lactation support.

Our aim for this study was to (1) describe the sociodemographic and psychosocial characteristics of clients enrolled in one Toronto CPNP site; and (2) determine which maternal sociodemographic and psychosocial characteristics were associated with dimensions of CPNP participation at this site.

Methods

We conducted a chart review of routinely collected data from a CPNP site in Toronto, Ontario, implemented by Parkdale Queen West Community Health Centre (the Parkdale Parents' Primary Prevention Project, or 5Ps), which has served families in the southwest area of Toronto for over 25 years. We retrospectively extracted data from archived intake forms, support logs and attendance records of clients who registered in the 5Ps CPNP between 2013 and 2016 and signed the program consent for their de-identified data to be used for evaluation purposes.

For clients who enrolled in the 5Ps CPNP for more than one pregnancy during the study timeframe, only their first pregnancy at the program was included in the study. Clients were also excluded if they were ineligible for the 5Ps CPNP due to miscarriage or referral to another CPNP site, or if their intake form was incomplete.

Description of the 5Ps CPNP

The 5Ps CPNP catchment area included densely populated, ethnically diverse neighbourhoods, one of which was designated a "neighbourhood improvement area" by the city of Toronto.[10,11] The site was staffed with individuals experienced in community programming and working with vulnerable families. The sole family support and outreach worker identified pregnant women in the catchment area by distributing flyers to medical walk-in clinics, family physician offices, the local hospital, obstetrics and gynecology offices and residential buildings over 2 days per month. Based on anecdotal reports, a large proportion of women learned about the program by word of mouth.

Weekly services at the 5Ps CPNP included group education sessions, individualized support from public health nurses and dietitians, community referrals, and a self-serve food bank. Participants were given one $10 grocery store gift card and two public transit tokens per visit and offered snacks and onsite childcare. Professional interpreters were available in-person for non-English speaking clients; previous studies conducted at this CPNP site reported that 7–10% of women required an interpreter.[12,13] Women could register at any point during their pregnancy, and there was no limit on the number of times they could attend during their pregnancy.

Data sources

Routine intake forms, administered by program staff at enrolment, collected data on clients' sociodemographic and psychosocial characteristics. Each client's chart also contained a log of one-on-one supports provided by 5Ps CPNP staff each week during the program. Examples of one-on-one supports included community referrals (e.g. public health program, shelter), health counselling and nutrition counselling. Clients could seek out program staff for one-on-one support, or staff could approach clients based on information provided during intake or when they

attended the program. Individual attendance was tracked electronically each week.

Ethics approval

Ethics approval was obtained from the Office of Research Ethics at the University of Toronto (34482). Upon enrolment in the 5Ps CPNP, clients were asked if their de-identified information could be used for program evaluation. Data for the current study were only extracted from the charts of clients who signed this consent form.

Primary outcome measures

Based on the only previous CPNP impact evaluation[3] and data availability, we constructed indicators of three key dimensions of prenatal participation in the 5Ps CPNP: initiation, intensity and duration. *Initiation* was determined by the estimated gestational age in weeks upon program enrolment, as recorded on client intake forms.

Intensity was determined by the number of times clients received one-on-one supports from 5Ps CPNP staff according to their support log. One-on-one support interactions were recorded under 12 categories defined by program staff. Group services provided to all clients (described in "Description of the 5Ps CPNP") were not recorded in individual support logs and were not counted as one-on-one supports in our analyses.

Duration was determined by the actual number of weeks clients attended the 5Ps CPNP, from enrolment to delivery, according to attendance records.

While there is potential for redundancy over these three dimensions of participation, there is value in exploring participation from different angles given the overall limited evaluation of participation in CPNP programs.

Independent variables

We extracted self-reported maternal sociodemographic and psychosocial characteristics from 5Ps CPNP intake forms. Maternal characteristics common to all versions of intake forms between 2013 and 2016 and that could therefore be extracted included:

- maternal age (years, continuous variable);
- years in Canada (born in Canada or, for those not born in Canada, < 1 year, 1–3 years or ≥4 years);
- refugee status (yes/no response to the question, "Did you arrive in Canada as a refugee or refugee claimant?");
- history of mental illness (yes/no response to the question, "Have you ever experienced or been diagnosed with depression, postpartum depression or a mental health concern?");
- education (less than high school, high school or postsecondary);
- marital status (single or living with partner);
- number of children (first-time mother or has 1 child or more);
- food deprivation during pregnancy (yes/no response to the question, "During your pregnancy, was there ever a time when you did not have enough food to eat?");
- abuse during pregnancy (yes/no response to the question, "From the beginning of your pregnancy, has anyone abused you physically, sexually or emotionally?");
- Ontario Health Insurance Program (OHIP) coverage (yes/no);
- household income (above low-income cut-off, below low-income cut-off or don't know income; assessed using the Statistics Canada family size-adjusted low-income cut-off values corresponding to clients' year of program enrolment.[14-16] For example, a family of four with a household income less than $39092 in 2016 would be living below the low-income cut-off[16]);
- ethnicity (East Asian, African, European, South Asian, Latin American, Caribbean, Southeast Asian, West Asian or Other; categorized based on United Nations geographic regions of the world[17])

Statistical analysis

We reported sociodemographic and psychosocial characteristics and 5Ps CPNP participation measures using descriptive statistics.

We assessed the association between maternal characteristics and the three dimensions of 5Ps CPNP participation (initiation, intensity and duration) as outcome variables. The continuous *initiation* variable was analyzed using a multivariable linear regression model. Results were reported using parameter estimates with 95% confidence intervals (CI). Count data (*intensity* and *duration*) were analyzed using multivariable Poisson regression models instead of linear regression models as the data did not follow a normal distribution. The Poisson models were adjusted for overdispersion using Pearson scaling, and model fit was assessed using a goodness-of-fit chi-square test. Results were reported using incidence rate ratios (IRR) with 95% CI.

For all analyses, the reference category for each categorical independent variable was the less vulnerable group (e.g. above the low-income cut-off). All independent variables were considered in the analyses except for abuse during pregnancy (frequency less than 10%) and ethnicity (predominance of one ethnic group and frequency less than 10% among the remaining categories). Independent variables used in the analyses were checked for statistical multicollinearity (variance inflation factor > 2.5), and none met this criterion.

SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) was used to conduct the statistical analyses. A p value of less than 0.05 was considered statistically significant.

We used the k-nearest-neighbours (KNN) algorithm to impute missing independent variables using the VIM package in R software version 3.5.1 (R Foundation, Vienna, AT)[18] and conducted sensitivity analyses for all models using the original dataset (no imputations).

Results

Study sample

We assessed 370 clients for eligibility and excluded 31 for the following reasons: 10 clients did not consent for their charts to be used for program evaluation purposes; 10 had a subsequent pregnancy during the study timeframe and their data were only included once; seven had a pregnancy loss or were not pregnant; three were referred to a CPNP site closer to their place of residence; and one did

not have any information on their intake form. A total of 339 clients were included in the analyses (see Figure 1). Of these, 16 consented to partial use of data and were therefore excluded from the *intensity* analysis.

The mean (SD) age of clients at enrolment was 31 (5.7) years. Only 16% (54/339) were born in Canada, and 33% (111/339) had lived in Canada for 3 years or less (Table 1). Of all the participants in the analyses, 47% (159/339) had high school education or less and 29% (97/339) were single. Of those who reported household income, 78% (220/281) were below the low-income cut-off.

Initiation

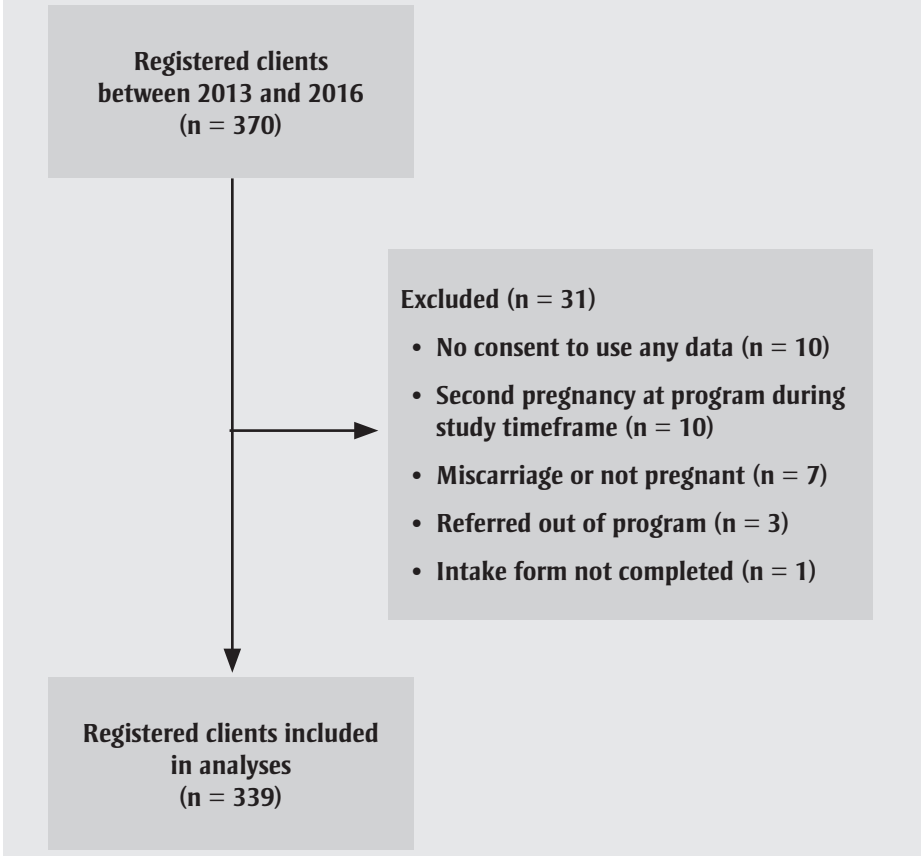
The median gestational age at enrolment in the 5Ps CPNP was 25 weeks (interquartile range [IQR] 17–30). Only 15% (50/336) enrolled during their first trimester of pregnancy (1–12 weeks); 53% (179/336) enrolled during their second trimester (13–28 weeks) and 32% (107/336) during their third trimester (29–40 weeks).

The linear regression model showed no difference in initiation based on maternal age, number of years in Canada, refugee status, marital status, food deprivation or OHIP coverage (Table 2). Clients who reported a history of mental illness enrolled in the 5Ps CPNP earlier than those with no history of mental illness (parameter estimate = −3.19 weeks; 95% CI: −5.71 to −0.67). Clients living below the low-income cut-off, compared to above the low-income cut-off, also enrolled in the program earlier (parameter estimate = −2.85 weeks; 95% CI: −5.55 to −0.16). Clients with less than high school education enrolled in the program later than those with postsecondary education (parameter estimate = 3.48 weeks; 95% CI: 0.20 to 6.76). Lastly, compared to clients with at least one child, first-time mothers also enrolled in the program later (parameter estimate = 3.20 weeks; 95% CI: 1.21 to 5.19).

Intensity

The median number of times clients received one-on-one supports from 5Ps CPNP staff was four (IQR 2–6).

FIGURE 1
Process of selection of clients registered in the 5Ps CPNP (2013–2016)



Abbreviations: 5Ps, Parkdale Parents' Primary Prevention Project; CPNP, Canada Prenatal Nutrition Program.

The top three one-on-one supports included community referrals (e.g. public health programs such as Healthy Babies Healthy Children), follow-up on referrals and health counselling from a public health nurse (e.g. prenatal care, breastfeeding information; see Table 3). Only 2% (6/323) of clients received no one-on-one supports, 34% (109/323) received one to three different types of one-on-one supports, 52% (167/323) received four to six different types of one-on-one supports and 13% received seven to nine different types of one-on-one supports (41/323).

The Poisson regression model showed no difference in intensity (determined by the number of times the client received one-on-one supports from program staff) based on maternal age, number of years in Canada, history of mental illness, education, marital status, number of children, food deprivation or OHIP coverage (Table 2). Refugee clients had fewer one-on-one contacts with program staff than did non-refugees (IRR = 0.72; 95% CI: 0.56 to 0.92). Clients living below the low-income cut-off, compared to above, had a higher number of one-on-one contacts (IRR = 1.29; 95% CI: 1.03 to 1.61).

Duration of attendance

The median attendance in the 5Ps CPNP was 9 weeks (IQR 4–14).

The Poisson regression model showed no difference in duration of attendance based on maternal age, number of years in Canada, refugee status, history of mental illness, education, number of children, food deprivation or OHIP coverage (Table 2). Mothers who were single attended the program for fewer weeks than those with a partner (IRR = 0.76; 95% CI: 0.63 to 0.92). Clients living below the low-income cut-off, compared to above, attended the program for a higher number of weeks (IRR = 1.29; 95% CI: 1.02 to 1.63).

Sensitivity analyses

We conducted sensitivity analyses using the original dataset without imputations for missing data to assess associations between sociodemographic and psychosocial characteristics and 5Ps CPNP initiation (n = 280/339), intensity (n = 282/339) and duration (n = 282/339) (Table 4). These analyses generally showed consistent results with our imputed analyses.

TABLE 1
Sociodemographic and psychosocial characteristics of the 5Ps CPNP clients included in the analyses, 2013–2016 (N = 339)

Characteristics[a]	n	%
Number of years in Canada		
Born in Canada	54	15.9
<1	53	15.6
1–3	58	17.1
≥4	159	46.9
Missing	15	4.4
Refugee status		
Yes	47	13.9
No	263	77.6
Missing	29	8.6
History of mental illness		
Yes	57	16.8
No	263	77.6
Missing	19	5.6
Completed education		
<High school	40	11.8
High school	119	35.1
Postsecondary	170	50.1
Missing	10	2.9
Marital status		
Single	97	28.6
With partner	225	66.4
Missing	17	5.0
Number of children		
First-time mother	169	49.9
≥1 child	157	46.3
Missing	13	3.8
Food deprivation during pregnancy		
Yes	97	28.6
No	218	64.3
Missing	24	7.1
Abuse during pregnancy		
Yes	24	7.1
No	294	86.7
Missing	21	6.2
OHIP coverage		
Yes	279	82.3
No	46	13.6
Missing	14	4.1
Household income[b]		
Below low-income cut-off	220	64.9
Above low-income cut-off	61	18.0
Don't know[c]	50	14.7
Missing	8	2.4
Ethnicity		
East Asian	109	32.2
African	39	11.5
European	32	9.4
South Asian	31	9.1
Latin American	22	6.5
Caribbean	20	5.9
Southeast Asian	14	4.1
West Asian	13	3.8
Other[d]	49	14.5
Missing[e]	10	2.9

Abbreviations: 5Ps, Parkdale Parents' Primary Prevention Project; CPNP, Canada Prenatal Nutrition Program; OHIP, Ontario Health Insurance Program.

[a] Mean (SD) age was 31 (5.7) years based on data from 338/339 participants (n = 1 missing).

[b] Based on the Statistics Canada size-adjusted low-income cut-off corresponding to the client's year of enrolment in the program (2013–2016).

[c] Clients who reported that they did not know their household income.

[d] Clients who self-reported their ethnicity as Canadian (n = 48) and Canadian/Aboriginal (n = 1).

[e] Clients who reported that they did not know their ethnicity (n = 6) or who did not report their ethnicity (n = 4).

Table 1 shows the proportion of missing values for each independent variable.

Discussion

This study investigated the sociodemographic and psychosocial characteristics of clients enrolled in the 5Ps CPNP site in Toronto, Ontario, and the association between these characteristics and dimensions of prenatal program participation. We found that 5Ps CPNP participants included a diversity of women with a range of vulnerabilities. Overall, household income was the only characteristic associated with all three dimensions of program participation. Household income below the low-income cut-off was associated with enrolment earlier in pregnancy, a higher number of one-on-one contacts with program staff and a longer duration of program attendance.

It is encouraging that a history of mental illness was associated with earlier enrolment in the 5Ps CPNP and that a household income below the low-income cut-off was associated with better program engagement overall according to our three dimensions of participation. This suggests that the program's social and tangible supports may be relevant to women with these characteristics and help meet their needs. Nevertheless, to enhance program participation among all registered clients, several subgroups may need to be targeted. According to our results, having no high school education and being a first-time parent was associated with later program initiation, while single marital status was associated with a shorter duration of program attendance. Further research should explore the needs of enrolled clients and barriers to their participation.

Our results indicate that refugee status was associated with having fewer one-on-one contacts with 5Ps CPNP staff. Staff experience (co-authors SS and BU) suggests that this is likely due to one of two possible reasons. First, many refugee clients are referred to the program from shelters and have access to various supports within the shelter system. Second, there is no in-house settlement support at the 5Ps CPNP; therefore, program staff often refer refugee clients who are not connected to the shelter system to a settlement service that can provide support that is more comprehensive to clients' needs.

Given the diversity of the Canadian population, the risk profile of program participants likely differs between CPNP sites across the country and across time. Limited published information is available on the characteristics of women enrolled in individual CPNP sites, making it challenging to compare our cohort with CPNP participants at other sites. National data from a 2015 CPNP participant survey found that 66% of clients had incomes below the low-income cut-off; 26% had less than high school education; 27% were single; 16% were recent immigrants (in Canada < 10 years); and 41% experienced food insecurity.[19] Food insecurity was characterized by an affirmative response to not having enough food for themselves/their family and no money to buy more in the previous 12 months.

In comparison to this national profile of CPNP clients, a similar proportion of our study participants had incomes below the low-income cut-off (65%) and were single

TABLE 2
Regression analysis of sociodemographic and psychosocial characteristics of 5Ps CPNP clients and participation in the prenatal program, 2013–2016

Characteristics	Initiation[a]		Intensity[b]		Duration[b]	
	Parameter estimate	95% CI	IRR	95% CI	IRR	95% CI
Maternal age, years	0.10	−0.08 to 0.28	1.00	0.98 to 1.01	1.00	0.98 to 1.01
Number of years in Canada						
<1 vs. Born in Canada (ref.)	1.29	−2.55 to 5.14	1.14	0.84 to 1.54	1.16	0.84 to 1.59
1–3 vs. Born in Canada (ref.)	0.90	−2.65 to 4.44	0.98	0.74 to 1.32	1.06	0.79 to 1.43
≥4 vs. Born in Canada (ref.)	1.55	−1.52 to 4.62	1.01	0.80 to 1.28	1.04	0.80 to 1.35
Refugee status						
Yes vs. No (ref.)	1.00	−1.85 to 3.85	**0.72**	**0.56 to 0.92**	0.93	0.73 to 1.18
History of mental illness						
Yes vs. No (ref.)	**−3.19**	**−5.71 to −0.67**	1.16	0.95 to 1.42	0.93	0.75 to 1.16
Completed education						
< High school vs. Postsecondary (ref.)	**3.48**	**0.20 to 6.76**	1.05	0.82 to 1.34	0.87	0.66 to 1.15
High school vs. Postsecondary (ref.)	−0.77	−2.94 to 1.41	0.95	0.80 to 1.12	1.06	0.90 to 1.26
Marital status						
Single vs. With partner (ref.)	2.15	−0.07 to 4.38	0.99	0.84 to 1.18	**0.76**	**0.63 to 0.92**
Number of children						
First-time mother vs. ≥1 child (ref.)	**3.20**	**1.21 to 5.19**	0.99	0.84 to 1.15	0.88	0.75 to 1.03
Food deprivation during pregnancy						
Yes vs. No (ref.)	0.40	−1.88 to 2.68	0.96	0.80 to 1.14	0.99	0.82 to 1.19
OHIP coverage						
No vs. Yes (ref.)	1.28	−1.83 to 2.68	1.07	0.85 to 1.35	0.79	0.60 to 1.02
Household income[c]						
Below vs. Above LICO (ref.)	**−2.85**	**−5.55 to −0.16**	**1.29**	**1.03 to 1.61**	**1.29**	**1.02 to 1.63**
Don't know[d] vs. Above LICO (ref.)	**−3.48**	**−6.71 to −0.25**	1.10	0.84 to 1.45	1.21	0.93 to 1.58

Abbreviations: 5Ps, Parkdale Parents' Primary Prevention Project; CI, confidence interval; CPNP, Canada Prenatal Nutrition Program; IRR, incidence rate ratio; LICO, low-income cut-off; OHIP, Ontario Health Insurance Program; ref., reference.

Note: Bolded data are statistically significant at $p < 0.05$.

[a] Prenatal program initiation (n = 336; determined by gestational age in weeks upon enrolment in the program) was modelled using a multivariable linear regression model.

[b] Prenatal program intensity (n = 323; determined by the number of times the client received one-on-one supports from program staff) and duration (n = 327; determined by the number of weeks the client attended the program from enrolment to delivery) were modelled using multivariable Poisson regression models as the data did not follow a normal distribution.

[c] Based on the Statistics Canada size-adjusted low-income cut-off corresponding to the client's year of enrolment in the program (2013–2016).

[d] Clients who reported that they did not know their household income.

(29%). Whereas 30% of study participants experienced food deprivation during pregnancy, in comparison to 41% of national CPNP clients who reported food insecurity, our rate refers specifically to the maternal experience.

In our cohort, a smaller proportion of mothers had less than high school education (12%) and a higher proportion were newcomers to Canada (33% lived in Canada ≤3 years).

This analysis focussed on the maternal characteristics of registered 5Ps CPNP clients and on their participation in this prenatal program. No research was conducted among women who were eligible but did not participate and so we were unable to determine the reach or uptake of the 5Ps CPNP. Levels of uptake of the national CPNP by target populations are also unknown. We do know that vulnerable women are participating in the CPNP, based on the demographics of program participants,[19] but further research on who is not enrolling in the CPNP, locally and nationally, and their reasons for this, would be valuable for strengthening programs and improving program monitoring and evaluation. Other studies have identified gaps in coverage of perinatal services in vulnerable populations, including a population-based study that found 78% of women receiving income assistance did not participate in Manitoba's Healthy Baby community support programs that attempt to reach vulnerable women.[20]

Overall, study participants engaged with the 5Ps CPNP later in their pregnancy, with a median gestational age at enrolment of 25 weeks and a median duration of attendance of nine visits. There is no

TABLE 3
Distribution of one-on-one supports received by 5Ps CPNP clients at least once at the prenatal program, 2013–2016

One-on-one support type	n (N = 323)[a]	%
Follow-up on referral	231	71.5
Health counselling	217	67.2
Community referral (e.g. public health program, shelter)	212	65.6
Extra food/nutrition or instrumental supports	168	52.0
Participant advocacy	168	52.0
Nutrition counselling	142	44.0
Settlement support	96	29.7
Mental health support	93	28.8
Child development advice	15	4.6
Case management/service coordination	14	4.3
Crisis intervention	4	1.2
Other	30	9.3

Abbreviations: 5Ps, Parkdale Parents' Primary Prevention Project; CPNP, Canada Prenatal Nutrition Program.

[a] Sixteen of the 339 clients did not consent for their one-on-one supports to be used for program evaluation.

known participation "threshold" for the CPNP, that is, it is unknown at what gestational age women should enrol or the number of visits needed to attain a specific health or social outcome. It would be expected that the participation threshold would vary for each woman according to her individual needs and risk profile. Nevertheless, efforts to engage vulnerable women in community programming during pregnancy are needed to improve birth and health outcomes.[21-23] In addition, the collection of outcome data across CPNP sites is limited and not standardized, and there is a need for an updated national evaluation.

Although not directly comparable to participation in community prenatal programs, studies have identified a range of maternal risk factors for late or inadequate utilization of available prenatal care. These risk factors typically include characteristics of vulnerability such as having lower education status, lower income or no health insurance or being a refugee or single.[24-28] Strategies to further engage vulnerable women in prenatal care and facilitate enrolment and retention in prenatal community support programs are needed. Primary and community health services (e.g. family doctors, obstetricians, social workers, community health centres) should be well connected to, and create partnerships with, CPNP sites in their geographic area to facilitate program referrals.[29] The experience of 5Ps CPNP staff suggests that an existing and trusting relationship between vulnerable women and community health care and social providers is important so that women who are referred to the CPNP feel comfortable accessing the program, but further research is needed to confirm this.

We conducted this research as one step towards gauging whether the CPNP can be leveraged to strengthen access to proactive postnatal lactation support for vulnerable women. Over three-quarters of the study participants (79%) went on to attend some type of postnatal drop-in program at the community health centre at least once, suggesting interest in continuing engagement with this site. Further research is needed to explore program delivery models for integrating in-home lactation support with the 5Ps CPNP as a program enhancement.

Canadian data show that more work needs to be done to align breastfeeding practices with public health recommendations.[4,30] Data on infant feeding practices of CPNP participants are limited and should be further explored. Breastfeeding initiation by CPNP clients is comparable to the 91% national rate, but breastfeeding duration and exclusivity are unknown.[4,19] Muhajarine et al.[31] found that, despite an 89% breastfeeding initiation rate by CPNP participants nationally, 60% of the mothers discontinued breastfeeding by 4 weeks postpartum. Systematic reviews confirm the importance of postnatal breastfeeding support for improving breastfeeding practices.[32,33] The CPNP's established program and social support structure and stated aim to support breastfeeding positions it well to address ongoing disparities in breastfeeding rates.[2,34] We found that the 5Ps CPNP is serving a diverse group of vulnerable women with few differences in participation based on maternal characteristics. These findings provide information that can be used to support program enhancements at this site, including those that extend to the postnatal period. It would be valuable for other CPNP sites to analyze sociodemographic and psychosocial characteristics of participants and investigate associations with participation to inform program delivery strategies. In-depth assessment of engagement in specific CPNP program components may also be valuable.

Strengths and limitations

To our knowledge, this is the first study to investigate the association between maternal characteristics and participation in a CPNP site. A strength of this research is the focus on vulnerable women's participation in a community prenatal program targeting this group specifically. Another strength is the use of existing program data sources, resulting in a cost-efficient strategy that can inform service provision at this site and strengthen future monitoring efforts at the community level.

In terms of limitations, all sociodemographic and psychosocial characteristics were self-reported by participants and could not be independently verified. We were also limited by the fact that we could not collect additional details on maternal characteristics beyond what was collected as part of the site's standard intake form. In addition, no information was available on motivators for attending the 5Ps CPNP or accessing one-on-one support at the program.

Given limitations of our sample size and potential redundancy between the three dimensions of participation, we were unable to create a combined indicator to analyze program participation as a dichotomous high/low exposure variable as others have done.[3] However, all registered clients in the study period were considered for inclusion in this study and 92% (339/370) were included. Most of those

TABLE 4
Regression analysis of sociodemographic and psychosocial characteristics of 5Ps CPNP clients and participation in the prenatal program (2013–2016) with no data imputations[a]

Characteristics	Initiation[b]		Intensity[c]		Duration[c]	
	Parameter estimate	95% CI	IRR	95% CI	IRR	95% CI
Maternal age, years	0.14	−0.06 to 0.33	1.00	0.99 to 1.02	1.00	0.98 to 1.01
Number of years in Canada						
<1 vs. Born in Canada (ref.)	0.69	−3.81 to 5.19	1.08	0.79 to 1.50	1.31	0.94 to 1.84
1–3 vs. Born in Canada (ref.)	−0.12	−4.26 to 4.01	0.91	0.67 to 1.25	1.16	0.84 to 1.59
≥4 vs. Born in Canada (ref.)	1.48	−2.01 to 4.97	0.92	0.72 to 1.19	1.04	0.79 to 1.36
Refugee						
Yes vs. No (ref.)	1.13	−1.97 to 4.22	**0.73**	**0.57 to 0.95**	0.91	0.71 to 1.16
History of mental illness						
Yes vs. No (ref.)	**−3.27**	**−6.44 to −0.10**	1.13	0.89 to 1.42	0.96	0.75 to 1.23
Completed education						
<High school vs. Postsecondary (ref.)	3.52	−0.003 to 7.05	1.06	0.82 to 1.37	0.83	0.63 to 1.10
High school vs. Postsecondary (ref.)	−1.80	−4.17 to 0.58	0.94	0.78 to 1.12	1.13	0.95 to 1.35
Marital status						
Single vs. With partner (ref.)	1.71	−0.73 to 4.15	0.95	0.79 to 1.14	**0.79**	**0.65 to 0.96**
Number of children						
First-time mother vs. ≥1 child (ref.)	**3.49**	**1.30 to 5.68**	0.98	0.83 to 1.16	0.88	0.75 to 1.03
Food deprivation during pregnancy						
Yes vs. No (ref.)	−0.10	−2.63 to 2.42	0.93	0.78 to 1.13	1.04	0.86 to 1.25
OHIP coverage						
No vs. Yes (ref.)	0.67	−2.68 to 4.02	1.15	0.91 to 1.46	0.79	0.61 to 1.02
Household income[d]						
Below vs. Above LICO (ref.)	−1.23	−4.28 to 1.81	1.25	0.99 to 1.59	1.18	0.93 to 1.51
Don't know[e] vs. Above LICO (ref.)	−3.08	−6.68 to 0.52	1.11	0.83 to 1.47	1.19	0.90 to 1.58

Abbreviations: 5Ps, Parkdale Parents' Primary Prevention Project; CI, confidence interval; CPNP, Canada Prenatal Nutrition Program; IRR, incidence rate ratio; LICO, low-income cut-off; OHIP, Ontario Health Insurance Program; ref., reference.

Note: Bolded data are statistically significant at $p < 0.05$.

[a] Sensitivity analyses were conducted to assess associations between sociodemographic and psychosocial characteristics and 5Ps CPNP participation using the original dataset without imputations for missing independent variables.

[b] Prenatal program initiation (n = 280; determined by gestational age in weeks upon enrolment in the program) was modelled using a multivariable linear regression model.

[c] Prenatal program intensity (n = 282; determined by the number of one-on-one supports the client received from program staff) and duration (n = 282; determined by the number of weeks the client attended the program from enrolment to delivery) were modelled using multivariable Poisson regression models.

[d] Based on the Statistics Canada size-adjusted low-income cut-off corresponding to the client's year of program enrolment (2013-2016).

[e] Clients who reported that they did not know their household income.

who were excluded were ineligible for the 5Ps CPNP (e.g. they were not pregnant) or were having a repeat pregnancy and were therefore already included in the study on the basis of the previous pregnancy. Thus, selection bias is expected to be minimal.

This study was based on data from one CPNP site and may not be generalizable to other sites. However, the 5Ps CPNP catchment area is in a densely populated, ethnically diverse urban area of Toronto (population > 88 000) and is one of the larger CPNP sites in the city.

Conclusion

Our findings confirm that a diversity of women with a range of vulnerabilities enrolled in the 5Ps CPNP site in Toronto, with few differences in participation based on maternal characteristics. Overall, mothers with incomes below the low-income cut-off enrolled in the program earlier in their pregnancy, had a higher number of one-on-one contacts with program staff and attended the program for a longer duration. We found that women with less than a high school education and no previous children may need to be further supported to enrol in the 5Ps CPNP earlier in pregnancy, while lone parents may need additional support to continue attending the program once enrolled.

Our findings contribute evidence to guide perinatal service provision and ongoing monitoring decisions at the 5Ps CPNP. Further research is needed to explore new program delivery models as a means to enhance perinatal services for vulnerable women.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Authors' contributions and statement

JF, DWS and DLO conceptualized the study. JF, AM, DWS and DLO designed the study with input from SI, SS, BU, VT and EDR. JF and SI performed data collection and analysis. AK provided primary statistical guidance. All authors provided primary guidance on data interpretation. JF wrote the first draft of the manuscript and all authors read and approved the final manuscript.

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Original quantitative research

Adolescents' adoption of COVID-19 preventive measures during the first months of the pandemic: what led to early adoption?

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Abstract

Introduction: The objectives of this study were to explore the extent to which adolescents adopted COVID-19 preventive measures in the first few months of the pandemic and to understand their adoption by looking at interconnected adoption-related factors and determining the strength of these factors, particularly among subgroups not expected to be early adopters.

Methods: Analyses focus on data collected during Spring 2020 from 29 eastern Quebec secondary schools that participated in the COMPASS study. Participants (n = 6052) self-reported their knowledge, perception of risk and preventive practices to do with the COVID-19 pandemic. Data were analyzed using structural equation models based on gender and anxiety level.

Results: The majority of respondents reported adopting the recommended COVID-19 preventive measures. The results showed three paths leading to adolescents' adoption of these measures: pandemic knowledge; perception of risk related to COVID-19; and, in particular, discussions with relatives about preventive measures and what to do in case of infection.

Conclusions: While most of the adolescent participants in this study appeared to comply with COVID-19 preventive measures, factors such as discussions with relatives emerge as elements to foster in order to improve adolescents' adoption of preventive measures.

Keywords: *adolescents, youth, COVID-19, adoption of preventive measures, structural equation modelling, SEM*

Highlights

- Adolescents' compliance of COVID-19 preventive measures is high, even in subgroups with lower adoption rates.
- In addition to accurate pandemic knowledge and proper risk perception, discussions with relatives should also be considered as a means of improving adoption of COVID-19 preventive measures by adolescents.

Introduction

Emerging evidence suggests that the health effects of COVID-19 infection tend to be less strong in children, including adolescents, than in adults.[1,2,3,4] Still, youth populations contribute to the spread of COVID-19 through school-based outbreaks and household transmission.[5,6] Because some studies identified youth as a population with potentially low compliance with COVID-19 infection preventive measures,[7,8] it is imperative to understand which youth were early adopters of the preventive measures, and what drove them to adopt the measures in order to design effective awareness campaigns that target this population.

Recent studies show that perception of risk contributes to adults' intention of adopting COVID-19 preventive measures.[9] Health-related stress also affects preventive behaviours.[10] The degree of knowledge about the epidemic also drives individual adoption of preventive measures, with knowledge about the transmission and gravity of the disease factors motivating adults' behaviours.[9]

How these factors are associated with adolescents' adoption of preventive measures is currently unknown. Yet this information is critical when developing messages targeting youth, particularly in subpopulations known to be less likely to follow preventive measures, such as males and individuals reporting lower anxiety levels.[11,12]

Using surveillance data collected from youth attending secondary schools in Quebec during the early stages of the COVID-19 pandemic (April–May 2020), our aim was to determine:

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(1) the extent to which youth adopted COVID-19 preventive measures early on;

(2) how implementation of preventive measures can be explained via interconnected factors that are likely to predict their adoption; and

(3) if adoption of COVID-19 preventive measures and the relation to these interconnected adoption-related factors differ based on gender and anxiety level.

Methods

Survey design and study population

The present study is based on data collected in the province of Quebec as part of the COMPASS (**C**annabis, **O**besity, **M**ental health, **P**hysical activity, **A**lcohol, **S**moking, **S**edentary behaviour) study (https://uwaterloo.ca/compass-system/).[13] COMPASS is a longitudinal multicentre study of adolescent life in Canada. School surveys have been conducted annually in three regions of the province of Quebec since the Spring of 2017, in partnership with the school communities and the regional public health departments. During the 2019/20 data collection cycle, the COVID-19 pandemic forced the closure of Quebec schools for in-person learning on 16 March 2020, and the COMPASS team transitioned its tools from paper-based within-school data collection protocols to online data collections using Qualtrics XM (Seattle, WA, USA).

Data collection occurred between March and May 2020.

The study population includes all students in the 5 years of the secondary level (equivalent to Grades 7 to 11 in the USA and the rest of Canada) of 29 Eastern Quebec secondary schools who had not already completed inputting their data for the 2019/20 data collection cycle before the pandemic-related school closures. Of the 16748 solicited adolescents, 6052 (36.1%) answered the online questionnaire. Parents' refusal rate was less than 1% (108 participants).

Informed consent

The COMPASS protocol involves active-information passive-consent parental permission procedures. Students could decline to participate at any time.

Ethics approval

All procedures involving human participants were in accordance with the ethical standards of the institutional and/or provincial research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. All procedures in the COMPASS study received ethics approval from the University of Waterloo Research Ethics Board (ORE 30118), as well from the Research Ethics Review Board of the Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale (#MP-13-2017-1264) and participating school board review panels.

Ethics approval was obtained to include additional measures pertaining to youth respondents' knowledge, attitudes and behaviours to do with the COVID-19 pandemic.[14]

Measures

One new component of the online questionnaire referred to adolescents' knowledge, perception of risk and practices in relation to the COVID-19 pandemic.[14] Most questions were adapted from a questionnaire developed by the World Health Organization (WHO) and information provided on the WHO website.[15-17] Items extracted from the WHO questionnaire were translated, adapted and pretested by the COMPASS research team.

Dependent variable: adoption of COVID-19 preventive measures

Adoption of COVID-19 preventive measures was determined based on responses to a set of five questions about the measures that were in place at the time of data collection. We asked study participants to report how frequently they had, since pandemic-related restrictions began (1) avoided gatherings and public places; (2) cancelled non-essential meetings; (3) washed their hands more often than previously; (4) disinfected often-touched objects; (5) and avoided coughing in public. Respondents could choose from three answers: "always," "sometimes" or "never." The "adoption score" is a continuous variable ranging from 0 to 10, with 10 representing the highest level of adoption of these five preventive measures (Cronbach $\alpha = 0.62$).

Factors linked to the adoption of COVID-19 preventive measures

Four factors that could be related to the adoption of preventive measures were preselected based on the current (albeit limited) literature and some key elements of the Health Belief Model:[18] pandemic knowledge; perception of risk of COVID-19 for youths; worries about the COVID-19 pandemic; and discussions in relation to COVID-19 with relatives.

Pandemic knowledge was determined using a set of 17 questions that were based on health facts about COVID-19 disease transmission and symptoms as reported by WHO.[17] Participants were asked if they believe each fact to be true, choosing yes/no responses. The "pandemic knowledge score" is a continuous variable ranging from 0 to 17, with 17 representing the highest level of knowledge (Cronbach $\alpha = 0.78$).

Perception of risk of COVID-19 to youths was assessed based on agreement with a single statement: "I think that COVID-19 represents very little risk of complications to young people." Participants chose possible responses on a 5-point scale from true to false. The answers were subsequently recoded into three categories: (1) true; (2) mostly true; and (3) neutral, mostly false and false. The "perception of risk score" is a continuous variable ranging from 0 to 2, where 0 is equivalent to the perception that COVID-19 represents very little risk to youths (answer choices 1 and 2).

Worries about the COVID-19 pandemic were determined using a set of five questions of the worry battery. Participants were asked about their worries about the current circumstances; their personal health; their family members' health; and their stress level. Response options ranged from 0 (true) to 4 (false). The "worries score" is a continuous variable ranging from 0 to 20, with 20 representing the highest level of worry (Cronbach $\alpha = 0.77$).

Discussions in relation to COVID-19 with relatives were determined based on agreement with two statements: (1) "I discussed measures to prevent infection with family, friends and/or health care professionals"; and (2) "I discussed what to do in case of infection with family, friends and/or health care providers." For both

statements, respondents could choose one of three answers: "always," "sometimes" or "never." The "discussions score" is a continuous variable ranging from 0 to 4, with 4 equivalent to the highest level of discussions with relatives about COVID-19 preventive measures and what to do in case of infection (Cronbach α = 0.78).

Other variables

Participants were asked to report their gender, choosing from one of four options: "female"; "male"; "I describe my gender in a different way"; or "I prefer not to say." Based on the responses, we classified participants as "female" or "other."

Anxiety level was determined via the Generalized Anxiety Disorder 7-item scale (GAD-7)[19] questionnaire. The recommended cut point for further evaluation of generalized anxiety is a score of 10; those with a score of 9 or less are characterized as less anxious, and those with a score of 10 or higher as more anxious.

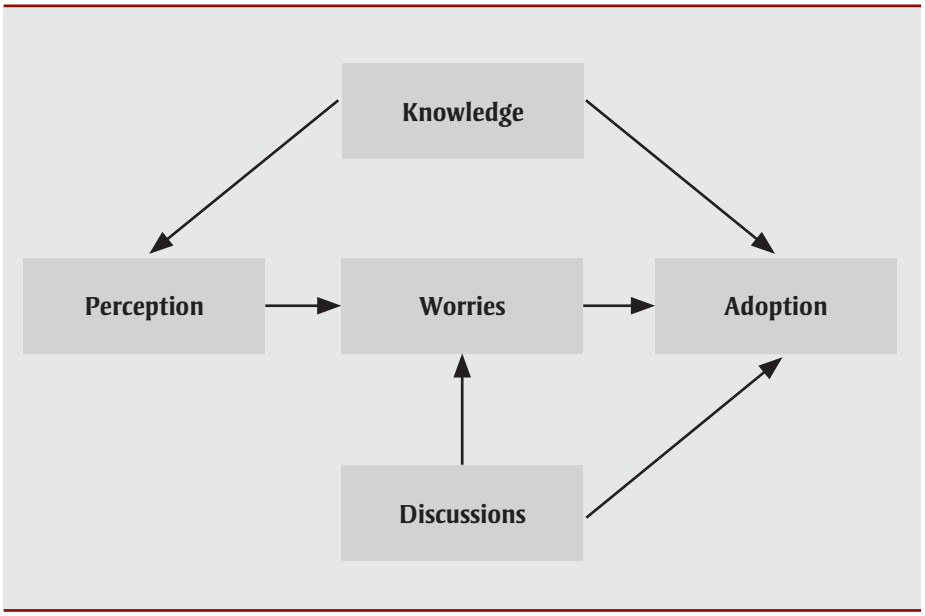
Each participant's age was determined through the question "How old are you today?", with response options 12 years or younger, 13 years, 14 years, 15 years, 16 years, 17 years, 18 years, or 19 years and older.

Statistical analyses

We used structural equation models to explore how adoption of preventive measures was linked to pandemic knowledge, perception, worries and discussions with relatives. The influences of these factors are known to be interconnected, and adoption is therefore conceptualized as the result of a complex non-linear causal process.[18] Structural equation modelling (SEM) is the standard approach to empirically address these kinds of issues.

Estimating was initiated using a preliminary statistical model derived from the literature and the Health Belief Model[18] (see Figure 1). The fit of the initial model was not satisfactory and various iterations were completed to adjust the model and improve the goodness of fit, eventually leading to the final model (see Figure 2). Full information maximum likelihood method was used to control for missing data. Robust estimators accounted for the hierarchical structure of the data (respondents clustered in schools). Goodness of fit was assessed based on commonly accepted standards: (1) the model that minimizes the Bayesian Information Criterion (BIC) / Akaike Information Criterion (AIC) estimator; (2) root mean square error of approximation (RMSEA) below .05; (3) Tucker-Lewis index (TLI) and comparative fit index (CFI) as close to 1 as possible.[20] Statistical differences in group comparisons are shown by the confidence intervals of the mean differences.

FIGURE 1
Hypothesized model of the relationship between pandemic knowledge, perception of risk to youths, discussions with relatives, worries and adoption of COVID-19 preventive measures[a]



[a] Goodness of fit indices: χ^2 = <.001; root mean square error of approximation (RMSEA) = .223; comparative fit index (CFI) = .416; Tucker-Lewis index (TLI) = −.314.

Based on the gender and anxiety level of the participants, we created four subgroups: more anxious females; less anxious females; more anxious others; and less anxious others. Socioeconomic status was considered to be a possible confounder in the preliminary analysis, but was found to have no influence on model estimators and was not retained in the final model.

All analyses were performed with STATA version 15.1 SEM routine (StataCorp, College Station, TX, US). The SEM group routine was used to allow model parameters to vary across the four subgroups.

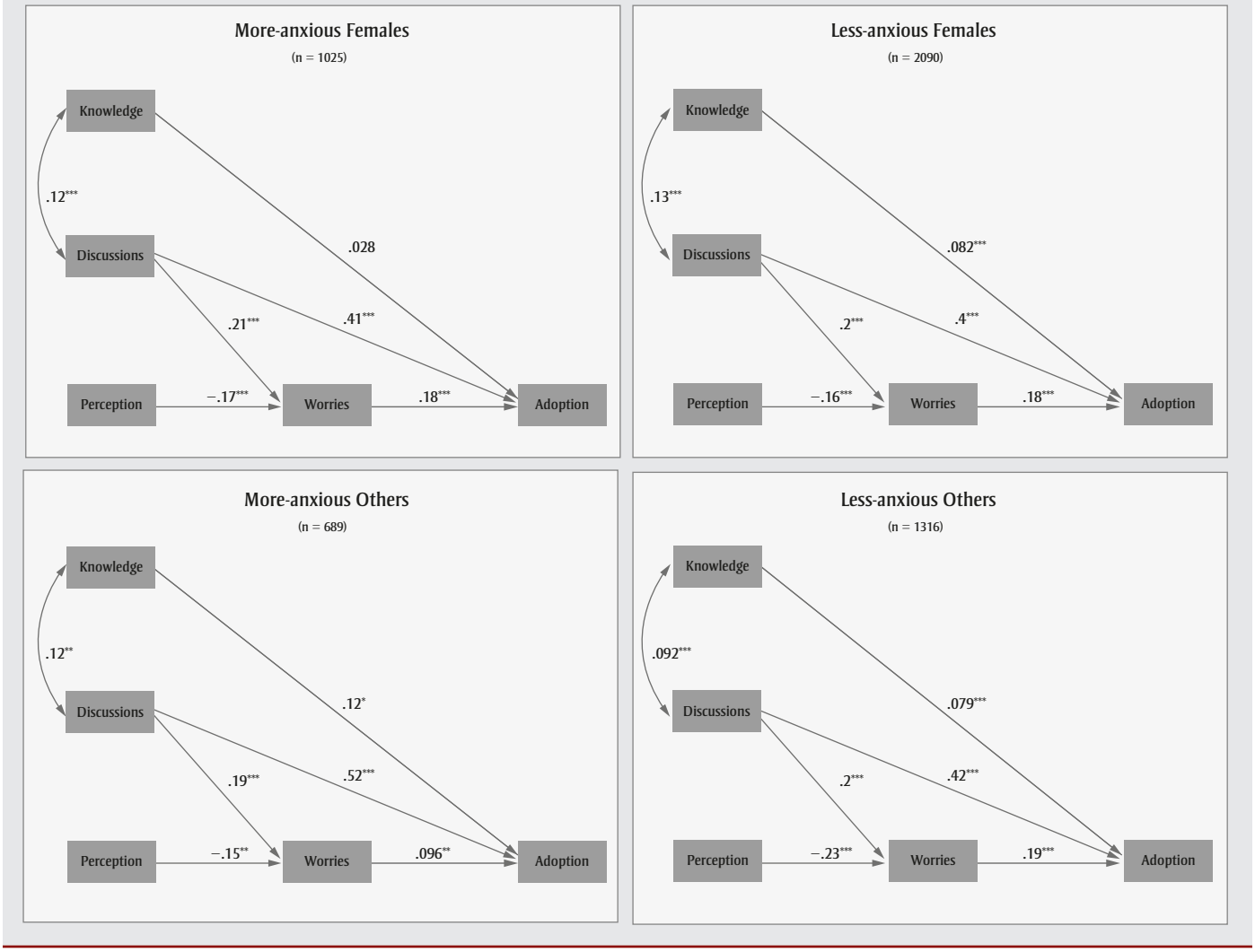
Results

Of the 6052 participants, 60% (n = 3553) were female and 33% (n = 3413) had an anxiety score of 10 or higher. Mean age was 14.6 years. The majority reported having adopted preventive measures during the first months of the pandemic (Table 1). In fact, more than 9 out of 10 participants reported washing their hands more often and avoided coughing in public, while more than 8 out of 10 reported avoiding social gatherings and public places and cancelling non-essential meetings/gatherings. Over two-thirds of the respondents cleaned and disinfected frequently touched objects. Cronbach α was 0.62, suggesting a moderate level of covariation in the adoption of the measures.

More female participants than other participants adopted all five preventive measures; the differences were statistically significant ($p < 0.05$). Effects of anxiety levels did not differ statistically significantly except for cancelling non-essential meetings/gatherings ($p < 0.05$).

Gender and anxiety level affected mean pandemic knowledge, worries and adoption scores (see Table 2). Female participants have higher mean worries scores than do other participants. In addition, compared with other adolescents, female participants have a higher mean pandemic knowledge score and mean adoption score. These same patterns are observed when comparing female participants and others based on anxiety level.

FIGURE 2
Structural equation analyses of adoption and its related factors, by gender and anxiety level, showing standardized parameter coefficients[a]



Note: Age variable has been omitted.

[a] Goodness of fit indices: $\chi^2 = <.001$; root mean square error of approximation (RMSEA) = .223; comparative fit index (CFI) = .416; Tucker-Lewis index (TLI) = −.314.

*$p < 0.05$.

**$p > 0.01$.

***$p \leq 0.001$.

The results of the stratified SEM analyses showed three paths leading to adolescents' adoption of COVID-19 preventive measures (Figure 2). First, pandemic knowledge has a statistically significant direct effect on adoption except for more anxious females. Second, discussions with relatives have a statistically significant total effect, indirectly through worries, on all adoption, especially by more anxious others. Of all the factors, this one has the strongest effect on adoption by all groups. Third, perception of risk has a significant negative indirect effect on adoption through worries. We were able to confirm that more than 93% of participants worried about the health of their family members versus 44% for their own health (further information and data available on request from the authors).

These effects are stable in all four groups. The only group where age has a statistically significant negative effect is on less anxious others (data available on request from the authors). The model also suggests that some unmeasured factors statistically significantly influence the association between the knowledge of the pandemic and the discussions with relatives. SEM analysis of the entire sample show similar results in regard to the three observed paths (data available on request from the authors).

Discussion

Our study results show that the majority of adolescents were early adopters of the main protective measures against COVID-19 infection, that is, handwashing, disinfecting frequently touched objects, avoiding coughing in public, avoiding gatherings and public places and cancelling non-essential meetings. In contrast to young adults who report low compliance rates with adopting preventive measures,[7] studies addressing adolescents' adoption depict

TABLE 1
Adolescent participants' adoption of COVID-19 preventive measure in the first months of the pandemic based on gender and anxiety level, COMPASS, Quebec, March–May 2020 (N = 6052)

Sample	COVID-19 preventive measure, % (n)				
	Wash hands more often	Avoid coughing in public	Avoid gatherings and public places	Cancel meetings	Disinfect frequently touched objects
All (n = 6052)	94 (4705)	93 (4659)	89 (4423)	83 (4168)	74 (3703)
Gender					
Female (n = 3553)	95 (2915)	95 (2891)	91 (2761)	87 (2654)	78 (2392)
Other (n = 2408)	92 (1780)	91 (1758)	86 (1654)	78 (1504)	68 (1306)
Anxiety level					
More anxious (n = 3413)	93 (1491)	92 (1475)	87 (1397)	81 (1304)	75 (1211)
Less anxious (n = 1717)	95 (3107)	94 (3076)	89 (2921)	84 (2764)	74 (2411)

a more nuanced portrait. Dardas et al. (2020),[12] in their study of Jordanian high-school students' COVID-19 preventive practices, found that adolescents reported positive disinfecting behaviours and adequate social distancing, and avoided crowded places and social gatherings; however, 40% of their sample did not practise correct hand washing and mask wearing. Similar results were also obtained in a study of Italian high-school students' practices.[21]

At the time of data collection, health authorities had not yet recommended mask wearing as a COVID-19 preventive measure. The results from the next data collection (Spring 2021) will help verify whether adolescents continued to apply the various preventive measures including mask wearing.

Knowledge about the pandemic, perception of risk of COVID-19, worries about the pandemic and discussions with relatives were all significantly related to adoption of COVID-19 prevention measures. Our results highlighted three paths in the pattern of associations to adoption. First, adoption appears to be significantly if indirectly related to a higher perceived risk. Second, except for more anxious females, there is a significant direct link between knowledge and adoption.

The third path links discussions with relatives to adoption. Here too, a direct link coexists with an indirect link mediated by worries, especially on more anxious others. Adolescence is a time where friends

TABLE 2
Adoption of COVID-19 preventive measures and factors linked to the adoption of these measures, by gender and anxiety level, COMPASS, Quebec, March–May 2020 (N = 6052)

Sample	Mean scores (95% confidence interval)				
	Perception of risk[a]	Pandemic knowledge[b]	Worries[c]	Discussions[d]	Adoption[e]
All	0.79 (0.77 to 0.82)	10.82 (10.75 to 10.90)	6.44 (6.32 to 6.56)	1.92 (1.89 to 1.96)	7.05 (6.99 to 7.11)
Gender					
Female	0.72 (0.69 to 0.75)	11.21 (11.12 to 11.30)	7.14 (6.98 to 7.29)	2.01 (1.96 to 2.06)	7.33 (7.26 to 7.39)
Other	0.91 (0.87 to 0.95)	10.21 (10.08 to 10.34)	5.36 (5.18 to 5.54)	1.79 (1.73 to 1.85)	6.61 (6.51 to 6.71)
Differences	−0.19 (−0.24 to −0.14)	1.00 (0.85 to 1.15)	1.77 (1.53 to 2.01)	0.22 (0.14 to 0.30)	0.71 (0.59 to 0.83)
Anxiety level					
More anxious	0.81 (0.77 to 0.85)	10.67 (10.53 to 10.81)	6.77 (6.53 to 7.00)	1.93 (1.86 to 2.00)	7.05 (6.94 to 7.16)
Less anxious	0.79 (0.76 to 0.82)	10.93 (10.85 to 11.02)	6.26 (6.12 to 6.39)	1.92 (1.87 to 1.97)	7.05 (6.98 to 7.12)
Differences	0.02 (−0.03 to 0.07)	−0.26 (−0.42 to −0.10)	0.51 (0.25 to 0.77)	0.01 (−0.07 to 0.09)	−0.01 (−0.13 to 0.12)
More anxious					
Female	0.73 (0.67 to 0.79)	11.19 (11.03 to 11.34)	7.70 (7.39 to 8.00)	2.00 (1.91 to 2.09)	7.36 (7.23 to 7.48)
Other	0.93 (0.86 to 1.00)	9.90 (9.65 to 10.15)	5.38 (5.04 to 5.73)	1.83 (1.72 to 1.94)	6.58 (6.38 to 6.78)
Differences	−0.20 (−0.29 to −0.11)	1.29 (1.01 to 1.57)	2.31 (1.85 to 2.78)	0.17 (0.03 to 0.31)	0.78 (0.55 to 1.00)
Less anxious					
Female	0.72 (0.68 to 0.75)	11.25 (11.14 to 11.35)	6.85 (6.67 to 7.03)	2.02 (1.96 to 2.08)	7.31 (7.22 to 7.39)
Other	0.91 (0.86 to 0.96)	10.43 (10.28 to 10.58)	5.31 (5.10 to 5.51)	1.77 (1.69 to 1.84)	6.65 (6.53 to 6.77)
Differences	−0.19 (−0.25 to −0.13)	0.82 (0.64 to 1.00)	1.55 (1.27 to 1.83)	0.25 (0.15 to 0.35)	0.65 (0.51 to 0.79)

[a] The perception of risk score is a continuous variable ranging from 0 to 2, where 0 is equivalent to the perception that COVID-19 represents very little risk to youths.

[b] The pandemic knowledge score is a continuous variable ranging from 0 to 17, with 17 representing the highest level of knowledge related to COVID-19.

[c] The worries score is a continuous variable ranging from 0 to 20, with 20 representing the highest level of worry.

[d] The discussions score is a continuous variable ranging from 0 to 4, with 4 equivalent to the highest level of discussions with relatives about COVID-19 preventive measures and what to do in case of infection.

[e] The adoption of COVID-19 preventive measure score is a continuous variable ranging from 0 to 10, with 10 representing the highest level of adoption of five COVID-19 preventive measures.

are very important and their opinions matter.[5] Adolescents are much more socially influenced by friends than by adults in engaging in prosocial behaviours.[22] Nonetheless, the impact of discussions between parents and adolescents have been shown to have an effect on condom use.[23] Promoting discussions with relatives in order to improve adolescents' adoption of COVID-19 preventive measures, if effective and accurate, may benefit compliance via a snowball effect. In fact, research has found peer-led interventions to be a way to increase adoption of preventive measures.[5]

Most promotion campaigns aimed at influencing adolescent behaviour are based on increasing adolescents' knowledge and awareness of the health risks. Unfortunately, these interventions are predominantly adult led and often unsuccessful with adolescents.[24]

Worrying was expected to influence adoption of preventive measures because higher anxiety levels are associated with increased use of COVID-19 preventive measures among adults.[25] It was also anticipated that this association would be influenced by the perception of risk and discussions with relatives. Nonetheless, our results showed that adolescents with a perception of higher risk of COVID-19 complications for youths are less worried about COVID-19 than peers without this perception of risk. A potential explanation may be that most adolescents do not worry about their own health but do worry about that of family members, some of whom may be at greater risk. Adolescents discussing COVID-19 preventive measures and what to do in case of infection with relatives worry more as well. This could be because such discussions lead to a better understanding of the gravity of the situation and potential consequences on human health.

Even if the three adoption paths discussed mostly apply to the four subgroups analyzed, based on gender and anxiety level, model comparisons demonstrate certain nuances. As seen in previous studies, female adolescents tend to adopt more preventive measures than do their peers.[12,26,27] A possible explanation is that some of the factors that lead to adoption, such as a higher level of knowledge and worry, are particularly associated with females.[4,20-28] In fact, our results show that female adolescents have a higher levels of pandemic knowledge and worries (which is emphasized by a higher level of anxiety) than do their non-female peers.

If a main objective is to increase the adoption of preventive measures, a noteworthy finding is that anxiety in non-female adolescents influences the effects of the different factors that lead to adoption. Indeed, discussions in relation to COVID-19 with relatives have an even greater influence on more anxious non-females than on less anxious non-females. Patterns are similar for perception of risk, worries and pandemic knowledge. These findings shed light on the importance of not looking for a unique model to apply to everyone because gender and anxiety levels influence the adoption of preventive measures and their factors.

Strengths and limitations

This study has some limitations. First, the cross-sectional study design hampers the ability to infer potential causal relations; however, we can expect adoption of preventive measures to be influenced by constructs other than those investigated.

Second, because of school closures, completing an online questionnaire at home was the only possible way to collect data on adolescents' behaviours and their perceptions of risk. Consequently, the usual participation rate (above 90% in class) was strongly affected in some schools. A review of the literature on adolescents' participation rates in online health surveys usually round up to between 30% and 40% and demonstrate self-selection bias.[29]

Third, the population of participating schools was based on schools from the eastern part of the province of Quebec. Thus, the study's conclusions may not reflect the reality in other regions and countries because of differences in severity and duration of pandemic-related restrictions.

Fourth, these results are derived from an exploratory analysis where replication needs to be assessed. Still, the large number of participants in this study provide significant information about the adoption of preventive measures by the adolescent population.

Finally, the COMPASS platform offers a unique opportunity to follow and analyze changes over time in adolescents' perceptions of and attitudes towards the COVID-19 pandemic as well as their acceptance and adoption of preventive measures.

Conclusions

Most of the adolescents participating in this study appear to have complied with the COVID-19 preventive measures—even those from population subgroups with lower adoption rates. While accurate pandemic knowledge and proper risk perception should be promoted among youths, policy makers and health care providers should also consider ways of promoting discussions with relatives as a way of improving adolescents' adoption of COVID-19 preventive measures.

The longitudinal nature of the COMPASS study will allow researchers to follow, over the long run, the evolution of adherence to preventive measures, the influences of changes in interconnected adoption-related factors, and the impact of specific interventions intended to influence them. Most importantly, further studies are needed to better disentangle these relations and explore how contextual, personal and policy aspects are intertwined and how to develop comprehensive and appropriate approaches to reinforce and sustain preventive measures among youth.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Authors' contributions and statement

CBD and SH conceptualized and conducted the analysis.

CBD conducted the literature review.

CBD led the writing and wrote the first draft.

STL conceptualized and leads the larger COMPASS study where SH and RB are the COMPASS-Québec provincial leads.

All authors provided feedback on drafts and reviewed and approved the final manuscript.

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At-a-glance

Programs and interventions promoting health equity in LGBTQ2+ populations in Canada through action on social determinants of health

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Abstract

Sexual and gender minorities (SGM) experience a number of health inequities. That social determinants of health drive these inequities is well-documented, but there is little evidence on the number and types of interventions across Canada that address these determinants for these populations. We conducted an environmental scan of programs in Canada that target SGM, and classified the programs based on their level of intervention (individual/interpersonal, institutional and structural). We found that few programs target women, mid-life adults, Indigenous people or ethnoracial minorities, recent immigrants and refugees, and minority language speakers, and few interventions operate at a structural level.

Keywords: *sexual and gender minorities, SGM, health equity, social determinants of health, minority health, health status disparities, health promotion*

Highlights

- A number of gaps exist in programs promoting health equity and interventions by addressing social determinants of health for sexual and gender minorities in Canada.
- Efforts to develop new programming should consider LGBTQ2+ communities who are underserved by existing services (e.g. Indigenous people, ethnoracial minorities, women, recent immigrants or refugees).
- Very few programs addressed employment, disability, education or housing, which are important upstream determinants of health.
- Most programming focussed on the individual and interpersonal levels of intervention.
- Systemic interventions were scarce; efforts should focus on examining existing structural-level interventions to consider scalability.

Introduction

LGBTQ2+* individuals often have poorer physical and mental health than heterosexual and cisgender people.[1,2] The physical health disparities that lesbian, gay and bisexual populations experience range from poorer general health status to increased rates of cancer, cardiovascular disease, asthma, diabetes, arthritis and other chronic conditions.[1] Transgender youth also experience mental health disparities, including higher risk of reporting psychological distress, self-harm, major depressive episodes and suicide,[2] which have been positively associated with experiences of discrimination, harassment and violence.[3,4] Canadian LGBTQ2+ youth often experience exclusion, isolation and fear.[5] Many of the health inequities observed in sexual and gender minority (SGM) populations are hypothesized to stem from societal stigma,[6] which may include the co-occurrence of stereotyping, labelling, status loss, separation and/or discrimination,[7,8,9] and from negative social experiences that create heightened stress.[1,2]

Processes of stigma and discrimination play a central role in driving health inequities for SGM populations, contributing to experiences of stress and trauma throughout a lifetime. They also lead to inequitable access to the social and material resources needed to promote good health (e.g. employment, income, housing, quality and quantity of education, and health care).[10] For example, 40% of the 2873 trans and non-binary respondents to a 2019 Canadian survey were living in a low-income household and 45% reported having one or more unmet health care needs within the previous year.[11] Bisexual women and men in Canada report, respectively, 2.8 and 2.5 times higher rates of household food insecurity than their heterosexual counterparts and poorer health outcomes when compared to their gay and lesbian peers.[12] These inequities may be amplified for individuals whose sexual orientation or gender

* LGBTQ2+ is an umbrella acronym used in this document to describe individuals with a diverse sexual orientation and/or gender identity, which includes, but is not limited to, individuals who identify as lesbian, gay, bisexual, transgender (trans), queer and/or are Indigenous Two-Spirit.

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identity intersects with other marginalized social identities, such as their ethnicity or class.[13]

To date, most research in this domain has focussed on health inequities and there has been substantially less research on intervention development and evaluation.[6] There is no comprehensive portrait of the interventions addressing these determinants among LGBTQ2+ people in Canada. We conducted an environmental scan between February and March 2019 to meet this need. Following the release of the Parliamentary Standing Committee on Health's report, *The Health of LGBTQIA2 Communities in Canada*,[14] in June 2019, we updated the scan with more entries. We shared the results with select community organizations for member checking in early 2020.

Methods

A systematic search identified programs focussing on determinants of health at the macro (structural or social, economic and political factors), meso (institutional) or micro (individual and interpersonal) levels. Programs targeting specific health behaviours or health outcomes were also included. The search was conducted by province and territory to identify programs across the country that address one or more of the social determinants of health and target SGM populations. The search excluded programs that included people who do not have lived experience as a sexual and/or gender minority person.

Preliminary scanning revealed an abundance of programs that focussed on "downstream" and individual-level considerations (i.e. reducing stigmatizing or discriminatory individual knowledge, attitudes and behaviours; increasing social connectedness). Given important linkages between the health inequities and structural conditions that SGM populations face, we focussed the scan on mid- and upstream interventions. We therefore excluded downstream recreational programs, such as LGBTQ2+ sports teams, choirs, coffee groups, school-based gay–straight alliances (GSAs), social programs and clubs offered by postsecondary institutions, affirming churches/religious institutions, Pride festivals and one-off events. (The initiatives excluded by these criteria alone could populate an entire scan.) Thus, this scan captures interventions at higher orders of the social ecosystem, such as systemic interventions, and interventions that target social determinants of health (other than social connectedness), such as lack of access to employment, stigma and discrimination, poverty and food insecurity.

First, we used the Google search engine for broad Internet searches of English and French websites. Second, we conducted targeted searches of the Canadian Agency for Drugs and Technologies in Health (CADTH) database, provincial 211 directories (which provide information on and referrals to community and social services) and Tri-Council funding[†] results. Third, in order to identify community organizations, programs or services, we inspected LGBTQ2+ Pride festival guides from 2018 as well as the three most recent programs from the Canadian Professional Association for Transgender Health, the Community-Based Research Centre Summit and Rainbow Health Ontario conferences. Finally, a scan of academic databases was conducted using Summon 2.0 (University of Victoria, Victoria, BC). All searches were considered complete when two subsequent website pages yielded no new or relevant information.

Program information was analyzed using NVivo 11 (QSR International Pty Ltd., Melbourne, AU). Coded data were analyzed for semantic themes in order to move beyond pure description of the data and into interpretation.[15] The analysis produced a description of the location and types of programs being implemented and the social determinants of health being addressed. Member checking was conducted by sharing the results of the scan with at least one organization listed in the scan in each province. Members were asked to identify any gaps they noticed either nationally or within their region.

Results

The final scan included 220 programs (see Table 1). Counts vary by information availability and some programs targeted multiple populations. A third of the programs (34.5%) were nonspecific, being available to all LGBTQ2+ people. In locations with smaller populations, this was almost exclusively the case. Most of the programs (65.5%) targeted specific LGBTQ2+ groups, with almost half of the targeted programming focussing on youth. The definition of "youth" varied across organizations, but was most commonly defined as those aged 29 years and younger. The scan yielded few programs for adults 55 years and older (data available from the authors on request).

The second most prominently targeted group was people with trans lived experience. Approximately 15% of targeted programs were oriented towards trans and gender diverse people, with some delivered by organizations that solely serve this population. These almost always focussed on providing support groups, primary health care or support navigating health care systems, particularly for gender-affirming care (e.g. referrals, accessing hormones, surgeries).

Approximately 20% of programs were designed specifically for gay, bisexual and other men who have sex with other men (Table 1); these were largely HIV/AIDS service organizations. Programs targeting men most often focussed on sexual health, with some focussing on social health, physical health, mental health and overall well-being.

Discussion

Our scan revealed inequities in program availability.[16] The emphasis on age-targeted programming may limit the range of programming available.[16] This could have implications for health systems planning and health promotion efforts among members of the "missing middle."[16]

Fewer than 10 programs focussed on Indigenous and Two-Spirit people or racialized/ethnic minority LGBTQ2+ people.[17-19] Often, these were support groups that catered to individuals with a shared ethnicity or cultural background. There were also few (<10) programs designed specifically for recent immigrants and/or refugees; those that did exist were exclusively located in large cities.[20] Further, while this search was only conducted in English and French, only seven programs were identified that were offered in a non-official language, which may be a significant barrier for speakers of other languages.

[†] Together, the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC) make up the Tri-Council funding agencies, the primary mechanism through which the Government of Canada supports research and training.

One program targeted LGBTQ2+ persons living with neurocognitive disabilities.

A minority of programs addressed important institutional and structural upstream determinants of health such as employment, education or housing,[17] where LGBTQ2+ people continue to experience significant barriers due to persistent stigma and discrimination. Indeed, the majority of interventions were more downstream programs targeting health care access and other individual- and interpersonal-level interventions. Health-oriented programs largely targeted men and trans people, and health-related programming for cisgender LGBTQ2+ women was notably lacking.[21,22] Further work should investigate how this disparity is reflected in health outcomes.

While systemic forces such as homo-, bi- and/or transphobia, cis-heterosexism and other intersecting systems of oppression create health inequities at all levels of the social ecology, most programming focussed on the individual and interpersonal levels of intervention. Some programs may be considered institutional-level interventions, but very few operate at a systemic or structural level. This gap leaves untried those strategies and interventions that reduce stigma-driven barriers to social and material resources faced by SGM populations.[11,23,24] However, in Canada LGBTQ2+ and other social movement organizations are often funded by governmental institutions that systemic- or structural-level interventions target.[25] System change to advance health equity via upstream, structural interventions can be influenced by both top-down (e.g. policy, funding) and bottom-up (e.g. advocacy) efforts, which is most successful when undertaken in concert and across sectors.[26,27]

Conclusion

Work is needed to better address the upstream determinants of health affecting diverse LGBTQ2+ people across Canada. Efforts to develop new programming should consider LGBTQ2+ communities who are underserved by existing services (e.g. women, Indigenous people, racialized/ethnic minority populations, people with recent immigration and refugee experiences). The large number of programs promoting social support and reducing social exclusion suggests these programs are still important to end users. This may also reflect a systemic funding preference

TABLE 1
Summary of results of environmental scan of programs targeting in sexual and gender minority populations, Canada, 2019

Category	n	%
Geography (n = 220)		
Canada	16	7.3
Alberta	29	13.2
British Columbia	27	12.3
Manitoba	15	6.8
New Brunswick	3	1.4
Newfoundland and Labrador	3	1.4
Northwest Territories	2	0.9
Nova Scotia	9	4.1
Nunavut	0	0
Ontario	65	29.5
Prince Edward Island	2	0.9
Quebec	45	20.5
Saskatchewan	3	1.4
Yukon	1	0.5
Social determinant addressed (n = 220)		
Social support	102	46.4
Social exclusion[a]	47	21.4
Access to health services	51	23.2
Ableism	1	0.5
Racism, xenophobia and anti-immigrant discrimination	11	5.0
Education	2	0.9
Employment	2	0.9
Housing	4	1.8
Community size (n = 220)		
Montréal, Toronto, Vancouver	67	30.5
Large cities (population: >100 000)	100	45.5
Small cities (population: 10 000–100 000)	19	8.6
Rural (population: <10 000)	2	0.9
Provincial	16	7.3
National	16	7.3
Language (n = 213)		
English	155	72.8
French	26	12.2
Both English and French	32	15.0
Other	7	3.3
Level of intervention (n = 220)		
Health promotion[b]	41	18.6
Individual and interpersonal	128	58.2
Institutional	47	21.4
Structural	4	1.8

Continued on the following page

TABLE 1 (continued)
Summary of results of environmental scan of programs targeting in sexual and gender minority populations, Canada, 2019

Category	n	%
Health promotion and other individual-level interventions by population (n = 302)		
Bisexual	1	0.3
Disability	1	0.3
Gay, bisexual and other men who have sex with men	53	17.5
Trans and gender diverse	46	15.2
Lesbian, bisexual and other women who have sex with women	10	3.3
LGBTQ	46	15.2
Migrants and newcomers	7	2.3
Older adults[c]	10	3.3
Parents, partners and other supports	30	9.9
Racialized people	12	4.0
Two-Spirit	6	2.0
Youth[c]	80	26.5
Nonspecific vs. targeted (n = 220)		
Nonspecific	76	34.5
Targeted	144	65.5

Abbreviations: HIV, human immunodeficiency virus; LGBTQ2+, lesbian, gay, bisexual, transgender, queer and/or Indigenous Two-Spirit; STI, sexually transmitted illness.

Note: Not all information was available for every program, and counts between categories are not equivalent.

[a] Refers to programs that promote inclusivity of LGBTQ2+ people in non-LGBTQ2+ specific spaces, structures and organizations.

[b] Refers to programs addressing specific health outcomes explicitly, such as HIV/STI screening, harm reduction supply distribution, counselling and addictions services.

[c] Only those programs that specifically mentioned participant ages were counted in these categories, i.e. programs for youth (<30 years) and older adults (≥55 years).

for downstream interventions, as opposed to more complex and long-term upstream systems intervention and evaluation. Given the scarcity of systemic interventions, future efforts should focus on identifying promising practices for designing, delivering and evaluating structural-level interventions that promote health equity and adapting these to address the specific contexts of SGM populations.

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Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

BEJ and NJL conceptualized this work and designed the study with RH. BH conducted the scan, conducted initial data analysis and drafted the initial paper. RH revised the analysis and completed the final paper draft. All authors helped to interpret the data, revised the paper drafts and approved the final version.

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Release notice

Two approaches, one shared learning journey to support climate-health adaptation planning

The Public Health Agency of Canada, Ontario Region (PHAC), the Simcoe Muskoka District Health Unit (SMDHU) and Cambium Indigenous Professional Services (CIPS) collaborated to conduct two knowledge projects on climate change adaptation planning: *Two Approaches, One Shared Learning Journey to Support Climate-Health Adaptation Planning*.

PHAC and SMDHU undertook a scoping review to collate the literature on climate-health adaptation interventions that address risks related to the six climate-sensitive categories deemed most relevant to Ontario: extreme weather, extreme temperature, air quality, vector-borne disease, ultraviolet radiation and water and food quality and quantity.

The first learning approach refers to a knowledge synthesis project designed to identify the range, characteristics and critical gaps in the literature available on climate-health adaptation planning, including traits of climate-health adaptation interventions. Planning/decision-making and health communication approaches were the most frequently described, and risks of vector-borne disease and extreme temperature were the most commonly mentioned, while ultraviolet radiation and food and water risks were least commonly mentioned. Only seven articles addressed mental health.

An important gap in the results of the search was the absence of an Indigenous perspective. This was due to methodology rather than to a lack of Indigenous literature. To address this, CIPS was invited to undertake, as a second learning approach, a knowledge synthesis project based on the lived experience of Kerry-Ann Charles-Norris of the Georgina Island First Nation. She illustrates an Indigenous perspective and the importance of including such perspectives into climate adaptation. She also introduces critical concepts of Indigenous ways of knowing and doing, as well as some best practices that public health authorities must understand and apply in order to engage meaningfully with Canada's Indigenous Peoples.

The report is available here: https://www.simcoemuskokahealth.org/docs/default-source/TOPICS_Climate-Change/two-approaches-one-shared-learning-journey-to-support-climate-health-adaptation-planning_dec-30_final-docx.pdf.

Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals. Look for the following articles published in 2021:

Abdessemed M, Mougharbel F, Hafizi K, […] **Lang JJ**, et al. Associations between physical activity, sedentary time and social-emotional functioning in young children. Ment Health Phys Act. 2021;21:100422. https://doi.org/10.1016/j.mhpa.2021.100422

Aflaki K, Park AL, **Nelson C**, **Luo W**, et al. Identifying maternal deaths with the use of hospital data versus death certificates: a retrospective population-based study. CMAJ Open. 2021;9(2):E539-47. https://doi.org/10.9778/cmajo.20200201

Antequera A, Lawson DO, Noorduyn SG, […] **Avey M**, et al. Improving social justice in COVID-19 health research: interim guidelines for reporting health equity in observational studies. Int J Environ Res Public Health. 2021;18(17):9357. https://doi.org/10.3390/ijerph18179357

Barnett TA, **Contreras G**, Ghenadenik AE, et al. Identifying risk profiles for excess sedentary behaviour in youth using individual, family and neighbourhood characteristics. Preventive Med Reports. 2021;24:101535. https://doi.org/10.1016/j.pmedr.2021.101535

Baumeister A, **Corrin T**, **Abid H**, **Young KM**, **Ayache D**, **Waddell L**. The quality of systematic reviews and other synthesis in the time of COVID-19. Epidemiol Infect. 2021;149:e182. https://doi.org/10.1017/S0950268821001758

Boileau-Falardeau M, **Farooqi S**, **O'Rourke C**, **Payne L**. Revisiting the Innovation Strategy performance measurement process: insights from practice. Can J Public Health. 2021;112:262-9. https://doi.org/10.17269/s41997-021-00514-7

Bradley Dexter S, **Kavanagh Salmond K**, **Payne L**, **Chia MC**, Di Ruggiero E, **Mahato S**. The art and science of a strategic grantmaker: the experience of the Public Health Agency of Canada's Innovation Strategy. Can J Public Health. 2021;112:186-203. https://doi.org/10.17269/s41997-021-00512-9

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Doggett A, **Godin KM**, **Schell O**, **Wong SL**, **Jiang Y**, et al. Assessing the impact of sports and recreation facility density within school neighbourhoods on Canadian adolescents' substance use behaviours: quasi-experimental evidence from the COMPASS study, 2015-2018. BMJ Open. 2021;11(8):e046171. https://doi.org/10.1136/bmjopen-2020-046171

Lee N, **Salmond KK**. Monitoring vested health partnerships. Can J Public Health. 2021;112:231-45. https://doi.org/10.17269/s41997-021-00515-6

Liu S, Evans J, Boutin A, **Luo W**, **Gheorghe M**, et al. Time trends, geographic variation and risk factors for gastroschisis in Canada: a population-based cohort study 2006–2017. Paediatr Perinat Epidemiol. 2021;35(6):664-73. https://doi.org/10.1111/ppe.12800

Rollo S, Fraser BJ, Seguin N, […] **Lang JJ**, et al. Health-related criterion-referenced cut-points for cardiorespiratory fitness among youth: a systematic review. Sports Med. 2021. https://doi.org/10.1007/s40279-021-01537-3

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