Health Promotion and Chronic Disease Prevention in Canada

Research, Policy and Practice

Volume 37 · Number 6 · June 2017

Inside this issue

To promote and protect the health of Canadians through leadership, partnership, innovation and action in public health.
— Public Health Agency of Canada

Published by authority of the Minister of Health.

ISSN 2368-738X
Pub. 160268
Journal_HPCDP-Revue_PSPMC@phac-aspc.gc.ca

Également disponible en français sous le titre : *Promotion de la santé et prévention des maladies chroniques au Canada : Recherche, politiques et pratiques*

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Indexed in Index Medicus/MEDLINE, SciSearch® and Journal Citation Reports/Science Edition

Public Health Agency of Canada | Agence de la santé publique du Canada

Canada

https://doi.org/10.24095/hpcdp.37.6.01

Neighbourhood built environment characteristics associated with different types of physical activity in Canadian adults

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This article has been peer reviewed.

Abstract

Introduction: The aim of this study was to estimate the associations between neighbourhood built environment characteristics and transportation walking (TW), recreational walking (RW), and moderate-intensity (MPA) and vigorous-intensity physical activity (VPA) in adults independent of sociodemographic characteristics and residential self-selection (i.e. the reasons related to physical activity associated with a person's choice of neighbourhood).

Methods: In 2007 and 2008, 4423 Calgary adults completed land-based telephone interviews capturing physical activity, sociodemographic characteristics and reasons for residential self-selection. Using spatial data, we estimated population density, proportion of green space, path/cycleway length, business density, bus stop density, city-managed tree density, sidewalk length, park type mix and recreational destination mix within a 1.6 km street network distance from the participants' geolocated residential postal code. Generalized linear models estimated the associations between neighbourhood built environment characteristics and weekly neighbourhood-based physical activity participation (≥ 10 minutes/week; odds ratios [ORs]) and, among those who reported participation, duration of activity (unstandardized beta coefficients [B]).

Results: The sample included more women (59.7%) than men (40.3%) and the mean (standard deviation) age was 47.1 (15.6) years. TW participation was associated with intersection (OR = 1.11; 95% CI: 1.03 to 1.20) and business (OR = 1.52; 1.29 to 1.78) density, and sidewalk length (OR = 1.19; 1.09 to 1.29), while TW minutes was associated with business (B = 19.24 minutes/week; 11.28 to 27.20) and tree (B = 6.51; 2.29 to 10.72 minutes/week) density, and recreational destination mix (B = −8.88 minutes/week; −12.49 to −5.28). RW participation was associated with path/cycleway length (OR = 1.17; 1.05 to 1.31). MPA participation was associated with recreational destination mix (OR = 1.09; 1.01 to 1.17) and sidewalk length (OR = 1.10; 1.02 to 1.19); however, MPA minutes was negatively associated with population density (B = −8.65 minutes/week; −15.32 to −1.98). VPA participation was associated with sidewalk length (OR = 1.11; 1.02 to 1.20), path/cycleway length (OR = 1.12; 1.02 to 1.24) and proportion of neighbourhood green space (OR = 0.89; 0.82 to 0.98). VPA minutes was associated with tree density (B = 7.28 minutes/week; 0.39 to 14.17).

Conclusion: Some neighbourhood built environment characteristics appear important for supporting physical activity participation while others may be more supportive of increasing physical activity duration. Modifications that increase the density of utilitarian destinations and the quantity of available sidewalks in established neighbourhoods could increase overall levels of neighbourhood-based physical activity.

Keywords: *physical activity, walkability, neighbourhood, urban form, built environment*

Highlights

- Neighbourhood built environment characteristics are important for supporting different types of neighbourhood-based physical activity, and not just walking.
- Built environment characteristics, in particular sidewalks and non-recreational destinations, within 1.6 kilometres of home could encourage higher overall levels of neighbourhood-based physical activity in adults.
- Policies that encourage the creation of built environments supportive of physical activity in Canadian cities could contribute to increases in physical activity, and in turn improve population health.

Introduction

Fewer than 20% of Canadian adults achieve adequate levels of physical activity considered necessary for optimal health.[1,2] Furthermore, Canadian adults on average spend only about three minutes per day participating in vigorous-intensity physical activity (i.e. physical activity that requires at least a six-fold higher energy expenditure than that expended during physical rest).[2] Compared with vigorous-intensity physical activity, Canadian adults on average spend substantially more time—approximately 20 minutes per day—participating in moderate-intensity physical activity (i.e. physical activity that requires a three- to five-fold increase in energy expenditure over that expended during physical rest).[2] Yet, vigorous-intensity physical activity may provide health benefits over and above those typically provided

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by moderate-intensity physical activity.[3-7] After adjustment for total energy expenditure, participating in vigorous-intensity physical activity has been found to provide greater cardiovascular health benefits compared with moderate-intensity physical activity.[7] Vigorous-intensity physical activity is positively associated with improvements in aerobic fitness[7,8] and negatively associated with the risk of chronic disease and all-cause mortality.[9] Thus, improving population levels of both moderate and vigorous-intensity physical activity is important for reducing chronic health conditions such as cardiovascular disease, type 2 diabetes, hypertension, depression, overweight and obesity and some cancers, which place significant burden on the Canadian health care system.[10]

Specific intra-individual, interindividual and environmental factors may influence the type and intensity of physical activity that adults undertake.[11] During the past two decades, evidence on the associations between the built environment and physical activity has emerged rapidly, yet much of this evidence is derived from studies investigating the relations between neighbourhood built environment characteristics and walking and cycling.[12,13] Built environment characteristics such as land use mix, residential density, pedestrian connectivity and overall walkability are consistently found correlates of walking.[12] Notably, although there are certain characteristics that are associated with both types of walking, some built environment characteristics appear more important for supporting transportation walking, while others are more important for supporting recreational walking.[12,14,15] Similarly, researchers have found that different built environment characteristics influence the intensity of physical activity undertaken (i.e. walking, moderate-intensity or vigorous-intensity physical activity).[8,13,16] Studies on the relations between the built environment and vigorous-intensity physical activity are rare; nevertheless, findings to-date suggest that self-reported and objectively measured neighbourhood built environment characteristics such as sidewalks;[17] bike trails;[8] high quality green and open space;[18] monuments;[18] intersection density;[19] density of local roads;[19] proximity, availability, and use of physical activity–related facilities;[16,17,20-22] safety;[17] aesthetics and interesting sights;[8,17] and walkability[23] are potentially important for supporting vigorous-intensity physical activity. Information about which specific built environment characteristics are associated with which specific types of physical activity could inform the planning and development of health-supportive neighbourhoods.[13,24]

Residential self-selection, the nonrandom process of individuals choosing to reside in neighbourhoods that align with their physical activity preferences, has plagued built environment–physical activity researchers to-date, in particular as it affects evidence derived from cross-sectional study designs. Residential self-selection, if not statistically controlled or adjusted for in cross-sectional studies, may result in inflated estimates of the association between built environment characteristics and physical activity.[14,25] Nevertheless, only a few cross-sectional studies have estimated built environment–physical activity associations while statistically adjusting for residential self-selection.[14] Furthermore, the measurement of neighbourhood-specific, self-reported measures of physical activity is similarly rare. Physical activity measures that ignore the context in which behaviour is undertaken (e.g. inside the neighbourhood) may underestimate the true associations between the neighbourhood built environment characteristics and physical activity.[24] Controlling for residential self-selection, capturing summer and winter patterns of physical activity and collecting neighbourhood-specific physical activity data has the potential to provide more accurate estimates of the association between the neighbourhood built environment and physical activity, which in turn could better inform urban and transportation policy and practices that result in the desired improvements in physical activity.

The aim of this study was to estimate the relative associations between objectively measured neighbourhood built environment characteristics and weekly participation and time spent in different neighbourhood-based physical activities, namely, transportation walking, recreational walking, moderate-intensity physical activity, vigorous-intensity physical activity, and total physical activity while adjusting for residential self-selection and sociodemographic characteristics.

Methods

Detailed descriptions of the data collection and previous analysis are presented elsewhere.[26, 27] Briefly, we used random-digit dialling to recruit two independent cross-sectional samples of adults from households located within the Calgary municipal area. Telephone interviews were undertaken from July 2007 to October 2007 (n = 2199; response rate = 33.6%) and repeated from January 2008 to April 2008 (n = 2223; response rate = 36.7%). The two samples, recruited using the same methodology, provided data regarding summer and winter physical activity patterns.[28] Cellular phone numbers were not used to supplement the list of telephone numbers as they were not readily available for Calgary residents at the time the study was undertaken. One eligible and consenting adult (≥ 18 years of age) from each sampled household completed a telephone interview capturing, among other characteristics, physical activity, residential self-selection, sociodemographic variables and residential postal code. The Conjoint Health Research Ethics Board at the University of Calgary granted ethics approval for this study.

Variables

Neighbourhood built environment

We geocoded residential six-digit postal codes using longitude and latitude coordinates from Statistics Canada's Postal Code Conversion File and used ArcGIS version 10 (Environmental Systems Research Institute, Inc., Redlands, CA, USA) to create a 1.6 km radius, line-based network polygon (i.e. a "walkshed") around each participant's home.[29,30] We used postal codes because complete household addresses were not available for all participants. In Canada, geocoded urban postal codes provide valid estimates of household geographical location.[31] In urban areas, the last three digits of a postal code indicate a specific city block, i.e. the area on one side of the street located between two intersecting streets, or a single building such as a large apartment. Other studies have also used the 1.6 km walkshed for estimating associations between neighbourhood built environment characteristics and physical activity;[32,33] it is the approximate distance a typical adult can walk (i.e. at a speed of 6.4 km/h) in approximately 15 minutes.

We used ArcGIS with existing municipal administrative databases to estimate built environment characteristics within each walkshed. Built environment characteristics estimated for each walkshed included (per square kilometre [km^2]) intersections; licensed businesses and services; bus

stops; sidewalk length (in metres) and mix of recreational destinations. We assigned administrative neighbourhood boundary–level data when walkshed-level data were not available (i.e. population per km^2, count of city-managed trees per km^2, length in metres of path/cycle ways per km^2 and proportion of green space area). While our preference was to estimate all nine built environment variables at the walkshed level, data at this level were not available for all built environment variables. Thus, rather than removing these variables from the analysis completely, we decided to retain these neighbourhood-level built environment variables in the study due to their potential associations with physical activity. Previous evidence[12,13,26,27] informed our choice of built environment variables included in this study. All built environment variables were transformed into z-scores.

Neighbourhood-based physical activity

Participants responded to items adapted and pilot tested[34] from the Neighbourhood Physical Activity Questionnaire.[35] Participants were asked to consider four types of physical activity—transportation walking, recreational walking, moderate-intensity physical activity and vigorous-intensity physical activity—they had undertaken within a 15-minute walk of home. For transportation walking, participants were asked "In a usual week how many times do you walk as a means of transportation, such as going to and from work, walking to the store or walking to the bus stop or LRT in your neighbourhood or local area?" For recreational walking, participants were asked "In a usual week how many times do you walk for recreation, health or fitness (including walking your dog) in or around your neighbourhood or local area?" Participants also reported their total minutes of transportation and recreational walking in their neighbourhood in a usual week. Similarly worded items also captured neighbourhood-based moderate-intensity physical activity (activity undertaken for recreation, health or fitness "that does not make you breathe harder or puff and pant") and vigorous-intensity physical activity (activity undertaken for recreation, health or fitness activity "that makes you breathe harder or puff and pant").

Some evidence suggests that there may be different correlates for physical activity initiation versus maintenance.[36] Thus, we estimated two variables for each physical activity type: (1) nonparticipation (< 10 minutes/week) versus participation (≥ 10 minutes/week); and (2) duration (minutes/week) among those who reported participation. The New Canadian Physical Activity Guidelines recommend that moderate-to-vigorous physical activity be undertaken in bouts of at least 10 minutes.[37] Minutes for the four types of activity were also summed to obtain total weekly minutes of neighbourhood-based physical activity.

Residential self-selection

Participants reported the importance (i.e. not at all, somewhat or very important) of a predetermined list of items capturing reasons for choosing to reside in their current neighbourhood. Using a principal component analysis reported elsewhere,[27] 19 items were reduced to four residential self-selection scales: (1) access to places that support physical activity (Cronbach's alpha [α] = 0.79); (2) access to local services (α = 0.61); (3) sense of community (α = 0.71); and (4) ease of driving (α = 0.54). The six items that loaded onto the "access to places that support physical activity" scale included those capturing the importance of proximity to parks, proximity to recreational facilities, proximity to trails, places to be physically active, places to walk or cycle to and attractive scenery (e.g. mountains). Four items loaded on the "access to local services" scale were ease of walking, proximity to school or work, proximity to transit and proximity to stores or services. Four items (sense of community, safety from crime, attractive streets and cleanliness of streets) loaded onto the "sense of community" scale. Two items, (the importance of access to highways and ease of driving) loaded onto the "ease of driving" scale. Three items capturing the importance of affordability, proximity to downtown and proximity to friends and family did not load onto any scale and were subsequently removed from further analysis. Responses to the individual items belonging to each of the four scales were summed, with higher scores indicating a stronger preference for or reasons for choosing to reside in the neighbourhood based on access to places for physical activity, access to local stores and services, sense of community and ease of driving.

Sociodemographic characteristics

Participants reported their gender, age, highest education level achieved (i.e. high school or less, college, university), number of dependents < 18 years of age at home (i.e. none, one or ≥ 2 children), and whether they owned/were buying or rented the home in which they resided (i.e. owner/buyer versus nonowner).

Statistical analysis

Descriptive statistics including frequencies and measures of central tendency and variation (i.e. means, standard deviations and medians) were estimated for built environment characteristics, physical activity, residential self-selection and sociodemographic variables. Pearson's correlations (r) were estimated between the nine built environment variables. For neighbourhood-based transportation walking, recreational walking, moderate-intensity physical activity and vigorous-intensity physical activity, we used generalized linear models (binomial distribution with a logit link function) to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for the association between usual weekly participation and each built environment characteristic adjusting for covariates (i.e. residential self-selection in relation to access to physical activity opportunities, access to stores and services, sense of community and ease of driving), sociodemographic characteristics, and survey season. Covariate-adjusted generalized linear models (gamma distribution with identity link function) estimated the linear association (unstandardized beta coefficient [B] and 95% CI) between usual weekly minutes of neighbourhood-based transportation walking, recreational walking, moderate-intensity physical activity, vigorous-intensity physical activity, and total physical activity, and each of the nine built environment characteristics. We evaluated goodness of fit using normed chi-square (NC; NC = model chi-square/degrees of freedom) estimated for the fully adjusted models. Models with NC values less than or equal to 2 were considered to have acceptable fit. Model coefficients with p-values less than .05 were considered statistically significant. We performed our analyses using IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, NY, USA).

Results

Of those participants who were recruited into the study (n = 4423), 4034 provided complete physical activity, residential self-selection and sociodemographic data.

More people in the sample were women, had a university education, were without dependents under age 18 years and were home owners (Table 1). The average (standard deviation) age of the sample was 47.1 (15.6) years. On average, participants considered access to physical activity opportunities, access to shops and stores, sense of community and ease of driving to be somewhat important reasons for residing in their current neighbourhood (Table 1). Pearson's correlations between the nine built environment variables ranged from $r = -0.30$ (i.e. between proportion [%] of green space area and population/km^2) to $r = 0.62$ (i.e. between businesses/km^2 and bus stops/km^2). All but five of the 36 estimated correlations between the built environment variables were smaller than ± 0.30 (results not shown).

Weekly participation in neighbourhood-based physical activity

More than half of participants reported participation in neighbourhood-based walking for transportation (59.1%) or recreation (74.9%) (Table 1). Fewer participants reported participation in neighbourhood-based moderate-intensity (35.5%) and vigorous-intensity physical activity (45.5%). Adjusting for all covariates, participation in transportation walking was positively associated with intersection density (OR = 1.11; 95% CI: 1.03–1.20), business density (1.52; 1.29–1.78) and sidewalk length (1.19; 1.09–1.29) (Table 2). Sidewalk length was also positively associated with participation in neighbourhood-based moderate-intensity (1.10; 1.02–1.19) and vigorous-intensity physical activity (1.11; 1.02–1.20). Adjusting for covariates, path/cycleway length was positively associated with participation in neighbourhood-based recreational walking (1.17; 1.05–1.31) and vigorous-intensity physical activity (1.12; 1.02–1.24). Further, recreational destination mix was positively associated with participation in neighbourhood-based moderate-intensity physical activity (1.09; 1.01–1.17). The proportion of green space in the neighbourhood was negatively associated with participation in vigorous-intensity physical activity (0.89; 0.82–0.98) (Table 2). For comparison, the estimated associations between participation in neighbourhood-based physical activity and built environment characteristics without residential self-selection adjustment are reported in Table 3.

TABLE 1
Sample sociodemographic, neighbourhood built environment, residential self-selection and physical activity characteristics, Calgary, 2007–2008 (n = 4034)

	%	Mean (standard deviation), median
Sociodemographic characteristics		
Age in years		47.1 (15.6), 46.0
Sex (women)	59.7	
Highest education achieved		
High school diploma or less	32.0	
College	26.0	
University	42.0	
Number of children at home		
None	62.7	
One or more	37.2	
Home ownership (owners)	81.5	
Built environment characteristics		
Intersections/km^2 [a]		175.6 (26.6), 174.4
Businesses/km^2 [a]		29.3 (50.6), 15.6
Bus stops/km^2 [a]		13.8 (12.7), 12.6
Mix of recreational destinations/km^2 [a]		1.13 (1.08), 1.00
Sidewalk length (in metres)/km^2 [a]		16 140.4 (3656.3), 15 690.0
Total population/km^2 [b]		3120.1 (1652.6), 2782.3
Proportion (%) of green space area [b]		18.0 (10.0), 15.0
Path/cycleway length (in metres)/km^2 [b]		2464.4 (1438.6), 2391.7
City-managed trees/km^2 [b]		1586.1 (515.1), 1658.3
Reasons for residential self-selection [c]		
Access to physical activity opportunities		2.0 (0.5), 2.0
Access to stores and services		2.1 (0.5), 2.2
Sense of community		2.4 (0.5), 2.5
Ease of driving a motor vehicle		2.1 (0.6), 2.0
Physical activity participation and minutes in a usual week [d]		
Transportation walking in neighbourhood	59.1	121.2 (146.0), 60.0 [e]
Recreational walking in neighbourhood	74.9	186.2 (177.6), 120.0 [e]
Moderate-intensity PA in neighbourhood	35.5	141.1 (148.9), 90.0 [e]
Vigorous-intensity PA in neighbourhood	45.5	171.5 (157.5), 120.0 [e]
Total PA in neighbourhood	91.2 [f]	372.2 (344.3), 270.0 [e]

Abbreviations: km^2, square kilometres; PA, physical activity.

[a] Estimated for the 1.6 km walkshed.

[b] Estimated for the neighbourhood administrative boundary.

[c] Higher scores represent increased importance of the factor in choice of neighbourhood.

[d] Participants could report more than one type of physical activity.

[e] Estimate based on those reporting participation (i.e. ≥ 10 minutes/week).

[f] Percentage of sample reporting participation in at least one of the activities above.

Weekly minutes of neighbourhood-based physical activity

For those reporting participation, mean minutes were higher for neighbourhood-based recreational walking (186.2 ± 177.6 minutes/week), followed by vigorous-intensity physical activity (171.5 ± 157.5 minutes/week), moderate-intensity physical activity (141.1 ± 148.9 minutes/week), and transportation walking (121.2 ± 146.0 minutes/week) (Table 1). Adjusting for covariates, neighbourhood-based transportation walking was significantly ($p < .05$)

TABLE 2
Generalized linear model (binomial distribution and logit link function) estimated ORs and 95% CIs for associations between participation in neighbourhood-based physical activity and built environment characteristics, Calgary, 2007–2008 (n = 4034)

	Neighbourhood-based physical activity in a usual week			
	Any transportation walking	Any recreational walking	Any moderate-intensity physical activity	Any vigorous-intensity physical activity
	OR (95% CI)	OR (95% CI)	OR (95%CI)	OR (95% CI)
Built environment characteristics[a]				
Intersections/km^2 [b]	1.11 (1.03–1.20)*	1.04 (0.96–1.13)	1.06 (0.99–1.13)	1.06 (0.98–1.14)
Businesses/km^2 [b]	1.52 (1.29–1.78)*	1.04 (0.93–1.16)	1.04 (0.95–1.15)	0.97 (0.88–1.07)
Bus stops/km^2 [b]	0.95 (0.84–1.07)	0.96 (0.88–1.04)	0.97 (0.90–1.04)	0.98 (0.91–1.06)
Mix of recreational destinations/km^2 [b]	1.02 (0.95–1.10)	1.03 (0.94–1.12)	1.09 (1.01–1.17)*	1.02 (0.95–1.10)
Sidewalk length (m)/km^2 [b]	1.19 (1.09–1.29)*	1.06 (0.97–1.16)	1.10 (1.02–1.19)*	1.11 (1.02–1.20)*
Total population/km^2 [c]	0.98 (0.90–1.08)	0.97 (0.88–1.06)	0.97 (0.89–1.05)	0.96 (0.88–1.04)
Proportion of green space area[c]	0.99 (0.90–1.09)	0.92 (0.84–1.02)	0.93 (0.85–1.02)	0.89 (0.82–0.98)*
Path/cycleway length (m)/km^2 [c]	1.08 (0.97–1.20)	1.17 (1.05–1.31)*	0.99 (0.90–1.09)	1.12 (1.02–1.24)*
City-managed trees/km^2 [c]	1.05 (0.97–1.14)	1.01 (0.93–1.10)	1.01 (0.94–1.08)	1.03 (0.96–1.11)
Chi-square/degrees of freedom[d]	1.011	1.010	1.005	1.009

Abbreviations: CI, confidence interval; km^2, square kilometres; m, metres; OR, odds ratio.

Note: Model estimates adjusted for gender, age, education, home ownership, number of children aged < 18 years, season, reasons for residential self-selection and built environment characteristics.

[a] All built environment variables are standardized (z-score).

[b] Estimated for the 1.6 km walkshed.

[c] Estimated for the neighbourhood administrative boundary.

[d] Values closer to 1 represent better goodness of fit. Goodness of fit based on the fully adjusted model.

* $p < .05$.

TABLE 3
Generalized linear model (binomial distribution and logit link function) estimated ORs and 95% CIs for associations between participation in neighbourhood-based physical activity and built environment characteristics *without adjustment for residential self-selection variables*, Calgary, 2007–2008 (n = 4034)

	Neighbourhood-based physical activity in a usual week			
	Any transportation walking	Any recreational walking	Any moderate-intensity physical activity	Any vigorous-intensity physical activity
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Built environment characteristics[a]				
Intersections/km^2 [b]	1.10 (1.02–1.18)*	0.98 (0.90–1.06)	1.03 (0.96–1.10)	1.02 (0.95–1.09)
Businesses/km^2 [b]	1.67 (1.42–1.95)*	1.04 (0.93–1.16)	1.06 (0.96–1.16)	1.00 (0.91–1.10)
Bus stops/km^2 [b]	0.98 (0.86–1.13)	0.96 (0.89–1.04)	0.98 (0.90–1.05)	1.00 (0.93–1.07)
Mix of recreational destinations/km^2 [b]	1.06 (0.98–1.14)	1.03 (0.95–1.12)	1.10 (1.02–1.18)*	1.04 (0.97–1.12)
Sidewalk length (m)/km^2 [b]	1.21 (1.12–1.32)	1.02 (0.94–1.11)	1.08 (1.00–1.16)*	1.08 (1.00–1.16)*
Total population/km^2 [c]	0.98 (0.90–1.07)	0.92 (0.84–1.01)	0.94 (0.87–1.02)	0.93 (0.86–1.00)
Proportion of green space area[c]	0.99 (0.90–1.08)	0.92 (0.83–1.01)	0.93 (0.85–1.02)	0.90 (0.82–0.98)*
Path/cycleway length (m)/km^2 [c]	1.08 (0.97–1.20)	1.21 (1.09–1.35)*	1.02 (0.93–1.12)	1.16 (1.06–1.27)*
City-managed trees/km^2 [c]	1.07 (0.99–1.16)	1.02 (0.94–1.10)	1.01 (0.94–1.09)	1.03 (0.96–1.11)
Chi-square/degrees of freedom[d]	1.021	1.004	1.004	1.002

Abbreviations: CI, confidence interval; km^2, square kilometre; m, metres; OR, odds ratio.

Note: Model estimates adjusted for gender, age, education, home ownership, number of children aged < 18 years and season.

[a] All built environment variables are standardized (z-score).

[b] Estimated for the 1.6 km walkshed.

[c] Estimated for the neighbourhood administrative boundary.

[d] Values closer to 1 represent better goodness of fit. Goodness of fit based on the fully-adjusted model.

* $p < .05$.

associated with business density (B = 19.24 minutes/week; 95% CI: 11.28–27.20), recreational destination mix (−8.88 minutes/week; −12.49 to −5.28) and density of city-managed trees (6.15 minutes/week; 2.29–10.72) (Table 4). Further, population density was negatively associated with neighbourhood-based moderate-intensity physical activity (−8.65 minutes/week; −15.32 to −1.98). Density of city-managed trees was positively associated with neighbourhood-based vigorous-intensity physical activity (7.28 minutes/week; 0.39–14.17). Notably, only business density (27.35 minutes/week; 9.86–44.83) and sidewalk length (18.69 minutes/week; 7.69–29.69) were associated with total neighbourhood-based physical activity. No built environment characteristics were significantly associated with weekly minutes of recreational walking (Table 4). For comparison, the estimated associations between weekly minutes of neighbourhood-based physical activity and built environment characteristics without residential self-selection adjustment are reported in Table 5.

Discussion

The study findings suggest that different objectively measured neighbourhood built environment characteristics are associated with various types of physical activity in adults. In support of previous evidence,[12,14,15] neighbourhood built environment characteristics appeared to be more important for neighbourhood-based transportation walking versus recreational walking. Similar to findings from other studies, we also found differences in the neighbourhood built environment characteristics that were associated with moderate-intensity versus vigorous-intensity physical activity.[8,13,16] Further, these findings suggest that the built environment correlates of physical activity *participation* (i.e. ≥ 10 minutes/week vs. < 10 minutes/week) may be different from the built environment correlates of the *duration* of time spent in physical activity. The findings are novel in that we estimated associations between the built environment and different types of *neighbourhood-based* physical activity while also statistically adjusting for residential self-selection, and that we examined both physical activity participation and duration as separate outcomes.

We observed a greater number of built environment characteristics to be significantly associated with transportation walking compared with recreational walking. Similar to others, we found connectivity (intersection density), availability of destinations (business density), and the availability of sidewalks (sidewalk length) to be positively associated with transportation walking.[12,38] Importantly, our findings suggest that increasing the density of businesses within neighbourhoods could

TABLE 4
Generalized linear model (gamma distribution and identity link function) estimated unstandardized beta coefficients (B) and 95% CIs for associations between time spent in neighbourhood-based physical activity and built environment characteristics, Calgary, 2007–2008

	Neighbourhood-based physical activity in a usual week among those reporting "any participation" only				
	Transportation walking minutes (n = 2385)	Recreational walking minutes (n = 3022)	Moderate-intensity physical activity minutes (n = 1434)	Vigorous-intensity physical activity minutes (n = 1835)	Total physical activity minutes (n = 3678)
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Built environment characteristics[a]					
Intersections/km²[b]	−1.50 (−5.51 to 2.51)	−1.93 (−7.86 to 3.99)	−3.53 (−9.57 to 2.51)	4.25 (−2.48 to 10.98)	5.14 (−5.07 to 15.34)
Businesses/km²[b]	19.24 (11.28 to 27.20)*	1.82 (−6.59 to 10.23)	2.72 (−5.39 to 10.83)	−0.28 (−8.92 to 8.37)	27.35 (9.86 to 44.83)*
Bus stops/km²[b]	0.34 (−6.72 to 7.40)	−1.66 (−8.12 to 4.80)	−2.41 (−8.60 to 3.79)	−3.22 (−9.78 to 3.34)	−11.36 (−24.00 to 1.29)
Mix of recreational destinations/km²[b]	−8.88 (−12.49 to −5.28)*	−3.69 (−9.57 to 2.19)	2.12 (−4.29 to 8.53)	3.87 (−3.56 to 11.30)	0.69 (−9.98 to 11.36)
Sidewalk length (m)/km²[b]	4.26 (−0.18 to 8.70)	1.10 (−5.20 to 7.40)	3.28 (−3.51 to 10.07)	4.51 (−2.59 to 11.61)	18.69 (7.69 to 29.69)*
Total population/km²[c]	−0.70 (−6.10 to 4.70)	0.16 (−6.94 to 6.61)	−8.65 (−15.32 to −1.98)*	−1.86 (−9.02 to 5.30)	−9.17 (−20.71 to 2.37)
Proportion of green space area[c]	−2.72 (−7.80 to 2.36)	3.07 (−4.52 to 10.66)	−2.84 (−10.72 to 5.04)	0.33 (−8.44 to 9.10)	−9.54 (−22.14 to 3.05)
Path/cycleway length (m)/km²[c]	3.02 (−2.89 to 8.92)	−0.12 (−8.16 to 7.91)	1.05 (−7.15 to 9.25)	−6.23 (−14.87 to 2.41)	5.60 (−8.89 to 20.09)
City-managed trees/km²[c]	6.51 (2.29 to 10.72)*	1.15 (−4.92 to 7.22)	1.95 (−4.43 to 8.32)	7.28 (0.39 to 14.17)*	7.81 (−2.95 to 18.57)
Chi-square/degrees of freedom[d]	1.309	0.904	1.013	0.812	0.823

Abbreviations: B, unstandardized beta coefficients; CI, confidence interval; km², square kilometre; m, metres.

Note: Model estimates adjusted for gender, age, education, home ownership, number of children aged < 18 years, season and reasons for residential self-selection (access to physical activity opportunities, access to services and shops, sense of community, ease of driving).

[a] All built environment variables are standardized (z-score).

[b] Estimated for the 1.6 km walkshed.

[c] Estimated for the neighbourhood administrative boundary.

[d] Values closer to 1 represent better goodness of fit. Goodness of fit based on the fully adjusted model.

* $p < .05$.

TABLE 5
Generalized linear model (gamma distribution and identity link function) estimated unstandardized beta coefficients (B) and 95% CIs for associations between time spent in neighbourhood-based physical activity and built environment characteristics *without adjustment for residential self-selection variables*, Calgary, 2007–2008

	Neighbourhood-based physical activity in a usual week among those reporting "any participation" only				
	Transportation walking minutes (n = 2385)	Recreational walking minutes (n = 3022)	Moderate-intensity physical activity minutes (n = 1434)	Vigorous-intensity physical activity minutes (n = 1835)	Total physical activity minutes (n = 3678)
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Built environment characteristics[a]					
Intersections/km²[b]	−0.33 (−4.78 to 4.12)	−6.35 (−12.40 to −0.30)*	−3.82 (−9.79 to 2.15)	2.23 (−4.60 to 9.06)	−1.49 (−12.55 to 9.57)
Businesses/km²[b]	23.41 (14.86 to 31.96)*	1.24 (−7.45 to 9.94)	3.63 (−4.47 to 11.72)	−0.12 (−9.01 to 8.76)	26.9 (8.45 to 45.40)*
Bus stops/km²[b]	6.70 (−1.62 to 15.02)	2.15 (−5.22 to 9.51)	−1.94 (−8.19 to 4.31)	−2.75 (−9.53 to 4.03)	−1.31 (−16.34 to 13.73)
Mix of recreational destinations/km²[b]	−4.44 (−8.64 to −0.23)*	−1.60 (−7.77 to 4.58)	2.58 (−3.81 to 8.97)	4.39 (−3.09 to 11.87)	5.17 (−6.46 to 16.81)
Sidewalk length (m)/km²[b]	4.14 (−0.65 to 8.93)	0.10 (−6.40 to 6.60)	3.17 (−3.58 to 9.92)	4.35 (−2.93 to 11.62)	19.27 (7.28 to 31.25)*
Total population/km²[c]	−1.34 (−7.06 to 4.39)	−0.05 (−7.04 to 6.95)	−8.84 (−15.47 to −2.22)*	−2.75 (−10.05 to 4.55)	−10.39 (−22.96 to 2.17)
Proportion of green space area[c]	−0.61 (−6.18 to 4.96)	2.79 (−5.09 to 10.67)	−3.29 (−11.18 to 4.60)	1.67 (−7.34 to 10.69)	−11.73 (−25.40 to 1.94)
Path/cycleway length (m)/km²[c]	4.96 (−1.50 to 11.42)	3.07 (−5.21 to 11.36)	1.73 (−6.46 to 9.92)	−5.50 (−14.34 to 3.33)	15.37 (−0.12 to 30.86)
City-managed trees/km²[c]	4.64 (−0.92 to 9.36)	1.84 (−4.42 to 8.11)	1.69 (−4.67 to 8.05)	7.24 (0.22 to 14.26)*	9.16 (−2.59 to 20.90)
Chi-square/degrees of freedom[d]	1.380	0.913	1.020	0.813	0.845

Abbreviations: B, unstandardized beta coefficients; CI, confidence interval; km², square kilometre; m, metres.

Note: Model estimates adjusted for gender, age, education, home ownership, number of children aged < 18 years and season.

[a] All built environment variables are standardized (z-score).

[b] Estimated for the 1.6 km walkshed.

[c] Estimated for the neighbourhood administrative boundary.

[d] Values closer to 1 represent better goodness of fit. Goodness of fit based on the fully adjusted model.

* $p < .05$.

result in increases in both transportation walking initiation, and the amount of overall time spent walking for transportation. We also found the density of city-managed trees to be associated with duration of time spent walking for transportation inside the neighbourhood. This finding was unexpected given that aesthetics (including gardens and trees) are often associated with recreational physical activity.[39] We speculate that the density of trees may be higher in older neighbourhoods, which typically offer infrastructure that is more supportive for transportation walking.[40,41] One built characteristic only—length of pathways and cycleways per square kilometre—was associated with participation in neighbourhood-based recreational walking, although this characteristic was not found to be associated with time spent in neighbourhood-based recreational walking.

The recreational destination mix per square kilometre was positively associated with participation in, but not minutes of, moderate-intensity physical activity. The recreational destination mix was, however, negatively associated with neighbourhood-based transportation walking minutes. One explanation for this could be that recreational and nonrecreational destinations compete for geographical space and so the more recreational facilities there are, the fewer utilitarian destinations there can be to walk to. Despite evidence suggesting the importance of parks in supporting physical activity,[42,43,44] we found no significant positive associations between the proportion of green space and any of our physical activity outcomes. Surprisingly, we found a higher proportion of green space area within a neighbourhood to be associated with a lower likelihood of participating in neighbourhood-based vigorous-intensity physical activity. Others have found the presence and quality of neighbourhood parks and open space to be positively associated with jogging.[18] We were not able to differentiate between the potentially different types of vigorous-intensity physical activity. Notably, our measure of green space did not differentiate between parks based on their quality, type or size, all of which may be important park characteristics associated with physical activity,[45,46] and included greenspace for the neighbourhood administrative boundary and was not specific to the 1.6 km walkshed. For many adults, parks may not be an important destination in and of themselves for vigorous-intensity physical activity, but rather may be destinations traversed along cycling and jogging/running routes.[47] Although we attempted to adjust for residential self-selection, it is possible that individuals who were inclined to participate in vigorous-intensity physical activity also chose to reside in neighbourhoods that had less green space.

Previous studies have found the availability of sidewalks to be important for supporting transportation walking[17,48] and moderate-intensity and vigorous-intensity

physical activity.[17] Our study also found sidewalks to be positively associated with transportation walking and overall physical activity inside the neighbourhood. Extending sidewalks in established neighbourhoods may be a cost-effective intervention with regard to promoting transportation walking.[49] Our findings suggest that sidewalks might also support other types and overall levels of neighbourhood-based physical activity that in turn could provide health benefits. Importantly, the number of business destinations and length of sidewalks were the only characteristics significantly associated with total minutes of neighbourhood-based physical activity. A one-standard-deviation increase in business density was associated with an increase in total neighbourhood-based physical activity of 25 minutes per week, while an increase of one standard deviation in sidewalk length was associated with an increase in total neighbourhood-based physical activity of 18 minutes per week. From a planning perspective, compared with some other built environment characteristics, sidewalks may be less difficult or costly to modify within the infrastructure constraints of existing neighbourhoods. Modifying zoning ordinances to allow the development of more shops and services mixed with residential land uses within new and existing neighbourhoods might contribute to higher levels of neighbourhood-based physical activity. We found it noteworthy that despite some negative associations between built environment characteristics and some physical activities (i.e. population density and moderate-intensity physical activity, recreational destination density and transportation walking, and proportion of green space and vigorous-intensity physical activity), no built environment characteristics were significantly negatively associated with total neighbourhood-based physical activity. Thus, improvements made to a neighbourhood's built environment to make it more supportive of physical activity are likely to result either in no change or an increase, and not a decrease, in overall neighbourhood-based physical activity.

Strengths and limitations

This study has several strengths, including the matching of the built environment with our definition of neighbourhood-based physical activity (i.e. within a 15-minute walk from home); statistical adjustment for residential self-selection; and estimating the relative associations between different built environment characteristics and four different physical activity behaviours as well as overall neighbourhood-based physical activity.

Despite these strengths, the use of self-reported physical activity is a limitation of this study due to potential measurement bias.[50] For our study, we considered the use of an objective measure of physical activity such as accelerometers less feasible than self-report. Notably, our estimates of weekly physical activity duration were higher than might be expected for this population, which may have partly been due to our exclusion of nonparticipants from these estimates.

The response rate may restrict the generalizability of our findings. Compared to the Calgary population, telephone-interview respondents were more educated, included a higher proportion of older adults (≥ 60 years of age), were more likely to have dependents younger than 18 years and included a higher proportion of women, people born in Canada and home owners.[28] Furthermore, only those households with landline telephones had an opportunity to be recruited into our study. Households with and without landline telephones may differ in regard to their health and sociodemographic characteristics.[51]

Despite statistically adjusting for residential self-selection, the direction of causality between the built environment and physical activity cannot be determined from our cross-sectional data. Most estimated associations between the built environment variables and physical activity were either unchanged or attenuated slightly after adjustment for the residential self-selection variables. Only one statistically significant association prior to adjustment for residential self-selection attenuated and was not statistically significant after adjustment (i.e. intersection density and recreational walking minutes). The findings here suggest that while adjusting for residential self-selection in cross-sectional built environment–physical activity studies is important, the impact on estimated associations might be small and for the most part may not impact the conclusions drawn. Natural experiments are needed to assess temporal relations between changes in the built environment and changes in physical activity.[52]

The modifiable areal unit problem implies that chosen operational definition of the neighbourhood can impact estimated associations with physical activity.[53] Definitions of neighbourhood boundaries can influence the estimated associations between the built environment and physical activity.[54,55] It is possible that our estimated associations, based on a 1.6 km walkshed, may not generalize to other walkshed boundary sizes. The use of Global Positioning System (GPS) monitors, together with accelerometers, is a promising approach for objectively capturing behaviour-defined neighbourhoods and physical activity for each individual.[56]

Our measures of the built environment, while comprehensive, are not exhaustive and did not include microlevel or streetscape characteristics. For instance, access to transit was represented only by the density of bus stops within the neighbourhood; however, access to train services, whether transit stops were sheltered from weather, route timetable and frequency of services, among other factors, might also contribute to decisions regarding transportation walking.

Conclusion

Importantly, our findings suggest that associations between the neighbourhood built environment and neighbourhood-based physical activity exist even after adjusting for reasons for residential self-selection. Further, we found evidence for behaviour-specific neighbourhood built environment correlates.[24] Modifications of some built environment characteristics may not have the same effect on all physical activities. Related to this, some neighbourhood built environment characteristics may be more important for promoting or supporting physical activity initiation or participation while other neighbourhood built environment characteristics may be more supportive of increasing physical activity duration among those who are already active. To increase total neighbourhood-based physical activity, our findings suggest that urban planners should consider, in particular, increasing the local density of business (utilitarian) destinations and quantity or length of available sidewalks. The impact of built environment characteristics on different physical activities should be considered when planning, designing and modifying neighbourhood built environments.

Acknowledgements

This study was part of the EcoEUFORIA project funded by the Canadian Institutes of Health Research (CIHR; Principal Investigator Dr. Alan Shiell). Gavin McCormack is supported by a CIHR New Investigator Award.

Conflicts of interest

The author declares no conflicts of interest.

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https://doi.org/10.24095/hpcdp.37.6.02

Cancer risk factors and screening in First Nations in Ontario

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This article has been peer reviewed.

Abstract

Introduction: A lack of identifiers in health administrative databases limits our understanding of the cancer burden in First Nations. This study compares cancer risk factors and screening between First Nations in Ontario (on and off reserve) and non-Aboriginal Ontarians using two unique health surveys.

Methods: We measured age-standardized prevalence estimates using the First Nations Regional Health Survey (RHS) Phase 2, 2008/10 (for First Nations on reserve) and the Canadian Community Health Survey (CCHS), 2007–2013 (for First Nations off reserve and non-Aboriginal Ontarians). We used prevalence rate ratios (RR) and Pearson's chi-square tests for differences in proportions to compare estimates between First Nations (on and off reserve) and non-Aboriginal Ontarians.

Results: A higher proportion of First Nation men, women and adolescents on reserve smoked (RR = 1.97, 2.78 and 7.21 respectively) and were obese (RR = 1.73, 2.33 and 3.29 respectively) compared to their non-Aboriginal counterparts. Similar patterns were observed for First Nations off reserve. Frequent binge drinking was also more prevalent among First Nation men and women living on reserve (RR = 1.28 and 2.22, respectively) and off reserve (RR = 1.70 and 1.45, respectively) than non-Aboriginal Ontarians. First Nation men and women on reserve were about half as likely to consume fruit at least twice per day and vegetables at least twice per day compared to non-Aboriginal men and women (RR = 0.53 and 0.54, respectively). Pap test uptake was similar across all groups, while First Nation women on reserve were less likely to have had a mammogram in the last five years than non-Aboriginal women (RR = 0.85).

Conclusion: First Nations, especially those living on reserve, have an increased risk for cancer and other chronic diseases compared to non-Aboriginal Ontarians. These results provide evidence to support policies and programs to reduce the future burden of cancer and other chronic diseases in First Nations in Ontario.

Keywords: *First Nations, cancer risk factors, cancer screening*

Highlights

- First Nation adults living on and off reserve are two to three times more likely to smoke cigarettes than non-Aboriginal adults.
- Among First Nations living on reserve, the prevalence of obesity was three times higher, and the proportion who ate fruit at least twice per day and vegetables at least twice per day was about half of that for non-Aboriginal Ontarians.
- First Nation women living on reserve are less likely to have had a mammogram for breast cancer in the last five years compared to non-Aboriginal women
- These results demonstrate that actions to improve the health of First Nations in Ontario (whether on or off reserve) are needed to reduce their future burden of cancer and other chronic diseases.

Introduction

First Nations are the largest of three groups collectively recognized by Canada's *Constitution Act of 1982* as the "Aboriginal peoples of Canada."[1] There are more First Nation people living in Ontario than in any other province or territory in Canada.[2] About half of all First Nations in Ontario live on reserves (46%), which are tracts of land set aside by the Canadian government for the use of First Nation communities.[3]

First Nations have experienced a long history of colonization and loss of cultural identity, which has dramatically impacted their way of life and all aspects of their health. The impact of these actions on health and well-being continues today. Across Canada, First Nations experience significantly lower rates of high school graduation, lower median personal income and more than twice the rate of unemployment compared to non-Aboriginal Canadians.[4] These inequities have contributed to major health consequences in the First Nation population, including significantly lower life expectancy[5] and a higher prevalence of chronic conditions.[6]

A lack of ethnic identifiers in Canadian health databases, including the Ontario Cancer Registry, has resulted in a gap in information about the burden of chronic diseases, such as cancer, in First Nations. In one study, the Ontario portion of the Indian Registry System (IRS) was linked with the Ontario Cancer Registry (1968–1991).[7] The study found cancer incidence was increasing disproportionately among First Nations compared to non–First Nations. A follow-up to this study found cancer survival was poorer for First

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Nations than non–First Nations in Ontario for various cancer sites.[8]

In the absence of more recent First Nations–specific cancer data, studying the prevalence of cancer risk factors and screening using population health surveys offers a timely approach to determining how and where prevention resources can be most effectively directed to reduce the future burden of cancer. Evidence confirms strong associations between five major risk factors related to lifestyle (tobacco smoking, alcohol consumption, body composition, physical inactivity and diet) and the risk of certain cancers.[9,10] Many of these factors are also common to other chronic diseases, such as cardiovascular disease, diabetes and respiratory diseases.[11] Thus, prevention efforts to address lifestyle risk factors will not only impact the future burden of cancer but also the burden of many other common and costly chronic conditions. One other study found many lifestyle risk factors for cancer to be more prevalent among the off-reserve First Nation population compared to non-Aboriginal Ontarians.[12] No study has examined cancer risk and screening in First Nations living on reserve in Ontario. This study aims to compare risk factors for cancer and screening participation as accurately as possible between First Nations in Ontario (both on and off reserve) and the non-Aboriginal population using two health surveys.

Methods

Data sources

Data for First Nations living off reserve in Ontario and non-Aboriginal Ontarians were obtained from the Ontario portion of the Canadian Community Health Survey (CCHS) cycles 2007–2013 (seven cycles for most questions; three cycles for cancer screening questions). Between 2007 and 2013, the CCHS response rate in Ontario varied from 65.8% to 73.6%.[13-19] The CCHS, administered by Statistics Canada, is a population-based survey of the Canadian population aged 12 years and over living in all provinces and territories, excluding individuals living on Indian reserves and Crown lands, institutional residents, full-time members of the Canadian Forces and residents of some remote regions.[20] To increase the sample size of First Nations living off reserve available for analysis, microdata files for seven annual releases of the CCHS (2007–2013) were combined as per methodology described by Statistics Canada.[21] Data for First Nations living on reserve were obtained from the Ontario portion of the First Nations Regional Health Survey (RHS) Phase 2 (2008/10), governed by the First Nations Information Governance Centre. The RHS is the only First Nations–governed national health survey that collects information about First Nations living on reserve and in northern First Nation communities aged 12 years and over.[22] The RHS Phase 2 was initiated in the spring of 2008 and completed in the fall of 2010. It was a single survey, with the data collection phase occurring over an 18-month period. Of 133 First Nation communities in Ontario, a total of 24 participated in the RHS Phase 2 (2008/10). The target sample for the RHS Ontario region was 4551 First Nation individuals, of which 2870 completed questionnaires (63.1%).[23]

Indicators of risk and screening

Unless otherwise specified, risk factor analyses included adult respondents aged 18 years and older, and adolescent respondents aged 12 to 17 years. We excluded respondents with a missing or invalid response to a given question from the denominator of that indicator. We based age limits and response cut-off points for each screening measure on Ontario guidelines for that screening modality. For cancer screening, relevant questions were only posed in the 2007, 2008 and 2011 CCHS surveys.

Our definition of each indicator is provided below:

Smoking: The proportion of respondents aged 20 years and older who reported smoking daily or occasionally. A cut-off of age 20 years was chosen to be consistent with other public health indicators.[24] The CCHS and RHS had equivalent questions and response categories for measurement of smoking.

Obesity: The proportion of respondents who, based on self-reported height and weight, had a body mass index (BMI) of 30 kg/m^2 or more. Pregnant and lactating women were excluded. The CCHS and RHS had equivalent questions and response categories for measurement of obesity.

Physical activity: The proportion of respondents classified as moderately active in the previous three months, based on daily estimated energy expenditure (EE) exceeding 1.5 kcal/kg/day. To determine EE, respondents were asked about the frequency and duration of different activities. The CCHS asks respondents about physical activity during leisure activities, while the RHS does not specify during leisure activities (therefore, the RHS indicator may also include, for example, physical activity for transportation or occupation). There was also some variation in types of activities between surveys. For example, in the RHS, traditional activities were included (such as hunting or trapping, fishing and berry picking or other food gathering). These were not listed as activities in the CCHS. In the CCHS and RHS, EE was calculated by combining information on frequency and duration with the metabolic equivalent of the activity, which takes into account the intensity of the activity.

Vegetable and fruit consumption: The proportion of respondents who ate vegetables (including potatoes) at least two times per day and fruit at least two times per day. This indicator is typically measured as consuming vegetables and fruit five or more times per day (in any combination, and excluding potatoes) as per the cancer prevention guidelines;[9] however, in the RHS, there are only two response categories to choose from when asked about average daily consumption of vegetables (which could include potatoes) or fruit: "once a day" or "several times a day." Respondents to the RHS who selected "several times a day" for both vegetables and fruit were included in our definition as having consumed fruit at least twice and vegetables at least twice, for a combined total of four or more times per day. For consistency, respondents to the CCHS who reported eating at least two vegetables (including potatoes) and at least two fruits were included in our definition as consuming fruit and vegetables a combined total of four or more times per day.

Alcohol abstinence: The proportion of respondents aged 19 years and older who reported not having an alcoholic drink in the previous 12 months. Pregnant women were excluded. The RHS and CCHS had equivalent questions and response categories for measurement of alcohol abstinence.

Frequent binge drinking: The proportion of respondents aged 19 years and older who reported having five or more drinks on one occasion at least two to three times per month in the previous 12 months. Pregnant women were excluded. The RHS and CCHS had equivalent questions and response categories for measurement of binge drinking.

Frequent binge drinking and smoking: The proportion of respondents aged 19 years and older who reported having five or more drinks on one occasion at least two to three times per month in the previous 12 months and who were current smokers. Pregnant women were excluded. The RHS and CCHS had equivalent questions and response categories for measurement of binge drinking and current smoking.

Cervical screening participation: The proportion of women aged 21 to 69 years who had a Pap test within the previous three years. There is no question in the RHS that asks women if they have had a total hysterectomy; therefore, women who indicated that they had a hysterectomy in the CCHS were included.

Breast screening participation: The proportion of women aged 50 to 74 years who had a mammogram within the previous five years. This indicator deviates from the recommended interval of breast cancer screening (every two years for women at average risk) to enable comparison between response categories of the RHS and CCHS (the RHS only asks women if they had a mammogram in the past one to three years or three to five years). Additionally, there is no question in the RHS that asks why a woman had a mammogram (e.g. for follow-up treatment, diagnosis or other breast problems); therefore, respondents to the CCHS who indicated they had a mammogram for reasons other than screening were also included in the definition.

Aboriginal identity

From 2007 to 2010, all CCHS respondents were asked "Are you an Aboriginal person, that is, North American Indian, Métis or Inuit?" Respondents who answered "yes" were also asked to specify the subpopulation to which they belonged, and a respondent could report multiple Aboriginal identities. As of 2011, the CCHS question about Aboriginal identity was restricted to those born in Canada, the United States, Germany or Greenland. To be consistent, we classified respondents in 2007 to 2010 as First Nations only if they had also reported being born in one of these four countries. "First Nations living off reserve" included those who responded to the CCHS and self-identified as First Nations or First Nations and Inuit. "Non-Aboriginal Ontarians" were defined as respondents to the CCHS who did not self-identify as Aboriginal, or who self-identified as Aboriginal but were born outside of Canada, the United States, Germany and Greenland. "First Nations living on reserve" were all those who responded to the RHS.

Age groups, education and geography

In our risk factor analyses, we stratified adults by age according to the following standard groupings: youngest age for indicator (18, 19 or 20) to 29 years; 30 to 44 years; 45 to 64 years; and 65 years or older. For cervical cancer screening, we defined age groups as 21 to 29 years; 30 to 44 years; and 45 to 69 years. For breast cancer screening, we defined age groups as 50 to 54 years; 55 to 64 years; and 65 to 74 years.

We categorized respondents' level of education into three groups based on the highest level of schooling attained: less than secondary school graduation, secondary school graduation and/or some post-secondary and post-secondary graduation.

We categorized geography of residence into north or south based on Statistics Canada's census divisions. We classified south as census division codes 3501 through 3547, and north as census division codes 3548 through 3560. According to this definition, of the 24 First Nation communities that participated in the RHS, 10 were located in the south of the province and 14 were located in the north. For instance, Moose Deer Point First Nation would be classified as south, and Wasauksing First Nation would be classified as north. A map showing the geography of north and south according to this definition, as well as First Nation communities that participated in the RHS, has been published.[25]

Analysis

Sampling weights assigned by Statistics Canada (for the CCHS) or the First Nations Information Governance Centre (for the RHS) were used to account for selection probability, nonresponse and noncoverage. We measured age-standardized prevalence (ASP) according to the 2006 Ontario Aboriginal identity population[26] and stratified it by gender, age group, education and geography. We used bootstrapping techniques to calculate the coefficient of variation (CV) and 95% confidence intervals (CIs). Estimates with a CV ranging from 16% to 33% were flagged to be interpreted with caution. We performed prevalence rate ratios and chi-square tests to compare estimates between First Nations and non-Aboriginal Ontarians. A p-value $< .05$ was considered statistically significant.

Results

The RHS identified 1500 First Nation adults and 600 First Nation adolescents living on reserve; the CCHS identified 2119 First Nation adults and 376 adolescents, and 123 105 non-Aboriginal adults and 11 636 adolescents living off reserve (Table 1).

First Nation adults living on reserve (ASP men = 50.4%, ASP women = 49.4%) and off reserve (ASP men = 44.2%, ASP women = 41.4%) had a significantly higher prevalence of smoking compared with non-Aboriginal adults (ASP men = 25.6%, ASP women = 17.8%) (Table 2, Figures 1 and 2). First Nation adolescents living on reserve (ASP = 30.3%) and off reserve (ASP = 13.8%) were also significantly more likely to smoke compared to non-Aboriginal adolescents (ASP = 4.2%).

A significantly higher proportion of First Nation adults living on reserve (ASP men = 34.8%, ASP women = 37.8%) and men living off reserve (ASP = 18.9%) reported abstaining from alcohol compared with their non-Aboriginal counterparts (ASP men = 15.7%, ASP women = 24.5%). First Nation women living off reserve had a similar prevalence of alcohol abstinence compared to non-Aboriginal women (24.2% vs. 24.5%).

First Nation men and women living off reserve (ASP men = 27.7%, ASP women = 10.7%) were significantly more likely to binge drink frequently compared to non-Aboriginal men and women (ASP men = 19.1%, ASP women = 6.3%). Among First Nations living on reserve, a similar proportion of men (ASP = 24.5%) and a significantly higher proportion of

TABLE 1
Sample sizes available for First Nations living on reserve (RHS, 2008/10), First Nations living off reserve and non-Aboriginal population (CCHS, 2007–2013), Ontario, Canada

Age group	Non-Aboriginal population (CCHS)	Off-reserve First Nations (CCHS)	On-reserve First Nations (RHS)
Adolescents (12–17)	11 636	376	600
Men (18+)	54 742	919	654
Women (18+)	68 363	1200	846
Women (21–69)[a]	26 183	619	719
Women (50–74)[b]	29 366	442	362

Abbreviations: CCHS, Canadian Community Health Survey; RHS, First Nations Regional Health Survey.

[a] Eligible for cervical cancer screening (Pap test) indicator.

[b] Eligible for breast cancer screening (mammogram) indicator.

women (ASP = 14.0%) reported frequent binge drinking compared to non-Aboriginal men and women. The prevalence of combined frequent binge drinking and smoking was significantly higher among First Nation men and women living on reserve (ASP men = 15.6%, ASP women = 10.4%) and off reserve (ASP men = 17.7%, ASP women = 7.5%) compared to non-Aboriginal men and women (ASP men = 8.0%, ASP women = 2.7%).

First Nations living on reserve (ASP men = 12.0%, ASP women = 19.9%) and women living off reserve (ASP = 27.7%) were significantly less likely to report eating vegetables at least twice and fruit at

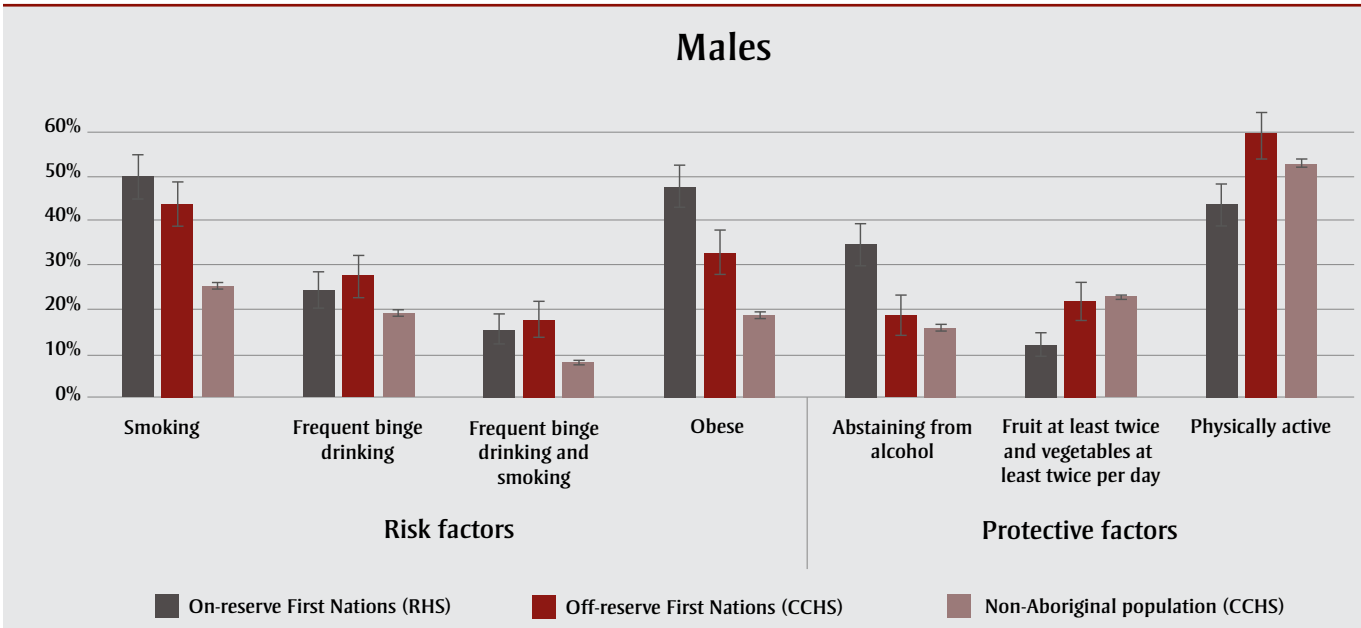
TABLE 2
Age-standardized prevalence (%) of risk factors for cancer and cancer screening in First Nations (on and off reserve) and non-Aboriginal people, Ontario, Canada (CCHS, 2007–2013 and RHS, 2008/10)

Characteristic	Subgroup (age in years)	Non-Aboriginal population (CCHS)		Off-reserve First Nations (CCHS)			On-reserve First Nations (RHS)		
		%	CI	%	CI	Prevalence rate ratio	%	CI	Prevalence rate ratio
Risk/protective factors									
Smoking	Adolescents (12–17)	4.2	3.8–4.7	13.8	9.0–18.6	3.29	30.3	24.8–36.4	7.21
	Men (20+)	25.6	24.9–26.4	44.2	39.1–49.2	1.73	50.4	45.4–55.4	1.97
	Women (20+)	17.8	17.2–18.3	41.4	36.4–46.4	2.33	49.4	45.3–53.5	2.78
Abstaining from alcohol	Men (19+)	15.7	15.1–16.4	18.9	14.3–23.5	1.20	34.8	30.1–39.5	2.22
	Women (19+)	24.5	23.7–25.3	24.2	20.2–28.3	0.99[NS]	37.8	33.8–41.9	1.54
Frequent binge drinking	Men (19+)	19.1	18.5–19.7	27.7	22.9–32.4	1.45	24.5	20.4–28.6	1.28
	Women (19+)	6.3	5.9–6.6	10.7	7.8–13.6	1.70	14.0	11.1–16.8	2.22
Smoking and frequent binge drinking	Men (19+)	8.0	7.6–8.4	17.7	13.5–22.0	2.21	15.6	12.1–19.0	1.95
	Women (19+)	2.7	2.4–2.9	7.5	4.9–10.1	2.78	10.4	8.0–12.9	3.85
Eating fruit at least twice and vegetables at least twice per day	Men (18+)	22.8	22.2–23.4	21.9	17.7–26.1	0.96[NS]	12.0	9.2–14.8	0.53
	Women (18+)	37.0	36.3–37.7	27.7	23.2–32.2	0.75	19.9	16.8–23.0	0.54
Obese	Adolescents (12–17)	4.8	4.2–5.4	7.5[a]	3.9–11.0	1.56	15.9	13.3–18.9	3.31
	Men (18+)	18.7	18.1–19.3	33.0	27.9–38.1	1.76	48.1	43.2–53.0	2.57
	Women (18+)	16.2	15.8–16.7	27.9	23.6–32.3	1.72	49.4	45.3–53.5	3.05
Physically active	Men (18+)	53.4	52.5–54.2	59.8	54.4–65.2	1.12	43.9	39.1–48.6	0.82
	Women (18+)	47.9	47.1–48.6	49.7	45.2–54.2	1.04[NS]	26.5	23.0–30.1	0.55
Cancer screening									
Pap test in the last 3 years	Women (21–69)	77.7	76.9–78.6	77.4	72.9–81.9	1.00[NS]	76.9	73.3–80.5	0.99[NS]
Mammogram in the last 5 years	Women (50–74)	82.1	80.6–83.6	81.7	73.7–89.8	1.00[NS]	69.8	63.8–75.7	0.85

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval; NS, not significant ($p > .05$); RHS, First Nations Regional Health Survey.

[a] High sampling variability; interpret with caution.

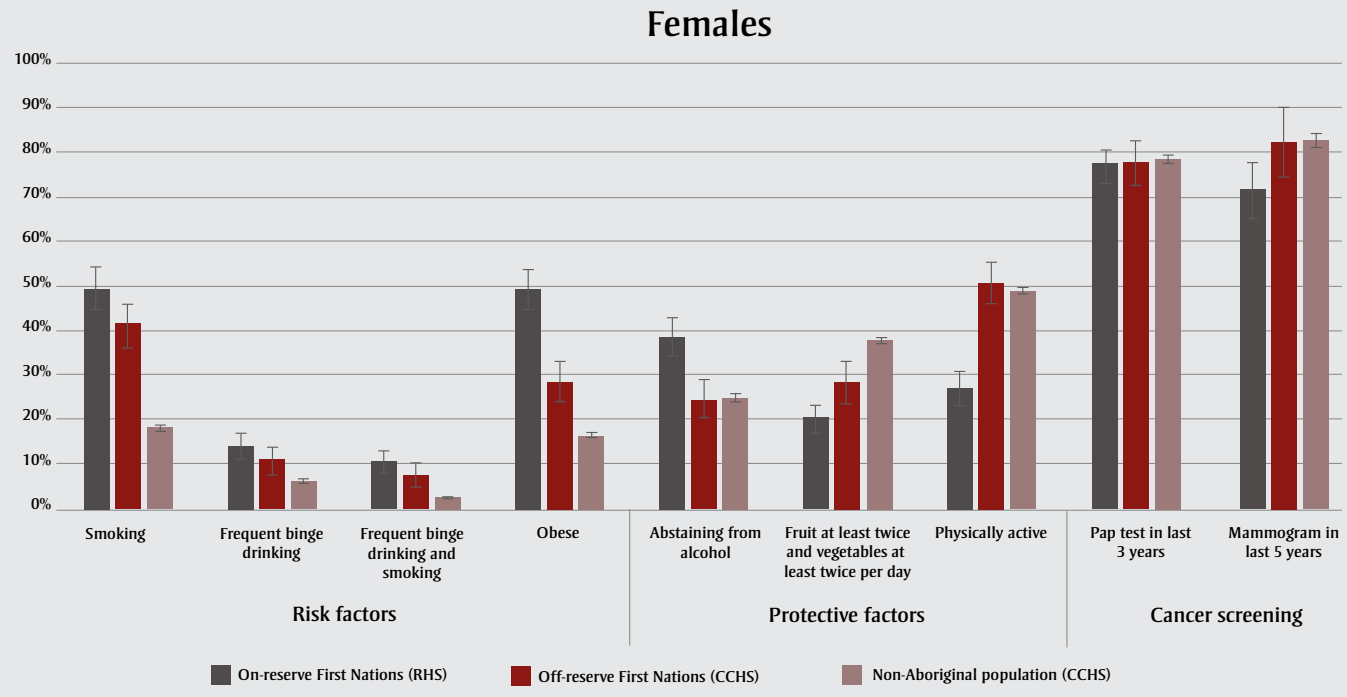
FIGURE 1
Age-standardized prevalence (%) of risk and protective factors for cancer in First Nation and non-Aboriginal adult males, Ontario, Canada



Data source: First Nations Regional Health Survey (RHS) 2008/10; Canadian Community Health Survey (CCHS) 2007–2013.

Notes: Age-standardized to the 2006 Ontario Aboriginal identity population. For age ranges for each variable, see text or Table 2. I represents 95% confidence interval.

FIGURE 2
Age-standardized prevalence (%) of risk and protective factors for cancer and cancer screening in First Nation and non-Aboriginal adult females, Ontario, Canada



Data source: Canadian Community Health Survey (CCHS) 2007–2013 (7 cycles for most questions, 3 cycles for cancer screening); First Nations Regional Health Survey (RHS) 2008/10.

Notes: Age-standardized to the 2006 Ontario Aboriginal identity population. For age ranges for each variable, see text or Table 2. I represents 95% confidence interval.

least twice per day compared to non-Aboriginal adults (ASP men = 22.8%, ASP women = 37.0%). The prevalence of obesity was significantly higher among First Nation adults living on reserve (ASP men = 48.1%, ASP women = 49.4%) and off reserve (ASP men = 33.0%, ASP women = 27.9%) compared to non-Aboriginal adults (ASP men = 18.7%, ASP women = 16.2%). Among First Nation adolescents, those living on reserve (ASP = 15.9%) and off reserve (ASP = 7.5%) were more likely to be obese compared to non-Aboriginal adolescents (ASP = 4.8%).

A significantly lower proportion of First Nation men and women living on reserve were physically active (ASP men = 43.9%, ASP women = 26.5%) compared to non-Aboriginal men and women (ASP men = 53.4%, ASP women = 47.9%). Among First Nations living off reserve, a significantly higher proportion of men (ASP = 59.8%) and a similar proportion of women (ASP = 49.7%) were physically active compared to non-Aboriginal men and women.

A similar proportion of First Nation women living on reserve (ASP = 76.9%) and off reserve (ASP = 77.4) were screened for cervical cancer in the last three years compared to non-Aboriginal women (ASP = 77.7%). However, the prevalence of mammogram uptake in the last five years was significantly lower among First Nation women living on reserve (ASP = 69.8%) compared to non-Aboriginal women (ASP = 82.1%). First Nation women living off reserve were equally likely to have had a mammogram in the last five years (ASP = 81.7%) as non-Aboriginal women (ASP = 82.1%).

The results for both on and off reserve First Nations compared to non-Aboriginal Ontarians generally remained consistent within age groups, levels of education and north/south geography, with wide confidence intervals indicating a large amount of variation in the estimates (data not shown).

Discussion

Across several indicators of lifestyle-associated risk presented in this study, First Nations in Ontario (especially those living on reserve) fared worse than non-Aboriginal Ontarians, suggesting they may experience a greater future burden of cancer and other chronic diseases. The high prevalence of smoking and obesity, low prevalence of fruit and vegetable consumption and low uptake of mammography among First Nations living on reserve are of particular concern. In the absence of recent, high-quality and comprehensive information on disease burden in First Nations in Ontario, this study provides important context for planning and priority setting.

In addition to lung cancer, smoking cigarettes is an established cause of many other types of cancer including mouth and throat, stomach, colorectal, pancreas, liver, cervix, ovary, kidney and bladder, and leukemia.[27] Smoking also increases the risk of many other serious chronic conditions, including cardiovascular disease, chronic respiratory diseases and possibly diabetes.[11,28] This study found a very high prevalence of smoking among First Nation adults and teens, especially those living on reserve, consistent with the high prevalence of smoking found among First Nations in other Canadian jurisdictions,[29-31] suggesting a heavy future burden of tobacco-related cancers and chronic disease.

Alcohol is a major cause of serious health conditions including certain types of cancer.[32] If alcohol is consumed, cancer prevention guidelines recommend a limit of one drink a day for women and two drinks a day for men.[9] Our study showed that First Nations living on reserve are more likely to abstain from alcohol. While this is promising, the prevalence of frequent binge drinking is also considerably higher among First Nations living on and off reserve compared to non-Aboriginal adults. Furthermore, First Nation adults, in particular men (both on and off reserve), are more likely to combine heavy drinking and smoking than are non-Aboriginal adults, substantially increasing their risk for cancers of the mouth and throat.[32,33]

Excess body weight increases the risk of many types of cancer, and risk for cancer rises with increasing BMI, even within the normal range.[9] Maintaining healthy weights at either an individual or community level must involve consideration of a complex interrelationship of lifestyle factors including diet, physical activity and social determinants.[34] The high prevalence of obesity combined with lower physical activity and limited vegetable and fruit intake observed in this study among First Nations (especially on reserve) are serious threats to good health and suggest a much higher risk for many chronic diseases, including cancer.

We observed a similar prevalence of Pap test uptake in First Nations (both on and off reserve) and non-Aboriginal women. These results are encouraging given that, historically, First Nation women were found to have significantly higher incidence of cervical cancer[7] and poorer survival[8] compared to non-First Nation women in Ontario. Continued efforts to provide education and increase access to cervical screening as well as appropriate and timely follow-up of abnormal tests and human papillomavirus (HPV) vaccination are required to further reduce the burden of cervical cancer in First Nation women.

First Nation women living on reserve had lower uptake of mammography than their non-Aboriginal counterparts. Studies have also shown that First Nation women have poorer survival from breast cancer than non-First Nation women, possibly explained by later stage at diagnosis.[8,35] Innovative solutions are required to improve access to breast cancer screening on reserve due to the complexity of mammography delivery, which requires sophisticated equipment and certified operators.

Colorectal cancer screening estimates are not available for First Nations living on reserve from the RHS. One study found that less than half of age-eligible First Nation adults living off reserve are up-to-date with colorectal screening tests (42%).[12] Furthermore, studies suggest the incidence of colorectal cancer is increasing more rapidly among First Nation men and women, and survival from colorectal cancer is poorer compared to the non–First Nation population of Ontario.[7,8]

Strengths and limitations

This study presents a unique collaboration between two organizations, Cancer Care Ontario and the Chiefs of Ontario, with special access to restricted survey data that has enabled measurement and comparison of cancer risk for First Nations living on and off reserve compared to non-Aboriginal Ontarians adjusting for differences in age of the populations. Combining multiple years of data from the CCHS provided a large enough sample size for estimating risk in the off-reserve First Nation population.

There are several limitations to address. Since both of these health surveys collect information through self-report, there may be a risk of social desirability bias, whereby survey respondents tend to underreport behaviours that are socially undesirable (e.g. smoking, drinking alcohol) and overreport behaviours that are considered desirable (e.g. alcohol avoidance, fruit and vegetable consumption, physical activity). It is unlikely that there would be a major difference in this effect across cultural groups, and therefore this would minimally affect the relative prevalence of any given risk factor.

Due to the nature of the questions and response categories in the RHS, some indicators deviated from the standard method of analysis and are therefore not directly comparable to other studies. These include vegetable and fruit consumption, which is typically measured as consuming vegetables and fruit five or more times per day (in any combination, and excluding potatoes) as per the cancer prevention guidelines;[9] excess alcohol intake, which is typically measured as intake exceeding cancer prevention guidelines (that is, no more than one drink a day for women or two drinks a day for men[9]); breast cancer screening, which typically excludes women who had a mammogram for reasons other than screening and is measured according to the recommended breast screening interval of every two years for women at average risk; and cervical screening, which typically excludes women who have had a hysterectomy. Recommendations for more comparable questions have been made to RHS survey administrators, who will work to continue to improve the survey in future releases.

There was a lack of information on distal factors (e.g. issues in access to health services, social capital) available for this study. This limits our ability to explain some of the observed high-risk behaviours (such as frequency of binge drinking and poor intake of vegetables and fruit), and warrants further investigation. We did not adjust the estimates for differences in socioeconomic status between populations. In another recently published study of cancer risk factors and screening among First Nations living off reserve and Métis in Ontario, investigators found very little change in prevalence in the Aboriginal population compared with the non-Aboriginal population after adjusting for income, education and rural/urban status.[12] We performed chi-square tests as a statistical test for differences in proportions between First Nations and non-Aboriginal Ontarians; however, these tests are influenced by large sample sizes. The point estimates and confidence intervals presented in this study primarily demonstrate the important differences between groups.

Conclusion

These results demonstrate that actions to improve the health of First Nations in Ontario (whether on or off reserve) are needed to reduce their future burden of cancer and other chronic diseases. There may be many social factors that determine whether an individual lives on or off reserve that should be considered when designing and implementing prevention policies and programs. The interaction between these factors, including distal (e.g. colonialism, social exclusion), intermediate (e.g. lack of community infrastructure, limited resources) and proximal (e.g. health behaviours, poverty, lower educational achievement, unemployment),[36] and their influence on lifestyle choices among First Nations are complex and understudied. In one report, culturally appropriate, evidence-based health policy recommendations for avoiding tobacco and alcohol, eating a healthy diet and being physically active were documented for First Nations, Inuit and Métis populations in Ontario through knowledge and experience shared by communities, organizations and individuals in a series of focus groups and interviews.[34] Further research of this kind is needed to inform the success of prevention initiatives. Implementation of policies and programs aimed at reducing the risk and burden of chronic disease in First Nations will require the support and participation of government and communities, and the collaboration of a wide range of organizations.

Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions

MM, AY, CJ, LM were involved in the design and/or conceptualization of the work. All authors were involved in acquisition, analysis or interpretation of the data and drafting and/or revising the paper. All authors have read and approved the final manuscript.

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Estimating how extra calories from alcohol consumption are likely an overlooked contributor to youth obesity

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This article has been peer reviewed.

Abstract

Introduction: Youth obesity rates in Canada continue to rise. In this study, we produced conservative estimates of the potential excess calories from alcohol use across different alcohol consumption patterns common among Canadian youth to assess whether alcohol use should be considered in future obesity prevention strategies.

Methods: Using data from 10 144 Grade 12 students participating in the COMPASS study (2013/14), we estimated the number of calories consumed per year from alcohol consumption. Our estimates were based on three different generic types of alcoholic beverages, which were grouped according to average calorie content (vodka coolers; beer [5%]; and beer [4%], wine and liquor) across different frequencies of alcohol use and binge drinking.

Results: Results indicated high potential caloric intake for students who binge drank, as well as high variability in the estimates for calories consumed based on common consumption patterns for the different beverage types. For instance, 27.2% of students binge drank once per month, meaning they consumed between 6000 and 13 200 calories in one year (equivalent to 0.78 – 1.71 kg of fat). For the 4.9% of students who binge drank twice per week, the total calories in one year would range from 52 000 to 114 400 (equivalent to 6.74 – 14.83 kg of fat).

Conclusion: Current recommendations for preventing youth obesity do not generally include any consideration of alcohol use. The high prevalence of frequent alcohol consumption and binge drinking by youth in this study and the substantial number of calories contained in alcoholic beverages suggest alcohol use among youth may warrant consideration in relation to youth obesity prevention.

Keywords: *alcohol use, binge drinking, prevention strategies, weight gain, obesity, extra calories, energy intake, youth*

Highlights

- Youth obesity is a public health concern. Current guidelines on obesity prevention focus on food and sugar-sweetened beverage consumption, but may overlook the potential impact of calories from alcoholic beverages.
- Frequent and heavy alcohol use is common among youth in Canada. Calories from alcohol lack nutritional value and tend to be additive to the diet.
- This study provides conservative estimates of calories consumed from alcohol based on observed drinking patterns among Grade 12 youth in Ontario and Alberta.
- A high prevalence of frequent alcohol consumption and binge drinking by youth corresponds to a substantial number of calories consumed over a one-year period.

Introduction

Excessive weight gain among youth is a public health problem, given the evidence that youth obesity is associated with a variety of immediate and long-term health effects including type 2 diabetes and heart disease.[1] Data from the 2009 to 2011 Canadian Health Measures Survey suggest that among Canadian youth aged 12 to 17 years, 29.6% of boys and 30.5% of girls were overweight or obese.[2] Considering that the prevalence of overweight and obesity among youth in Canada has increased dramatically in the past two decades,[3] a variety of prevention strategies and solutions have been developed to help stem this growing problem. These include both population-level[4,5] and clinical[6,7] approaches, generally focussed on achieving energy balance through increasing physical activity and improving diet.

In the domain of diet, the additional calories from sugar-sweetened beverage (SSB) consumption (e.g. fruit drinks or soft drinks) has recently received considerably more attention given their association with youth obesity.[8] In fact, a 2016 report by the Canadian Standing Senate Committee on Social Affairs, Science and Technology, *Obesity in Canada: A Whole-of-Society Approach for a Healthier Canada,* recommends the federal government consider a tax on SSBs.[9] However, while stakeholders work to develop strategies to stem SSB consumption in youth populations, little attention has been given to the potential impact of excess calories from alcoholic beverage consumption. Some evidence does exist highlighting an association between alcohol consumption and weight gain or obesity risk among youth,[10-13] especially among females.[12-13] Not only can alcohol represent a potentially significant source of calories (7.1 kcal/g) with limited to no nutritional value, but alcohol tends to be additive to caloric intake.[14-15] Alcohol

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intake can also act as an indirect risk factor for obesity through modified diet, such as increased food intake after alcohol consumption[15] and associations with disordered eating such as binge eating.[16]

The discussion around alcohol use and weight gain has generally been focussed on adult populations, and in fact little research is available on the link between alcohol use and weight gain or obesity in youth. High rates of frequent and heavy alcohol use are common among Canadian youth, with one 2011 study finding 25.5% of Grade 9 to Grade 12 students were considered current binge drinkers.[17] In addition, there is evidence that younger age of peak alcohol consumption is associated with both heavier drinking and obesity into adulthood.[18] Youth should therefore be considered a potential at-risk population when considering this link.

The COMPASS (Cohort Study of Obesity, Marijuana Use, Physical Activity, Alcohol Use, Smoking and Sedentary Behaviours) host study is a cohort study of secondary school students in Ontario and Alberta with the aim of measuring the impact of policy decisions on student health behaviours.[19] As part of this study, an annual student survey includes measures of drinking and binge drinking frequencies. Our study uses secondary data from the COMPASS study to produce conservative estimates of the potential total calories from alcohol use across different alcohol consumption patterns common among youth within the study. Considering there is ample literature discussing the problems associated with binge drinking during adolescence, the focus of this paper is not to make additional claims on the health risks of drinking, but rather to highlight the potential issue of additional calorie intake from alcohol consumption.

Methods

Design

This study uses secondary cross-sectional data from Year 2 (2013/14) of the COMPASS host study.[19] Year 2 data were used because the first year of study consisted of a smaller sample of schools, and as such Year 2 comprised a larger sample of Grade 12 students. The data were collected using the COMPASS Student Questionnaire and active-information passive-consent procedures. All procedures were approved by the University of Waterloo's Office of Research Ethics and participating school boards. A full description of the study methods is available in print[19] or online (www.compass.uwaterloo.ca).

Measurements

This study is based on secondary data obtained from the student questionnaire. The COMPASS student-level questionnaire collects individual student data pertaining to multiple behavioural domains (e.g. alcohol use, tobacco use, obesity, physical activity, eating behaviour, etc.), correlates of these behaviours and demographic characteristics. In each school, the questionnaire was used to collect whole-school samples during class time. The questionnaire items were based on national standards or current national public health guidelines as described elsewhere.[19]

Participants

In Year 2, 89 schools in Ontario (n = 79) and Alberta (n = 10) that approved the use of active-information passive-consent parental permission protocols were recruited to participate in COMPASS. Students could decline to participate at any time. The overall completion rate was 78.2% of enrolled students; the primary reason for nonparticipation was absenteeism at the time of the data collection. For the purpose of this paper, we used the Year 2 data from 10 144 students (4927 females, 5217 males) in Grade 12; previous research has demonstrated that the Grade 12 respondents (typically aged 16 to 18 years) have the highest rates of alcohol use.[17] Consistent with COMPASS data collection protocols, these students completed the COMPASS student questionnaire in class time on the day of their schools' scheduled data collection.

Measures

The two alcohol-consumption questions (on drinking frequency and binge drinking frequency) on the questionnaire are taken from existing national surveillance tools for youth populations in Canada.[20] The questionnaire defined one drink as "1 regular sized bottle, can or draft of beer, 1 glass of wine; 1 bottle of cooler; 1 shot of liquor; or 1 mixed drink" consistent with the standard serving sizes defined by the Canadian Centre on Substance Abuse (CCSA).[21]

Frequency of alcohol use

Drinking frequency was assessed by asking the question "In the last 12 months, how often did you have a drink of alcohol that was more than just a sip?" The response options were: "I have never drunk alcohol"; "I did not have a drink of alcohol in the last 12 months"; "I have only had a sip of alcohol"; "Less than once a month"; "Once a month"; "2 or 3 times a month"; "Once a week"; "2 or 3 times a

TABLE 1
Drinking and binge drinking frequencies by sex among Grade 12 students in Year 2 (2013/14) of the COMPASS Study, Ontario and Alberta, Canada

	Total		Males		Females	
	(n)	%	(n)	%	(n)	%
Drinking						
Did not drink	2408	24.3	1222	24.1	1186	24.4
Less than once per month	2193	22.2	932	18.5	1261	25.9
1–3 times per month	3467	34.9	1704	33.6	1763	36.2
1–3 times per week	1564	15.7	973	19.2	591	12.1
4+ times per week	301	3.0	235	4.6	66	1.4
Total	**9933**	**100.1[a]**	**5066**	**100.0**	**4867**	**100.0**
Binge drinking						
Did not binge drink	3900	39.2	1860	36.7	2040	41.9
Less than once per month	2205	22.2	1020	20.1	1185	24.4
1–3 times per month	2699	27.2	1412	27.8	1287	26.5
1 time per week	649	6.5	421	8.3	228	4.7
2+ times per week	484	4.9	360	7.1	124	2.5
Total	**9937**	**100.0**	**5073**	**100.0**	**4864**	**100.0**

[a] Total does not add up to 100.0 due to rounding.

week"; "4 to 6 times a week"; and "Every day." Response categories were combined to create five different frequencies of alcohol use: "Did not drink"; "Less than once per month"; "1 to 3 times per month"; "1 to 3 times per week"; and "4 or more times per week." The response rate for this question was 97.92%; students who did not respond to the question were excluded from the analyses.

Frequency of binge drinking

The binge drinking frequency measure provides additional insight into consumption levels by establishing a minimum threshold of five drinks per occasion. Respondents were asked "In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?" The response options were "I have never done this"; "I did not have 5 or more drinks on one occasion in the last 12 months"; "Less than once a month"; "Once a month"; "2 to 3 times a month"; "Once a week"; and "2 to 5 times a week", or "Daily or almost daily." Response categories were combined to create five different frequencies of binge drinking: "Did not binge drink"; "Less than once per month"; "1 to 3 times per month"; "1 time per week"; and "2 or more times per week." The response rate for this question was 97.96%; students who did not respond to the question were excluded from the analyses. While the available questionnaire measure for binge drinking does not align with the low-risk drinking guideline for binge drinking among females (four or more drinks on one occasion),[21] the questionnaire measure is consistent with national youth surveillance measures[20] and provides a more conservative estimate of binge drinking among females.

Analyses

We calculated drinking and binge drinking frequencies by sex, and used chi-square tests to examine differences in drinking patterns by sex. We obtained the calorie content of various types of alcohol from Health Canada's Canadian Nutrient File (CNF)[22] and scaled for standard drink sizes using standard drink definitions from the CCSA.[21] The CNF database identifies 12 alcoholic beverages and corresponding calorie counts. We scaled calorie counts to standard drink sizes using the CCSA definitions: one serving is equal to one bottle of beer or cooler (341 ml [12 oz.]), one shot of liquor (43 ml [1.5 oz.]), or one glass of wine (142 ml [5 oz.]). Using the CNF list, we grouped drinks by approximate number of calories per standard serving to identify three representative drink classes of high, medium and low calorie content. Vodka coolers have a high calorie content, at 220 calories per standard serving. Regular beer (5% alcohol by volume) has a moderate calorie content, at 140 calories per standard serving. Light beer (4% alcohol by volume), table wines (red and white) and liquor shots (including gin, rum, vodka and whiskey) all contain approximately 100 calories per standard serving. We estimated the number of calories students consumed from alcohol for different generic types of alcoholic beverages according to average calorie content [vodka cooler; beer (5%); and beer (4%), wine and liquor], and for the five categories each for frequency of alcohol use and frequency of binge drinking. We converted the estimated total calories consumed over a one-year period to equivalent kilograms using the formula 7716 calories equal one kilogram.[23] We used SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) for all statistical analyses. A significance level of $p < .05$ was used in all statistical tests.

Results

Drinking and binge drinking frequencies among the students in Year 2 are presented by sex in Table 1. Overall, 53.6% of students reported drinking alcohol at least once per month, while 18.7% reported drinking at least once per week. Although the prevalence of nondrinking was similar among males and females (24.1% and 24.4% respectively, $p = .774$), chi-square (χ^2) tests showed significantly different drinking patterns by sex ($\chi^2 = 235.19$, degrees of freedom [df] = 4, $p < .001$), with males drinking more frequently than females. Overall, 38.6% of students reported binge drinking at least once per month, while 11.4% reported binge drinking at least once per week. Chi-square tests showed significantly different binge drinking patterns by sex ($\chi^2 = 194.60$, df = 4, $p < .001$), with males binge drinking more frequently

TABLE 2
Additional calories students consumed by drinking and binge drinking over a one-year period, by beverage type and consumption frequency among Grade 12 students in Year 2 (2013/14) of the COMPASS Study, Ontario and Alberta, Canada

	% of students	Beverage type	Calories consumed	Equivalent kilograms of fat from alcohol calories
Drinking frequency				
Once per month	34.9	Vodka cooler	2 640	0.34
		Beer (5%)	1 680	0.22
		Beer (4%), wine, liquor	1 200	0.16
Once per week	15.7	Vodka cooler	11 440	1.48
		Beer (5%)	7 280	0.94
		Beer (4%), wine, liquor	5 200	0.67
Four times per week	3.0	Vodka cooler	45 760	5.93
		Beer (5%)	29 120	3.77
		Beer (4%), wine, liquor	20 800	2.70
Binge drinking frequency				
Once per month	27.2	Vodka cooler	13 200	1.71
		Beer (5%)	8 400	1.09
		Beer (4%), wine, liquor	6 000	0.78
Once per week	6.5	Vodka cooler	57 200	7.41
		Beer (5%)	36 400	4.72
		Beer (4%), wine, liquor	26 000	3.37
Twice per week	4.9	Vodka cooler	114 400	14.83
		Beer (5%)	72 800	9.43
		Beer (4%), wine, liquor	52 000	6.74

than females. Males were more than twice as likely as females to binge drink at least once per week (15.4% and 7.2%, respectively), and nearly three times as likely as females to binge drink two or more times per week (7.1% and 2.5%, respectively).

Calorie consumption estimates

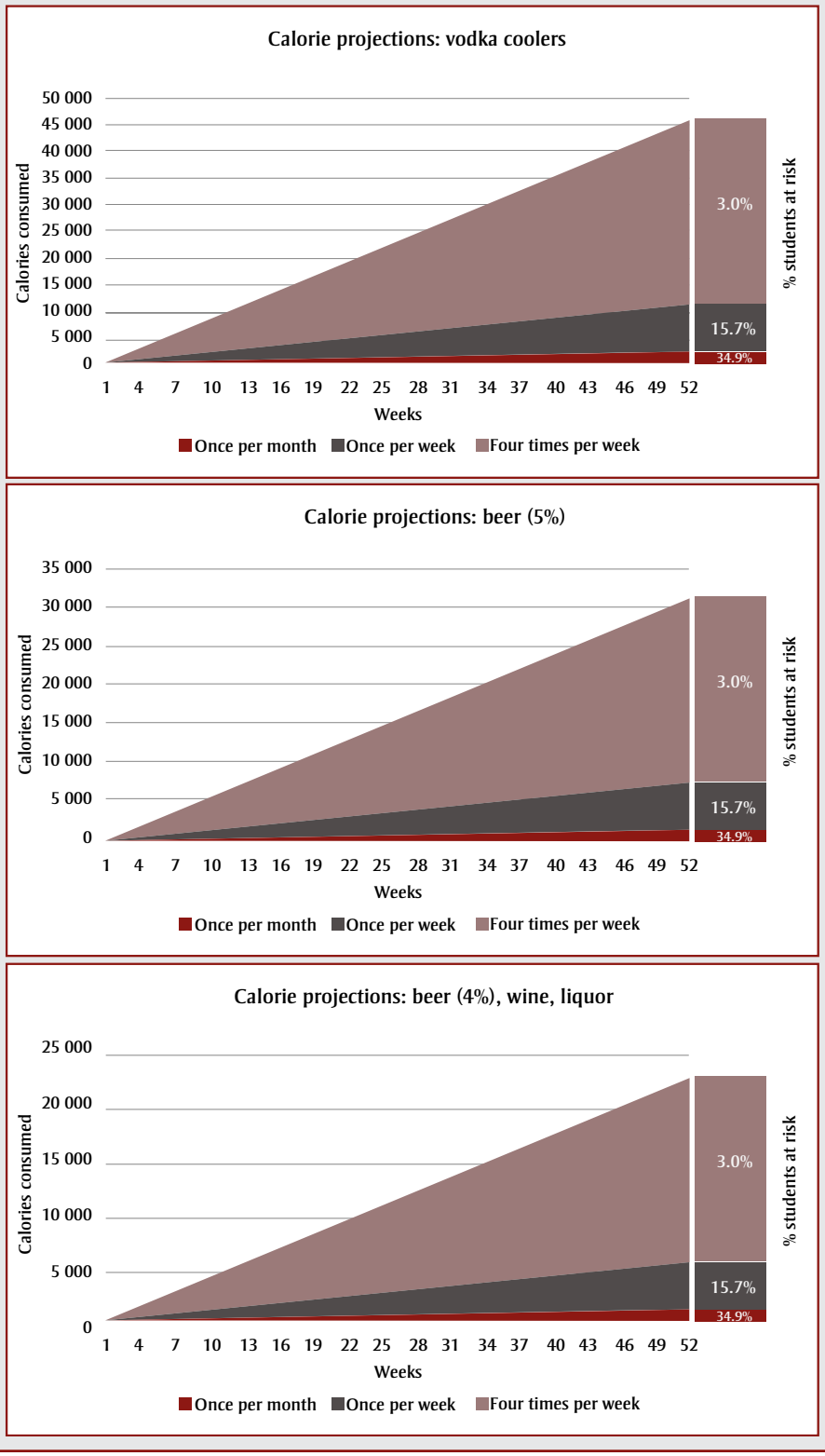
Table 2 presents estimates for the total calories consumed over a one-year period by students who reported drinking at least once a month, by alcohol consumption frequency and beverage type. The results show high variability in the total calories consumed across the different beverage types and consumption frequencies. For instance, among the 15.7% of students who drank once per week, if we assume they only consumed one drink per occasion, they would have consumed between 5200 and 11 440 calories in one year (equivalent to 0.67 – 1.48 kg of fat). Among the 3.0% of students (4.6% of males, 1.4% of females) who drank four times per week, the total calories in one year would range from 20 800 to 45 760 (equivalent to 2.70 – 5.93 kg of fat). Figure 1 shows the calorie estimates, assuming one drink per occasion by beverage type and the percentage of students who fall into each estimation range.

Among the 27.2% of students who binge drank once per month, if we assume they only consumed five drinks per binge drinking occasion, they would have consumed between 6000 and 13 200 calories in a one-year period (equivalent to 0.78 – 1.71 kg of fat; Table 2). Among the 4.9% of students (7.1% of males, 2.5% of females) who binge drank twice per week, the total calories in one year would range from 52 000 to 114 400 (equivalent to 6.74 – 14.83 kg of fat). Figure 2 shows the calorie estimates assuming five drinks per binge drinking occasion, by beverage type, and the percentage of students who fall into each estimation range.

Discussion

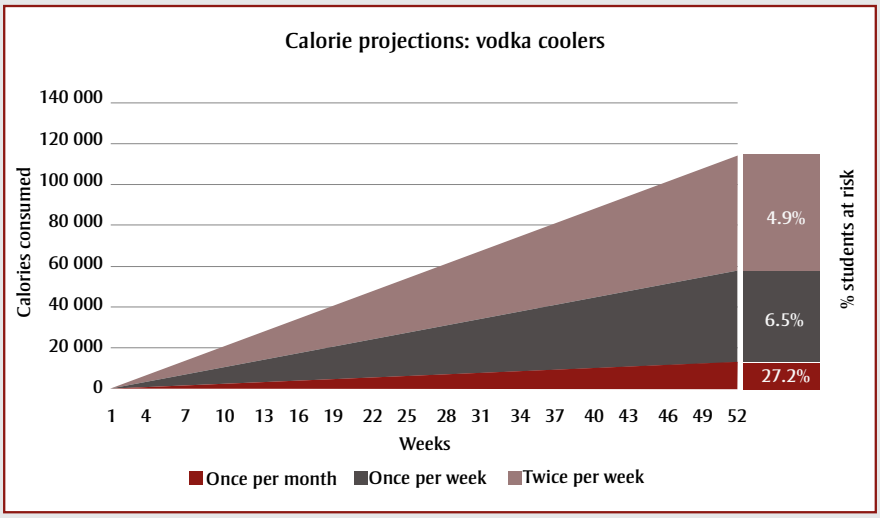
Youth obesity is a complex public health issue, particularly since obesity in adolescence can lead to adverse health consequences in adulthood.[24] Obesity risk in youth is influenced by a variety of factors, including individual lifestyle factors such as food intake and physical activity.[6,11] While alcohol use is only one component of the issue, modifiable risk factors are often interrelated,[25] and these interrelationships should be recognized when developing public health interventions.[26] Current recommendations for preventing youth obesity do not generally include any considerations pertaining to alcohol use.[4-7,9] For instance, even in the recent Senate report on obesity in Canada,[9] none of the 21 prevention recommendations designed to address

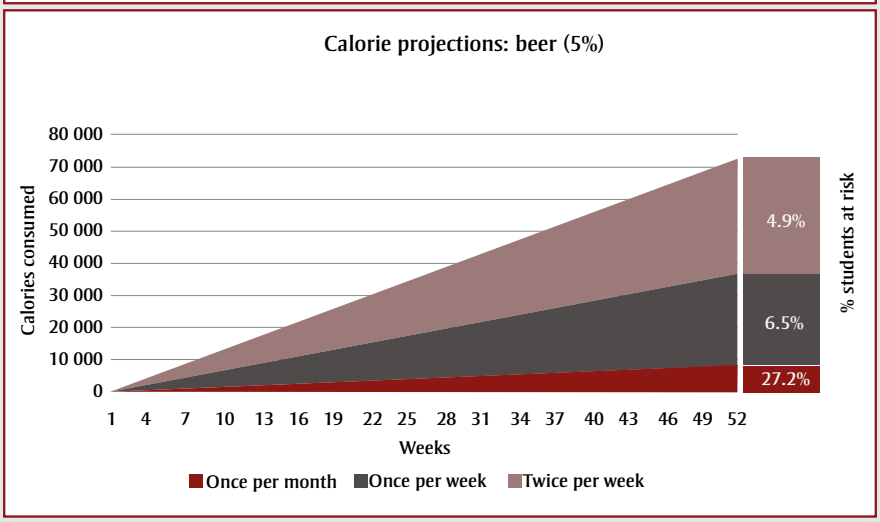
FIGURE 1
Projections for additional calories consumed by students for one drink per occasion over a one-year period, by beverage type among Grade 12 students in Year 2 (2013/14) of the COMPASS Study, Ontario and Alberta, Canada

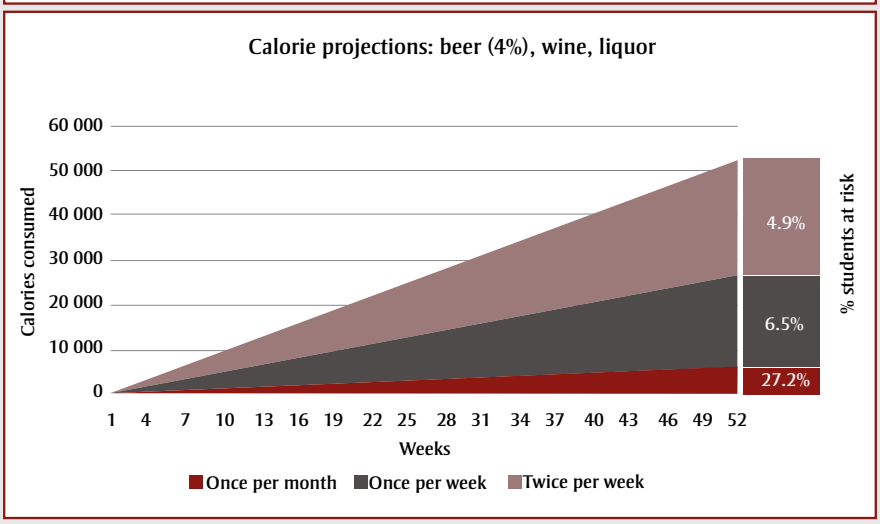


youth obesity in Canada mentioned or considered the potential role of alcohol use. In our study, the majority of youth in our sample reported consuming alcohol and our estimates clearly show that even moderate levels of alcohol consumption can contribute to substantial caloric intake over the course of a year. Among the highest-risk students who report consuming a larger volume of alcohol on a frequent basis (more than 1 in 10 students in our sample), the volume of total calories from alcohol consumption is even more concerning. We believe that the evidence presented here indicates that alcohol use is a potentially meaningful contributor to youth overweight and obesity, and warrants consideration when developing obesity prevention strategies.

FIGURE 2
Projections for additional calories consumed for five drinks per occasion over a one-year period by beverage type, among Grade 12 students in Year 2 (2013/14) of the COMPASS Study, Ontario and Alberta, Canada







Strengths and limitations

In this paper, we are the first to provide very conservative estimates of the potential calories consumed per drinking occasion based on estimates of students consuming either one drink or five drinks per drinking occasion from a large sample of Canadian youth. However, data from the 2015 Ontario Student Drug Use and Health Survey (OSDUHS) suggests that youth drinkers typically report drinking two or more drinks per drinking occasion rather than one.[27] There is also emerging evidence to suggest that youth binge drinking episodes often involve 10 to 15 drinks per occasion rather than five.[28] Despite the fact that we are presenting very conservative estimates, our projections for total calories consumed from alcohol are still quite high across a variety of drinking patterns that are common among Canadian youth.[17,29]

These data are subject to limitations. While the type of drink can be an important factor in total estimated calories, no information was available on the type of drinks typically consumed by students in the sample. Calorie information on mixed drinks was not included in the analysis, given the variability in types of mixes and proportions, so our estimates did not include the additional calories that would also be consumed from the added mix (i.e. soft drinks or juice). Many common cocktails can contain up to 490 calories per drink,[30] which further suggests that our estimates are very conservative. The estimates given were also based on standard drink sizes. There is the potential for underestimation of total calories consumed if drinks are made larger than the standard size. For example, one pint of regular beer may be viewed as a single drink by respondents despite being the equivalent of 1.66 standard drinks. Additional information on the types of drinks commonly consumed would allow for more accurate estimation of calorie intake.

These results are based on a secondary data analysis from a sample that is not nationally representative. Thus, the drinking patterns identified here may not be representative of all Canadian youth. Furthermore, due to the secondary nature of the analysis, the available measures to assess drinking and binge drinking frequency do not allow for specific measurements of alcohol intake. Additional information is needed on the number of drinks typically consumed per occasion, along with more exact frequencies of the number of drinking and binge drinking occasions.

There are numerous health risks associated with binge drinking during adolescence.[31] While this study focussed on the potential additional caloric intake from alcohol consumption, there are many other negative immediate and long-term consequences of underage drinking that warrant consideration in public health interventions and education initiatives.

Conclusion

Despite the limitations discussed, this analysis has highlighted the need for researchers and stakeholders to consider alcohol more closely as a modifiable risk factor for overweight and obesity among youth. The high prevalence of frequent alcohol consumption and binge drinking by youth in this study, and the substantial number of calories contained in alcoholic beverages, suggest alcohol may be a key component of the obesity discussion that should not be overlooked.

Acknowledgements

The COMPASS study was supported by a bridge grant from the Canadian Institutes of Health Research (CIHR) Institute of Nutrition, Metabolism and Diabetes (INMD) through the "Obesity—Interventions to Prevent or Treat" priority funding awards (OOP-110788; grant awarded to S. T. Leatherdale) and an operating grant from the CIHR Institute of Population and Public Health (IPPH) (MOP-114875; grant awarded to S. T. Leatherdale). Dr. Leatherdale is a Chair in Applied Public Health funded by the Public Health Agency of Canada (PHAC) in partnership with the CIHR Institute of Neurosciences, Mental Health and Addiction (INMHA) and IPPH.

Conflicts of interest

The authors state that they have no competing interests in this work.

Authors' contributions

KB performed the analyses, interpreted the results, wrote the first draft of the introduction and methods, and worked on drafting sections of the discussion for this manuscript. SL conceived the manuscript idea, led the COMPASS host study, wrote sections of the discussion, and edited all portions of the manuscript.

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Letter to the Editor

The professionalization of health promotion in Canada: a student perspective

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To the editor:

In a recent edition of *Health Promotion and Chronic Disease Prevention in Canada*, JR Graham[1] suggested that professionalizing health promotion could "narrow its agenda," negatively impacting its influence within public health practice. However, our current public health practice landscape could be broadened with the inclusion of health promotion initiatives. This letter argues that, from an undergraduate student perspective, contributions to the professionalization of health promotion are critically important to defend and sustain its central role within public health practice.

I am currently a health promotion intern, completing the final requirement of my undergraduate degree in health promotion at Dalhousie University. Degrees in health promotion are typically offered at the master's level; Dalhousie offers the only Canadian undergraduate program. The comprehensive curriculum allows students to explore topics such as mental health, sexual health and comprehensive school health, while developing skills in health promotion theories, policymaking and research. Professional experience is acquired through an internship in which students partner with organizations that serve diverse populations to collaborate on health promoting initiatives. As a result, graduates are prepared to excel in a broad range of sectors such as education, government, health care, business and research, or to pursue further studies in fields like nursing, occupational therapy and epidemiology. Although health promotion is often practised within these sectors, it has distinct objectives. Health promotion looks at health beyond the "absence of disease," and explores ways to address health equity in public policy and community development,[2] a perspective that is still not fully integrated in some professions.

With this degree, I will be able to pursue further studies and employment across a broad range of sectors including public health. Unfortunately, much of the public health workforce is unclear about the field of health promotion, including the scope of practice, and how it differs from standard public health practices. Fostering the professionalization of health promotion will allow for a clearer understanding of the field, and a professional space for health promoters to work collaboratively with a greater focus placed on the social and ecological determinants of health.[3]

I argue that advancements toward the professionalization of health promotion, such as the competency work critiqued by Graham,[1] contribute to the legitimization of the field. They may increase awareness among public health practitioners and the general population about the added value of health promotion approaches. With this increased awareness, health promoters may have a professional space to unite, communicate and collaborate. The professionalization of health promotion might not reduce it solely to a profession; instead, it will sustain the field while providing guidance and expertise to benefit others. Health promotion as a profession will allow developing health promoters like myself to dedicate our time, resources and skills to incorporating health promotion initiatives into the public health agenda.

Highlights

- Health promotion as a profession is not limited to those who work in health care, but provides opportunities to those in a variety of sectors.
- Health promotion, although connected to public health, is distinct, and its professionalization provides an opportunity to enhance public health practice.
- Providing a professional space for health promoters to unite, communicate and collaborate using the health promotion competencies will sustain the field.

Because health promotion can be practised within a variety of sectors, it often acts as an umbrella under which public health falls.[4] Although health promotion is recognized as an emerging profession, graduates often find that current public health institutions do not embrace their full skill set. Designating health promotion as a profession might contribute to further differentiating it from standard public health practice and promoting new employment opportunities for health promotion specialists. Health promotion work is often hidden behind public health practice.[4] Yet, I argue that health promotion has the potential to further the work of public health if both disciplines collaborate.

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Release notice

Healthy Behaviour Data Challenge

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The Public Health Agency of Canada, the Canadian Institutes of Health Research, and MaRS Discovery District have announced the launch of the Healthy Behaviour Data Challenge.

This Data Challenge responds to the call for new ways to address the limitations of self-reported health surveillance information and tap into the potential of innovative data sources (e.g. wearables, geographic information systems) and alternative methodologies for public health surveillance. Specifically, this Data Challenge is looking for innovators to propose and test creative new ways of sourcing data that can be used to measure indicators of physical activity, sleep or sedentary behaviour.

The creative ideas emerging from this Data Challenge will enhance public health surveillance to advance healthy behaviours among Canadians.

For more information and to apply, visit Healthy Behaviour Data Challenge. Applications are being accepted until 11:59 p.m. EDT, August 4, 2017.

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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 2017:

Foster WG, Evans JA, Little J, […] **León JA, Luo W.** Human exposure to environmental contaminants and congenital anomalies: a critical review. Crit Rev Toxicol. 2017;47(1):59-84. doi: 10.1080/10408444.2016.1211090.

Liu S, Metcalfe A, **León JA**, Sauve R, Kramer MS, Joseph KS. Evaluation of the INTERGROWTH-21st project newborn standard for use in Canada. PLOS ONE. 2017;12(3). doi: 10.1371/journal.pone.0172910.

Thombs BD, **Garcia AJ, Reid D**, Pottie K, Parkin P, **Morissette K**, et al. Recommendations on behavioural interventions for the prevention and treatment of cigarette smoking among school-aged children and youth. CMAJ. 2017;189(8):E310-E316. doi: 10.1503/cmaj.161242.

Trecker MA, Dillon J-R, Lloyd K, Hennink M, **Jolly A**, Waldner C. Can social network analysis help address the high rates of bacterial sexually transmitted infections in Saskatchewan? Sex Transm Dis. 2017. doi: 10.1097/OLQ.0000000000000599.

Wilson SE, Quach S, MacDonald SE, […] **Desai S**. Immunization information systems in Canada: attributes, functionality, strengths and challenges. A Canadian immunization research network study. Can J Public Health. 2017;107(6):e575-e582. doi: 10.17269/cjph.107.5679.