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Seeing the food swamp for the weeds: Moving beyond food retail mix in evaluating young people's food environments

Jennifer Ann Brown [a,1], Alexa R. Ferdinands [a,1], Rachel Prowse [a], Darcy Reynard [b], Kim D. Raine [a], Candace I.J. Nykiforuk [a,*]

[a] School of Public Health, University of Alberta, Edmonton, Alberta, Canada
[b] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada

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ABSTRACT

Nutritional health of children and youth is an increasing cause for concern in Canada. Through food and beverage messaging in multiple environments, young people develop eating behaviours with ramifications throughout their life course. Unhealthy food retailers near schools, recreation facilities, and childcare centres—key activity settings for healthy eating promotion—present repeated, compounding exposures to commercial geomarketing. Geomarketing impacts nutritional health by promoting highly processed, calorie-dense, and nutrient-poor foods and beverages across urban landscapes. While food retail mix (as a ratio of healthy to unhealthy food retailers) can be used to assess food environments at multiple scales, such measures may misrepresent young people's unique experience of these geographic phenomena. Moving beyond uniform conceptualization of food environments, new research methods and tools are needed for children and youth.

We investigated young people's food environments in the major Canadian cities of Calgary and Edmonton. Using government-initiated nutrition guidelines, we categorized 55.8% of all food retailers in Calgary, and 59.9% in Edmonton as 'unhealthy'. A Bernoulli trial at the 0.05 alpha level indicated few differences in prevalence proximal to activity settings versus elsewhere in both cities, demonstrating the limited applicability of food retail mix for characterizing young people's food environments. To model unhealthy food retailers geomarketing to children and youth, we considered their proximity to multiple activity settings, using overlapping radial buffers at the 250 m, 500 m, 1000 m, and 1500 m scales. Examining young people's food environments relative to the spaces where they learn and play, we determined that as many as 895 out of 2663 unhealthy food retailers fell within 1500 m of 21+ activity settings. By conceptualizing, measuring, and problematizing these "super-proximal" unhealthy food retailers, urban planners and public health researchers can use these techniques to pinpoint unhealthy food retailers, or "weeds in the food swamp," as a critical site for healthy eating promotion in municipalities.

1. Introduction

1.1. The current state of nutritional health among Canadian children and youth

The poor nutritional quality of foods and beverages consumed by children and youth is cause for concern in Canada. Comparisons between the 2004 and 2015 Canadian Community Health Surveys suggest modest gains in young Canadians' diets (e.g., marginally greater vegetable, fruit, and whole grain intake), but there is substantial room for improvement (Tugault-Lafleur & Black, 2019; Tugault-Lafleur et al., 2019). Energy dense, nutrient-poor, processed foods comprise more than half of young people's total daily energy intake in Canada (Moubarac, 2017).

Diet-related health conditions are highly prevalent among young people in Canada (Roberts et al., 2012), with approximately one in four

* Corresponding author. Centre for Healthy Communities, School of Public Health, University of Alberta 3-291 Edmonton Clinic Health Academy, 11405-87 Avenue NW, Edmonton, Alberta, T6G 1C9, Canada.
E-mail addresses: jennifer.ann.brown@ualberta.ca (J.A. Brown), aferdina@ualberta.ca (A.R. Ferdinands), prowse@ualberta.ca (R. Prowse), reynard@ualberta.ca (D. Reynard), kim.raine@ualberta.ca (K.D. Raine), candace.nykiforuk@ualberta.ca (C.I.J. Nykiforuk).
[1] Contributed equally as first authors.

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experiencing overweight or obesity (Statistics Canada, 2017a). Critically, dietary behaviors and food norms developed in early life can persist into adulthood (Venter & Harris, 2009), are often difficult to reverse (Scaglioni et al., 2018), and precede chronic disease onset (Forouzanfar et al., 2016). Chronic diseases like Type 2 diabetes, cardiovascular conditions, and cancer negatively impact both quality and length of life, and challenge health care system sustainability—warranting concerns about young people's nutritional health in Canada, and beyond (Health Canada, 2012; Standing Senate Committee, 2016; World Health Organization, 2016).

1.2. Food environment exposures and nutrition guideline interventions

Food environments are "collective physical, economic, policy and sociocultural surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status," (Swinburn et al., 2013, p. 2) and are a key *exposure* driving consumption of unhealthy foods and beverages among children and youth (Cummins & Macintyre, 2006; Swinburn et al., 2015). Glanz et al. (2005) proposed three categories, or *vectors*, for unhealthy food and beverage exposures; namely, *organizational environments* (home, school, work, and other institutions), *community environments* (food retailer type, location, and accessibility), and *consumer environments* (food and beverage availability, pricing, promotion, placement, and nutrition information). For young people, the concept of *organizational environments* can be reconsidered in terms of *activity settings* that support their development of daily routines, defined by King et al. (2013) as:

> … particular places in which they "do things", including active pursuits (doing artwork, visiting others, taking part in physical activities and doing chores) and more passive activities (reading and watching television) … encompassing both subjective experience and the objective perception of observable features and the prediction of common experiences (p.1578).

Outside of the home, the World Health Organization (2016) has identified schools, recreation facilities, and childcare centres as primary activity settings for healthy eating interventions targeting children and youth. Nutrition guidelines (food and beverage-based recommendations from health organizations) are important interventions in these settings—for meeting nutrient needs, promoting healthy options, fostering positive behaviours, and helping prevent chronic diseases (Government of Canada, 2019).

While schools, recreation facilities, and childcare settings work to implement nutrition guidelines within their institutions, the broader retail food environments surrounding these activity settings cannot be ignored. Traveling between home and their activity settings (often over distances necessitating the use of private vehicles or public transit) children and youth frequently encounter visual and other sensory messaging from commercial food producers, manufacturers, and marketers that have a financial stake in increasing retail consumption of high-margin, ultra-processed, convenience fast foods (Briefel et al., 2009; Swinburn et al., 2013; Taber et al., 2012); even young people's sports teams have become a site for advertising (Pauzé et al., 2020). As demonstrated in the major Canadian cities of Calgary and Edmonton, food retailers geographically visible and/or accessible to young people typically advertise and sell single-serving, calorie-dense, nutrient-poor snacks and meals "to-go," and are not "in the business" of promoting, or even meeting, nutrition guidelines (Benchmarking Food Environments, 2020).

A recent Cochrane review argued that proximity to tobacco, alcohol, and food retailers may have a *normalizing* influence, as:

> [e]xposure [can] increase the salience of, and the attention directed towards, products and elicit a 'mere exposure' effect – whereby repeated exposure to a product can elicit increased liking … implying a new social norm about which types of products are acceptable or commonplace, and this could influence selection and consumption (Hollands et al., 2019, p.7).

These exposures to unhealthy food environments may negatively impact young people's food practices and diets at a critical point in development, a time where they are formulating long-lasting mental maps of food environments to "make sense of the world" (Götz & Holmén, 2018, p. 160). Schools, recreation facilities, and childcare centres act as urban nodes geographically associated with overall household purchasing behaviours (Sadler et al., 2016; Sadler & Gilliland, 2015). Commonplace daily exposure to fast food dining rooms, drive-thrus, promotional signage, street-level advertising, and packaging materials marketed to children and youth normalize unhealthy foods and beverages—at the expense of healthy eating promotions. We argue that unhealthy food retailers present repeated, compounding exposures to these products and related messaging, as a form of locational geomarketing directly proximal to young people's activity settings. By "geomarketing," we refer to marketing that geographically, spatially, and/or temporally mediates retail supply and consumer demand, ensuring goods and services are featured and front-of-mind at the location, time, and place likeliest to influence purchasing decisions (Cliquet, 2006). Store displays and restaurant logos exploit similar techniques as marketing to young people through the media, using whimsical designs, colourful shapes, and cartoonish fonts and characters (Cairns et al., 2013; Elliott, 2012). Such repeated, compounding exposures, near the spaces where they learn and play, may be contributing to the overall poor diet quality of Canadian children and youth.

1.3. Social gradients and vectors of exposure for young people

Food environments are frequently evaluated by the healthfulness of their food retail mix (Minaker et al., 2011). As one key metric, the Centers for Disease Control and Prevention (2011) has developed the modified Retail Food Environment Index (mRFEI) of healthy to unhealthy food retailers, rating geographic areas on a scale of 0–100. Environments with an unhealthy food retail mix are frequently characterized as *food deserts* or *food swamps* (Minaker, 2016). *Food deserts* are areas where lower income (or otherwise marginalized) residents lack basic access to healthy food providers for an affordable, nutritious diet—especially fresh fruits, vegetables, whole grains, nuts, and legumes (United States Department of Agriculture, 2009). *Food swamps*, more common for the majority of urban settings in Canada, are communities where there is an oversaturation of unhealthy food retailers that *crowd out* more nutritious offerings (Minaker, 2016; Minaker et al., 2016; Rose et al., 2009). While ratio and proportion measures are widely used in the food environment literature, they are limited in their ability to discern the differences between food retailers (and the kinds of exposures they present) potentially misleading researchers toward an inaccurate reading of the healthfulness of food environments (Thornton et al., 2020).

There is general consensus that food environments pose steeper barriers to nutritional health for socioeconomically disadvantaged children and youth, with lower household incomes driving financial preferences for inexpensive, unhealthy foods and beverages (French et al., 2019; Senate of Canada, 2019). Some research indicates that frequency of exposure to unhealthy food retailers follows a social gradient—exacerbating income-driven preferences—with children attending lower socioeconomic status schools in Toronto, Canada encountering almost twice the density of fast food retailers daily (Ravensbergen et al., 2016). Although not a consistently observed phenomenon (and the mechanism is not yet clear) there may be a social gradient in which repeated exposure to geomarketing by unhealthy food retailers counteract nutrition guidelines implemented in activity settings, further exacerbating dietary inequities in Canada.

1.4. Research purpose

Nutrition guidelines for young people's development of positive food practices and diets have been implemented to varying extents in activity settings like schools, recreation facilities, and childcare centres. However, counteractive exposure to unhealthy food retailers in proximal retail food environments that place profits over health pose a challenge to successful nutrition guideline implementation. New empirical tools and methods are needed to evaluate this geographic phenomenon, providing more robust characterizations of food retailers in frequently accessed retail food environments for young people. Thus, the purpose of our research is five-fold:

1. Categorize the healthfulness of food retailers using criteria based on regional nutrition guidelines.
2. Assess the relative frequency of unhealthy food retailers in proximity to schools, recreation facilities, and childcare centres as activity settings for children and youth.
3. Quantify repeated, compounding exposure to unhealthy food retailers proximal to young people's activity settings.
4. Examine evidence for a social gradient comparing income levels of households with children and youth with repeated, compounding exposure to food retailer locations in proximity to multiple activity settings.
5. Characterize implications for urban planning and public health research to lessen negative impacts of geomarketing on young people's nutritional health.

Our research demonstrates how "seeing the food swamp for the weeds" (a play on "seeing the forest for the trees") can move healthy eating promotion beyond the food retail mix concept, revealing differing levels of exposure to unhealthy geomarketing near activity settings for young people.

2. Methods

2.1. Study area and population of interest

Our study area was comprised of Calgary and Edmonton, located 300 km apart in the most densely populated urban corridor of Alberta. As provincially incorporated municipalities, each city has considerable discretion over its food environments through land use planning, directed by the Calgary Food Action Plan in Calgary (City of Calgary, 2021) and City Environmental Strategies in Edmonton (City of Edmonton, 2021). As the two largest cities in the province, Calgary and Edmonton account for approximately 60% of the Alberta's population of 4.3 million people—about 2.7 million combined (Statistics Canada, 2018). The province has 274,112 children aged 4 years and younger (Statistics Canada, 2018), and 704,890 registered elementary, junior, and senior high school students (Government of Alberta, 2019). As such, we estimated more than 500,000 young people reside in Calgary and Edmonton, as our population-at-risk.

2.2. Data sources and geospatial processing

To support our objectives with geospatial and statistical analyses, a complete list of names and addresses was acquired across the following categories, in both cities:

- licensed food retailers (from the provincial food inspection agency);
- publicly-funded elementary, junior, and senior high schools (from schoolboard websites);
- public recreation facilities (from municipal recreation websites); and
- daycare and preschool childcare centres (from the provincial licensing database).

All locations were batch-geocoded in Google Earth as latitude and longitude, then manually matched to their building footprint (refining those coordinates) using combined satellite and *Street View* functions in the software. Geospatial data for Calgary and Edmonton (City of Calgary, 2019; City of Edmonton, 2019), and the most recent 2016 Canadian Census data (Statistics Canada, 2017b) were obtained at the dissemination area scale. Notably, dissemination areas are the smallest geographic units that publicly release census data, consisting of adjacent blocks with approximately 400–700 persons. For further analyses, all data were exported to QGIS, a specialized geographic information systems software (QGIS Development Team, 2019).

2.3. The Alberta Nutrition Guidelines for Children and Youth

For our first objective, we assessed healthfulness for each food retailer using the *Alberta Nutrition Guidelines for Children and Youth* (ANGCY), a government-initiated set of provincial nutrition guidelines targeting activity settings outside of the home – specifically defined as "childcare facilities, schools, [and] recreational facilities" (Government of Alberta, 2012, p. 1). Although ANGCY standards are voluntary, some activity settings mandate them across various food and beverage offerings, including menus, vending machines, and on-site food retailing (Benchmarking Food Environments, 2020). The ANGCY nutrient profiling system categorizes foods as "choose most often" (CMO), "choose sometimes" (CS), or "choose least often" (CLO), according to nutrient content. Foods categorized as CMO are nutrient-dense, including fresh or frozen fruits and vegetables, whole grains, low-fat dairy products, and lean meats. Foods categorized as CS are higher in sugar, fat, and salt but offer some nutrition benefits, like dried fruits, flavoured milks, and white breads. Finally, CLO foods are nutrient-poor, like baked goods, candies, sugary cereals, and deep-fried foods. The ANGCY advises different proportions of CMO, CS, and CLO foods and beverages dependent on activity settings, with more flexibility permitted to older children and youth. For example, only CMO foods and beverages are recommended in childcare centres, whereas a mix of 50% CMO and 50% CS items is permitted in high schools. CLO foods and beverages are not recommended for any activity setting in the ANGCY, except in small portions.

We extended ANGCY designations for foods and beverages to apply a simplified categorization schema to entire food retailer menus, based on our *Nutrition Guidelines Adapted Ranking for Retailers* (NutriGARR) classification system. Informed by the work of Minaker et al. (2009), the NutriGARR schema was developed by registered dietitians and public health researchers, and has been validated in recreation facilities (Prowse et al., 2018). Guided by British Columbia's Ministry of Education and Ministry of Health (2005) food classifications, Minaker et al. (2009) assessed food retailers on a postsecondary campus, ranking them from 1 (most healthy) to 8 (least healthy). Expanding on this ranking, Prowse et al. (2018) categorized food retailers ranked 1 or 2 as CMO; 3, 4, or 5 as CS; and 6, 7, or 8 as CLO, corresponding with the government-initiated ANGCY nutrition guidelines for Alberta. Additional food retailers outside the original ranking system (e.g., convenience stores) were incorporated into NutriGARR through consensus (Table 1).

We classified licensed food retailers in Calgary and Edmonton as CMO, CS, or CLO, according to the NutriGARR schema. As per analytical conventions established by the mRFEI (Centers for Disease Control and Prevention, 2011), sit-down restaurants, bars, nightclubs, and casinos were excluded. All duplicates were removed; other exclusions were provincially licensed premises not dedicated to food retailing (pharmacies, movie theatres, or department stores) and sites inaccessible to the general public (workplace cafeterias, hotels, or community associations) (Appendix A). A data set sample was double coded to assess inter-coder reliability using Lacy and Riffe's (1996) protocol, obtaining acceptable agreement Cohen's kappa values of 0.72 and higher.

Table 1
Nutrition Guidelines Adapted Ranking for Retailers (NutriGARR) classification of food retailers adapted according to the Alberta Nutrition Guidelines for Children and Youth (ANGCY) Choose Most Often (CMO), Choose Sometimes (CS), and Choose Least Often (CLO) Category System.

Type of Food Retailer	Original Ranking[a]	New Ranking
Sandwich	1	CMO
Smoothie	2	CMO
Grocery	–	CMO
Salad	–	CMO
Cafeteria	4	CS
Coffee	5	CS
Processed Food	–	CS
Convenience	–	CLO
Pizza	6	CLO
Asian Take-Out	7	CLO
Burger	8	CLO
Taco	–	CLO
Ice Cream	–	CLO
Bar, Lounge, or Brewery	–	CLO
Other Fried Food	–	CLO

[a] From Minaker et al., 2009

2.4. Multi-scale geospatial analyses

The geographic extent of young people's retail food environments in Calgary and Edmonton was calculated using a series of 250 m, 500 m, 1000 m, and 1500 m radial buffer distances around schools, recreation facilities, and childcare centres. Our multi-scale geospatial parameters were based on previous research reporting significant findings at some scales but not others (Engler-Stringer et al., 2014; Williams et al., 2014), as well as Minaker (2013) who used these four buffer distances for transparency, to facilitate comparison of outcomes at each of the different geographic scales, and to avoid biased reporting of results.

2.4.1. Assessing the relative frequency of unhealthy food retailers proximal to activity settings

For our second objective, we examined relative frequency of CLO food retailers located in proximity to activity settings at the 250 m, 500 m, 1000 m, and 1500 m buffer scales (compared to CLO food retailers located across either city) using binomial Bernoulli trials (Ghahramani, 2000). Statistically based on chi-squared testing, this test indicated whether randomly selected food retailers within activity setting buffers were more, equally, or less likely to be one of two outcomes (1) CLO, versus (2) CMO or CS when compared to those randomly selected outside the buffers. We provide total counts and percentage totals for CLO food retailers, with Bernoulli trial results reported for alpha $p < 0.05$ (Table 2).

2.4.2. Quantifying repeated, compounding exposure to unhealthy food retailers for young people

For our third objective, we generated a "compounded exposure" measure summarizing each CLO food retailer's proximity to multiple activity settings (i.e. its potential consumer market access from multiple nearby schools, recreation facilities, or childcare centres). This compounded exposure measure counted the instances that CLO food retailers fell within overlapping activity setting buffers geospatially overlaid at each scale. Employing this measure for further statistical analyses (see *Section 2.4.3* and Table 3), we have illustrated these results for Calgary and Edmonton at the 1500 m scale; data are displayed using the NAD83 10TM (Forest) projection (EPSG.io, 2018) (Fig. 1).

2.4.3. Examining evidence for a social gradient of exposure

For our fourth objective, we explored potential for a social gradient of exposure across Calgary and Edmonton, comparing compounded exposure measures assigned to all food retailers (and specifically CLO food retailers) at each scale with the median income levels of households with children and youth in dissemination areas where food retailers were located. Using 2016 Canadian Census data for *median after-tax income of households with children* (Statistics Canada, 2017b), we calculated z-scores ranking income levels of dissemination areas with food retailers in both cities combined $z = (x - \mu)/\sigma$; where x was the provided income level for each dissemination area, μ was the mean for all income levels, and σ was the standard deviation of all income levels. These z-scores were calculated to facilitate comparison and integration of this data with other socio-economic indicators in future research, supporting efforts to generate a more comprehensive social gradient index, as needed. We attributed dissemination area z-scores to food retailers, categorizing them into quintiles indicating lowest (1) to highest (5) incomes of households with children and youth. Using Analysis of Variance (ANOVA) and Fisher's Least Significant Difference (LSD) post-hoc testing at alpha $p < 0.05$, we tested the income categories against a null hypothesis of no social gradient for compounded exposure (Table 3).

3. Results

3.1. Geospatial overview

After examining 7366 initial premise licenses for Calgary, 2529 unique, non-duplicate food retailers were included for analyses, of which n = 1412 (55.8%) were coded as CLO, n = 539 (21.3%) as CS, and

Table 2
Bernoulli trial for the likelihood of encountering *Choose Least Often* (CLO) versus *Choose Most Often* and *Choose Sometimes* (CMO + CS) food retailers within 250 m, 500 m, 1000 m, and 1500 m buffers around all settings, schools, recreation facilities, and childcare centres, compared to the city-wide percentage of occurrences in Calgary (55.8%) and Edmonton (59.9%).

	Choose Least Often Food Retailers Within Buffer Distances															
	≤250 m				≤500 m				≤1000 m				≤1500 m			
	N	%	Δ%	p	N	%	Δ%	p	N	%	Δ%	p	N	%	Δ%	p
Calgary																
All Settings	621	54.0	−1.8	.139	1087	**52.8**	**−3.0**	**<.001***	1349	**52.4**	−3.4	**<.001***	1391	**52.9**	−2.9	**<.001***
Schools	201	**61.0**	**+5.2**	**.042***	654	**60.0**	**+4.2**	**.001***	1220	**57.6**	**+1.8**	**.002***	1339	56.0	+0.2	.523
Rec. Facilities	18	51.0	−4.8	.551	100	55.7	−0.1	>.999	331	55.0	−0.8	.668	557	54.0	−1.8	.198
Childcare	509	**52.3**	**−3.5**	**.009***	941	**49.9**	**−5.9**	**<.001***	1322	**49.7**	**−6.1**	**<.001***	1382	**50.9**	**−4.9**	**<.001***
Edmonton																
All Settings	490	60.3	+0.4	.800	887	58.9	−1.0	.151	1198	59.6	−0.3	.333	1239	59.9	±0.0	.883
Schools	182	62.2	+2.3	.409	541	60.0	+0.1	.979	1113	61.1	+1.2	.055	1231	**61.1**	**+1.2**	**.004***
Rec. Facilities	15	45.7	−14.2	.119	135	61.4	+1.5	.651	399	60.0	+0.1	.973	731	60.7	+0.8	.474
Childcare	427	60.2	+0.3	.894	787	**58.1**	**−1.8**	**.045***	1170	**58.5**	**−1.4**	**.004***	1232	**59.0**	**−0.9**	**.004***

*Values less than 0.050 indicate that the proportion of Choose Least Often to other food retailers within the buffer is significantly different from the city-wide percentage of occurrences in Calgary (55.8%) and Edmonton (59.9%) at the 0.050 alpha level, with the percentage difference reported as the city-wide percentage subtracted from the buffer percentage.

Table 3
Analysis of Variance (ANOVA) for repeated, compounding exposure counts by lowest (1) to highest (5) income categories of households with children and youth across all food retailers and *Choose Least Often* food retailers at 250 m, 500 m, 1000 m, and 1500 m buffers scales in Calgary and Edmonton.

		Calgary Households with Children and Youth Income Category[ϒ]					
		1	2	3	4	5	**p**
All Food Retailers							
	≤*250m*	1.07	0.79_{ab}	0.46	0.64_{a}	0.81_{b}	**<.001***
	≤*500m*	4.04	2.76	1.63_{a}	1.79_{a}	2.26	**<.001***
	≤*1000m*	14.21	9.13	6.20_{a}	6.61_{ab}	6.99_{b}	**<.001***
	≤*1500m*	25.78	19.05	13.29_{ab}	13.96_{ac}	14.38_{bc}	**<.001***
Choose Least Often							
	≤*250m*	1.06	0.75_{ab}	0.46	0.63_{ac}	0.77_{bc}	**<.001***
	≤*500m*	3.67	2.70	1.62_{a}	1.78_{a}	2.17	**<.001***
	≤*1000m*	12.53	8.70	6.10_{ab}	6.79_{ac}	6.71_{bc}	**<.001***
	≤*1500m*	23.36	18.38	12.94_{ab}	14.05_{ac}	13.80_{bc}	**<.001***
		Edmonton Households with Children and Youth Income Category[ϒ]					
		1	2	3	4	5	**p**
All Food Retailers							
	≤*250m*	0.76_{abcd}	0.85_{aefg}	0.72_{behi}	0.82_{cfhj}	0.71_{dgij}	.275
	≤*500m*	2.48_{abc}	3.06_{d}	2.42_{ae}	2.83_{bd}	2.37_{ce}	**<.001***
	≤*1000m*	9.15_{ab}	10.21_{c}	8.53_{ad}	9.97_{bc}	8.06_{d}	**<.001***
	≤*1500m*	18.61_{abc}	19.16_{ad}	17.42_{be}	19.16_{cd}	16.55_{e}	**<.001***
Choose Least Often							
	≤*250m*	0.83_{abcd}	0.84_{aefg}	0.69_{behi}	0.83_{cfhj}	0.78_{dgij}	.507
	≤*500m*	2.48_{abc}	3.10_{d}	2.35_{ae}	2.82_{bdf}	2.49_{cef}	**.011***
	≤*1000m*	9.17_{abcd}	10.30_{ae}	8.32_{bf}	9.85_{ce}	8.20_{df}	**.002***
	≤*1500m*	18.38_{abcd}	19.87_{ae}	16.86_{bf}	19.09_{ce}	16.49_{df}	**.003***

[ϒ]Categories were derived by calculating quintiles for z-scores of the median after-tax income of households with children for all of the dissemination areas in Calgary and Edmonton with food retailer locations.

* Categories that do not share a subscript are significantly different from each other at the 0.050 alpha level as determined by Analysis of Variance (ANOVA) and post-hoc testing with Fisher's Least Significant Difference (LSD).

n = 578 (22.9%) as CMO. After examining an initial 6738 premise licenses for Edmonton, 2087 food retailers were included, of which n = 1251 (59.9%) were CLO; n = 372 (17.8%) were CS; and n = 464 (22.2%) were CMO. There were 757 activity settings identified in Calgary (345 schools, 27 recreation facilities, and 385 childcare centres) and 747 in Edmonton (328 schools, 36 recreation facilities, and 383 childcare centres). For exploring a potential social gradient, there were 2332 food retailers in Calgary (n = 197 excluded), and 1814 food retailers in Edmonton (n = 273 excluded), where dissemination-area level data for median after-tax income of households with children were available (as opposed to food retailers located in industrially zoned dissemination areas). For geographic extent, the total study area of young people's food environments comprised the following percentages of total land use in Calgary (municipal area ~846 km^2) and Edmonton (~700 km^2) at the four scales: 250 m (12.8% of Calgary; 12.3% of Edmonton); 500 m (34.1% of Calgary; 32.9% of Edmonton); 1000 m (59.8% of Calgary; 55.4% of Edmonton); and 1500 m (71.8% of Calgary; 66.6% of Edmonton).

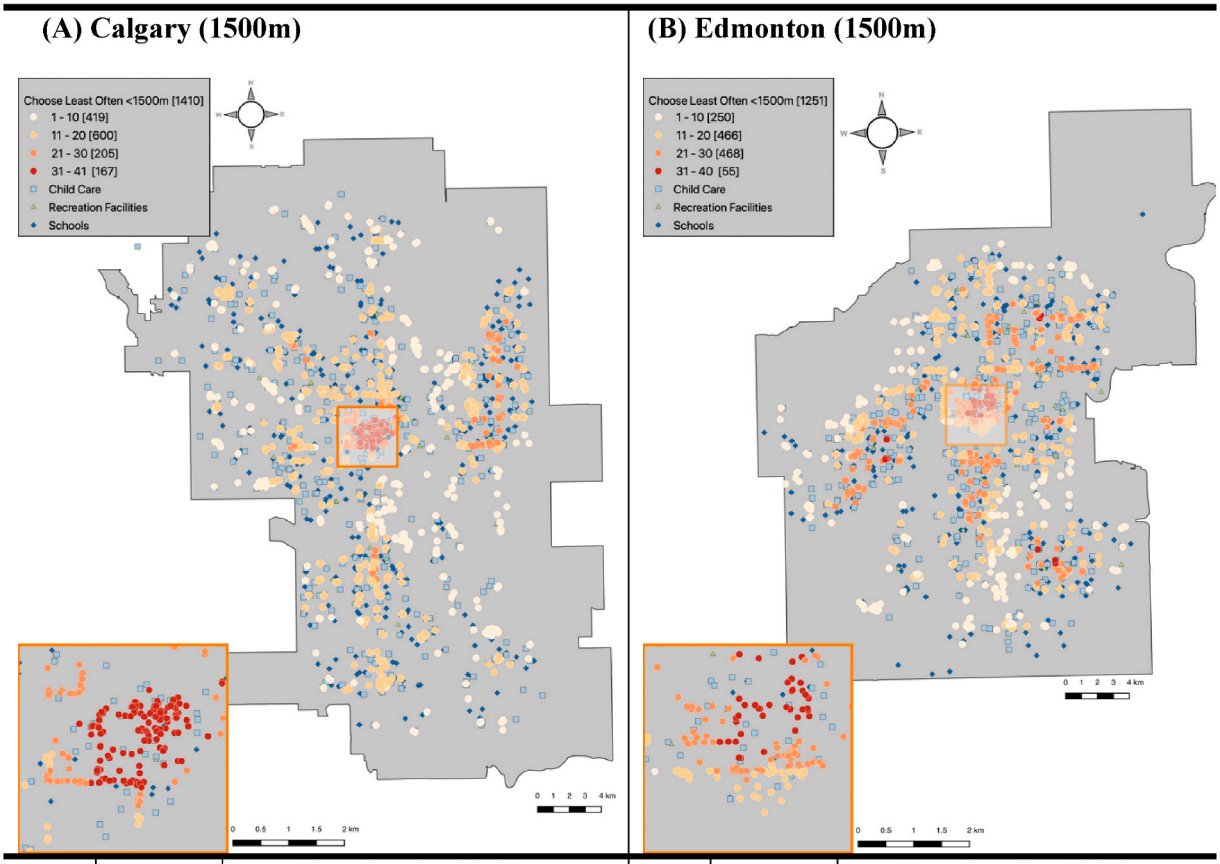
3.2. Relative frequency of unhealthy food retailers

Our Bernoulli trial examined the likelihood of randomly selected food retailers inside buffers being one of two outcomes: (1) CLO versus (2) CMO or CS, compared to elsewhere in the two municipalities—indicating whether retail food mix can usefully characterize food environments for children and youth (Table 2). The overall proportion of CLO food retailers in buffers ranged between 45.7% and 62.2%; however, our analysis indicated prevalence of CLO food retailers was not significantly different in proximity to activity settings, with few exceptions. In Calgary, overall, the likelihood of encountering a CLO food retailer within 500 m, 1000 m, or 1500 m of any activity setting (or within any scale for childcare centres) was significantly *lower* by a factor of 2.9%–6.1%. In contrast, there was a significantly *higher* likelihood of CLO retailers within 250 m, 500 m, and 1000 m of Calgary's 345 schools by 1.8%–5.2%. In Edmonton, similarly, there was a significantly *lower* likelihood of CLO food retailers within 500 m, 1000 m, and 1500 m of childcare centres by 0.9%–1.8%, and *greater* likelihood within 1500 m of schools by 1.2%. As such, Calgary and Edmonton tended toward the same ratio of CLO to non-CLO food retailers throughout, namely, 55.8% out of all food retailers in Calgary, and 59.9% out of all food retailers in Edmonton.

3.3. Repeated, compounding exposures in community and consumer nutrition environments

Our compounded exposure measure quantified CLO food retailers by proximity to multiple activity settings at the 250 m, 500 m, 1000 m, and 1500 m buffer scales (Fig. 1). These results illuminated that individually examining unhealthy food retailers as "weeds in the food swamp" (versus as part of the food retail mix) provides a valuable, dynamic indicator tailored to food environments for young people. In Fig. 1, we have illustrated that *as many as 673 CLO food retailers were located in proximity to 21–30 activity settings, and 222 more were located in proximity to 30+ activity settings, at the 1500m scale across Calgary and Edmonton.* Notably, the 1500 m buffer represents a geographically meaningful distance for young people's regular, recurring commutes between home and their activity settings, often travelled by private vehicle or public transportation. These 895 "super-proximal" CLO food retailers broaching 21+ activity settings totalled approximately *one third of the total 2663 CLO food retailers* across both cities; indicating pervasive geomarketing of unhealthy foods and beverages to young people. Our cartographic visualization of this data reveals that the 'downtowns' in both cities are particularly dense with these compounded exposures (Fig. 1).

Compounded exposure to *Choose Least Often* food retailers illustrated at the 1500m overlapping buffer scale



	CE Count	Overlapping Buffers 250m	500m	1000m	1500m
Calgary	1-10	621	1087	1009	419
	11-20	0	0	255	600
	21-30	0	0	85	205
	31+	0	0	0	167

	CE Count	Overlapping Buffers 250m	500m	1000m	1500m
Edmonton	1-10	490	887	783	250
	11-20	0	0	408	466
	21-30	0	0	7	468
	31+	0	0	0	55

Fig. 1. Compounded exposure (CE) count for *Choose Least Often* food retailers within 250 m, 500 m, 1000 m, and 1500 m overlapping buffers, with illustrations at the 1500 m overlapping buffer scale in (A) Calgary, with an inset of downtown Calgary; and (B) Edmonton, with an inset of downtown Edmonton.

3.4. Mixed evidence for a social gradient of exposure

Evidence for a social gradient of exposure to unhealthy food retailers was mixed (Table 3). In Calgary, CLO food retailers—and all food retailers—in the lowest income category of households with children and youth had significantly higher compounded exposure counts, compared to any of the other income categories. This clear pattern was not reproduced in Edmonton, where differences in compounded exposure counts for CLO food retailers—and all food retailers—were not significant by income category, overall. Notably, for Calgary and Edmonton, any evidence for evaluating a social gradient was consistent across CLO retailers *and* all retailers, indicating little distinction between CLO, CS, and CMO food retailers differentiated by the NutriGARR classification method.

4. Discussion

4.1. General implications

Our results indicate new empirical tools and methods to characterize unhealthy food retailers as "super-proximal" to activity settings and repeated, compounding exposures for young people are useful, within and beyond our current study setting. Notably, characterizing unhealthy food retailers by the same standard of healthfulness as nutrition guidelines employed within jurisdictions could help facilitate comparability between positive exposures to food environments within activity settings, and negative exposures in surrounding retail food environments (with the NutriGARR schema representing a highly simplified process for achieving this). Another key insight is that unhealthy food retailers present repeated, compounding exposures, independent of the food retail mix in which they are located. To illustrate this concept, consider that children and youth attend school and/or childcare centres on a

daily basis, and many visit recreation facilities up to several times per week– necessarily traveling through the buffers where proximal food retailers are found. Our measure of compounded exposure (characterizing unhealthy food retailers by their location) provides a telling indication ("weed by weed") of the potential extent of influence by unhealthy food retailers geomarketing energy dense, nutrient-poor, processed foods to large populations-at-risk attending activity settings. At the levels of urban planning and public health research, both insights indicate a need for more nuanced consideration of unhealthy food retailer influences than a simple calculation of food retail mix.

4.2. Overall objectives of the research

Through this research, we fulfilled five objectives using new empirical tools and methods for investigating the prevalence of geomarketing by unhealthy food retailers in the major Canadian cities of Calgary and Edmonton, Alberta.

Firstly, nutrition guidelines are a key healthy eating intervention in activity settings for children and youth; using the same nutrition guidelines to evaluate *retail food environments* offers an immediately comparable basis for understanding competing, nutrient-poor, commercial influences. We evaluated healthfulness of food retailers using the government-initiated ANGCY, applying our NutriGARR schema. We encourage public health researchers to similarly characterize food retailers using nutrition guidelines in their respective jurisdictions, facilitating frank discussions around food practices exhorted by commercial sector food producers, manufacturers, and marketers near where young people learn and play.

Secondly, using binomial Bernoulli trials, we assessed the relative frequency of unhealthy (or CLO) food retailers in 250 m, 500 m, 1000 m, and 1500 m buffers around activity settings, compared to other locations in our study area. We found that CLO food retailers comprised the majority across both cities—55.8% in Calgary, and 59.9% in Edmonton—but there was no strong pattern to distinguish significantly higher exposure near young people's activity settings using food retail mix. Overall, a significantly lower frequency of CLO food retailers at most scales in proximity to childcare centres across both Calgary and Edmonton by a factor of 0.9%–6.1% would likely not represent a geographically significant difference. The same could be said for Calgary's and Edmonton's schools, which presented significant results by only a combined factor of 1.2%–5.2%. Although the absolute proportion of CLO food retailers in Calgary (55.8%) and Edmonton (59.9%) is alarmingly high, our results indicate the empirical limitations of *food retail mix* (measures such as the Centres for Disease Control's mRFEI or characterizations of food swamps versus food deserts) in discerning the full extent of unhealthy food retailers' geomarketing influence on young people, specifically.

Thirdly, we quantified repeated, compounding exposures to unhealthy food retailers across multiple activity settings. Calculated as the count of the buffers within which CLO food retailers were located at the 250 m, 500 m, 1000 m, and 1500 m scales, our measure pinpointed locations of exceptional risk for unhealthy food and beverage exposures. Approximately *one third of all CLO food retailers in Calgary and Edmonton* could thus be classified as "weeds in the food swamp," or geomarketing sites located in proximity to 21 or more activity settings at the 1500 m scale. Given the potential for "super-proximal" unhealthy food retailers to influence young people's diets through a "'mere exposure' effect … influenc [ing] selection and consumption" (Hollands et al., 2019, p. 7), we argue these brick-and-mortar geomarketers are important targets for healthy eating promotion interventions among young people.

Fourthly, examining evidence for a social gradient of exposure to unhealthy food retailers, our results were mixed. In Calgary, all food retailers (and specifically CLO food retailers) in dissemination areas with the lowest income category of households with children and youth were located in proximity to a higher number of activity settings at every buffer scale. In Edmonton, this pattern was not clearly evident. In the absence of strong evidence, we note CLO food retailers comprised an overall proportion of 55.8% in Calgary, and 59.9% in Edmonton, with widespread consensus that greater densities of unhealthy food and beverage offerings pose steeper barriers to the nutritional health of socioeconomically disadvantaged young people.

Comparing the two largest municipalities within the same province, our findings highlight the inherent complexity of social gradient mechanisms. Our compounded exposure count demonstrated variation among unhealthy food retailers presenting more or less exposure to young people, even in densely populated areas like downtown Calgary and Edmonton (Fig. 1). However, consistent evidence for a social gradient may have been confounded by differences in urban planning practices and/or real estate prices affecting the relative concentration of residential, commercial, and other land uses resulting in co-location of activity settings and unhealthy food retailers in higher or lower socioeconomic status areas of each city, beyond the scope of the current research. It is also possible that due to the abundance of CLO food retailers, the exposure is so common that it becomes difficult to examine differences (Rose, 2001), at least without examining differences over *time*. Further work increasing the number of cities included within research sampling frames is needed to theorize, and validate, empirical measures of a social gradient of exposure to unhealthy food retailers proximal to young people's activity settings, elucidating possible mechanisms of important similarities (and significant differences) between geographies, and periods.

4.3. The roles of urban planning and public health research

Drawing on these insights, we achieved our fifth objective by proposing to problematize "super-promixal" unhealthy food retailers that surround schools, recreation facilities, and childcare centres frequently accessed by children and youth, with implications for urban planning and public health research to mitigate negative impacts on nutritional health.

Unhealthy food and beverage choices over the life course are associated with a significant burden of disease (Forouzanfar et al., 2016), requiring renewed consideration for how repeated, compounding exposures to unhealthy food retailers (and various other social factors) may negatively impact young people's food practices and diets. Social norms dictate that for profit, calorie-dense, nutrient-poor products are taken-for-granted in our everyday milieu; for example, unhealthy so-called "kids' foods" (e.g., fun-shaped chicken nuggets) have obtained a culturally cherished place in childhoods—through promotion by commercial food and beverage producers, manufacturers, and marketers (Elliott, 2011). These industries benefit from shifting social norms around timing, location, cost, and level of household participation in mealtimes; over the past several decades, this shift marks a trend toward diminishing food selection, purchasing, preparation, and storage skills, as well as declining nutritional health for young people (Slater, 2017; Slater & Mudryj, 2016; The Conference Board of Canada, 2013).

Moreover, food retailers present an integrated marketing platform on urban landscapes and in media advertising (Institute of Medicine, 2006). Exposure to unhealthy food geomarketing may be even greater than we have estimated, due to the emerging practice of *geofencing*; that is, "push notifications" of digital marketing from nearby retailers (e.g., Starbucks, McDonalds) sent to young people's parents with relevant apps installed on their mobile phones (Berman, 2016). Thus, we aimed to identify the many unhealthy food retailers (using regional nutrition guidelines) revealed as "super proximal" to activity settings for children and youth, as being key sites for yet-to-be determined healthy eating interventions in municipalities (Mah et al., 2016).

Through urban planning, municipalities have the authority to employ zoning and bylaws to enact "healthy zones" around young people's activity settings (e.g., 500 m buffers), limiting unhealthy food retailers nearby (Gittelsohn & Kumar, 2007; Mah et al., 2016). Such zones have been instituted in various jurisdictions, such as East London

in the United Kingdom (Ritson, 2009), Detroit in the United States (Mair et al., 2005), and throughout South Korea (Park, 2008). In the context of our study, these initiatives could help limit repeated, compounding exposure to unhealthy food retailers that pass the "super-proximal" threshold for multiple activity settings. Urban planning interventions of this nature would need to be customized to municipalities (accounting for differences in jurisdictions, built environments, demographics, and other contexts); nevertheless, our new empirical tools and methods could provide a useful starting point for tailoring "healthy zones" to regional nutrition guidelines, and food environments near young people's activity settings.

Public health research to advance understanding and application of our findings might examine the usefulness of our new empirical tools and methods across geographies, or investigate possible mechanisms of observed and hypothesized relationships in these (and other) results. In addition to geospatially based analyses, participatory approaches like PhotoVoice (e.g., Belon et al., 2016), GPS tracking (e.g., Sadler & Gilliland, 2015), and wearable cameras (e.g., Signal et al., 2017) could complement our study by offering nuanced insight into how children and youth *experience* unhealthy food retailers and their various geomarketing platforms in proximity to schools, recreation facilities, and childcare centres, over the course of daily life. We are actively pursuing elaboration of these results across geographies in Alberta, and are available to participate in collaborations that will further the evaluation and measurement of nutrition environments and healthy eating promotion interventions to improve young people's nutritional health (Olstad et al., 2014).

4.4. Study strengths and limitations

Research on retail food environments is rapidly expanding in Canada (Minaker et al., 2016), for which our research presents new empirical tools and methods to identify the level of exposures in proximity to activity settings for children and youth. We used publicly available data from official sources, enhancing the transferability of our methods, and reproducibility of our results. We have argued the value in extending nutrition guidelines beyond children's activity settings to broader retail food environments throughout our study; however, we do note that our NutriGARR system only coarsely represents food retailer menu offerings. Refinement of NutriGARR could involve assessing the nutrient profile of individual menu items for calculating a weighted index, potentially made easier through online menu databases like Menu Stat (Menu Stat, 2021)—although such resource-intensive information might initially need to come about via voluntary certification of food retailers through self-assessment for meeting nutrition guidelines. Nonetheless, the NutriGARR classification has been effectively used in other research to identify a relationship between the presence and proportion of CLO food retailers surrounding schools and reduced daily fruit and vegetable intake in grade 5 students (Sim et al., 2020).

While we concur with Hollands et al. (2019) that more frequent exposure to unhealthy food retailers themselves increases their normalizing influence, we did not account for the number of visible advertisements in locations, which could be an important topic for future research, and support more nuanced policy solutions. While exceeding analytical conventions for data sets in other research on food retail mix, our exclusion of certain food retailers (Appendix A) might also be revisited in further research—especially as retailers like pharmacies and dollar stores become more prominent in food and beverage offerings.

In terms of geographic methods, this research on young people's food environments conducted in the two western Canadian cities of Calgary and Edmonton provides evidence of geospatial variation in patterns of unhealthy food retailer exposures, even within politically, geographically, and historically similar jurisdictions. This evidence points to a need for caution when generalizing patterns from food environment research conducted in single jurisdictions. While our 250 m, 500 m, 1000 m, and 1500 m scale buffers addressed modifiable area unit considerations, their radial distances only roughly approximated the accessibility and impedance of road and sidewalk networks, whereas network-based methods might strengthen these kinds of future analyses.

For examination of a social gradient, use of 2016 Canadian Census data for *median after-tax income of households with children* provided just a snapshot of socioeconomic disadvantage. Moreover, our operationalization of activity spaces did not extend to private schools and/or private recreation facilities, which are generally located in more affluent neighborhoods compared with public facilities. Given starkly different results of our analyses in Calgary and Edmonton—both within the same provincial jurisdiction—future public health research on social gradients might attempt to generate an index using municipally-specific indicators weighted for the relative density and concentration of activity settings and unhealthy food retailers, as an additional opportunity to further refine this work across jurisdictions.

5. Conclusions

Our research advances the measurement and evaluation of food environments frequently accessed by young people in proximity to their schools, recreation facilities, and childcare centres, demonstrating the utility in characterizing food retailers according to regional nutrition guidelines, and the need for dynamic indicators extending beyond the scope of food retail mix. By conceptualizing and operationalizing compounded exposure, indicating "super-proximal" unhealthy food retailers in proximity to dozens or more activity settings, we have identified a means of pinpointing unhealthy food retailer locations (weeds in food swamps) as critical points for healthy eating interventions, implicating urban planning and public health research.

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Author statement

Jennifer Ann Brown: Conceptualization; Methodology; Validation; Formal Analysis; Investigation; Data Curation; Writing – Original Draft; Writing – Reviewing & Editing; Visualization; Project Administration **Alexa R. Ferdinands:** Conceptualization; Writing – Original Draft; Writing – Reviewing & Editing; Project Administration **Rachel Prowse:** Conceptualization; Methodology; Validation; Formal Analysis; Investigation; Data Curation; Writing – Reviewing & Editing; Project Administration **Darcy Reynard:** Conceptualization; Methodology; Software; Validation; Formal Analysis; Investigation; Data Curation; Writing – Reviewing & Editing; Visualization **Kim D. Raine:** Conceptualization; Resources; Writing – Reviewing & Editing; Supervision; Funding Acquisition **Candace I. J. Nykiforuk:** Conceptualization; Methodology; Resources; Writing – Reviewing & Editing; Supervision; Funding Acquisition.

Ethical statement

This paper is based on the secondary analysis of publicly available data for the geographic locations of facilities within the Canadian municipalities of Calgary and Edmonton. It did not involve human subjects, and was not subject to institutional ethics review.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2021.100803.

References

Belon, A. P., Nieuwendyk, L. M., Vallianatos, H., & Nykiforuk, C. I. J. (2016). Perceived community environmental influences on eating behaviors: A Photovoice analysis. *Social Science & Medicine, 171*, 18–29.

Benchmarking Food Environments. (2020). *Alberta's 2020 Nutrition Report Card on Food Environments for Children and Youth*. https://abpolicycoalitionforprevention.ca/evidence/albertas-nutrition-report-card/ (Accessed 14 October 2020).

Berman, B. (2016). Planning and implementing effective mobile marketing programs. *Business Horizons, 59*, 431–439.

Briefel, R. R., Crepinsek, M. K., Cabili, C., Wilson, A., & Gleason, P. M. (2009). School food environments and practices affect dietary behaviors of US public school children. *Journal of the American Dietetic Association, 109*, S91–S107.

Cairns, G., Angus, K., Hastings, G., & Caraher, M. (2013). Systematic reviews of the evidence on the nature, extent and effects of food marketing to children. A retrospective summary. *Appetite, 62*, 209–215.

Centers for Disease Control and Prevention. (2011). *Children's food environment state indicator report, 2011*. http://www.cdc.gov/obesity/. (Accessed 7 May 2020).

City of Calgary. (2019). *City boundary, Calgary city limits*. https://data.calgary.ca/Base-Maps/City-Boundary/7t9h-2z9s. (Accessed 24 August 2019).

City of Calgary. (2021). *Calgary food action plan*. https://www.calgary.ca/ca/cmo/calgary-food-system-assessment-and-action-plan.html. (Accessed 13 February 2021).

City of Edmonton. (2019). *City of Edmonton - corporate boundary*. https://data.edmonton.ca/Administrative/City-of-Edmonton-Corporate-Boundary/m45c-6may. (Accessed 24 August 2019).

City of Edmonton. (2021). *Food*. https://www.edmonton.ca/city_government/environmental_stewardship/food.aspx. (Accessed 13 February 2021).

Cliquet, G. (2006). *Geomarketing: Methods and strategies in spatial marketing*. London: Wiley-ISTE.

Cummins, S., & Macintyre, S. (2006). Food environments and obesity—neighbourhood or nation? *International Journal of Epidemiology, 35*, 100–104.

Elliott, C. (2011). "It's junk food and chicken nuggets": Children's perspectives on "kids"' food and the question of food classification. *Journal of Consumer Behaviour, 10*, 133–140.

Elliott, C. D. (2012). Packaging fun: Analyzing supermarket food messages targeted at children. *Canadian Journal of Communication, 37*, 303–318.

Engler-Stringer, R., Le, H., Gerrard, A., & Muhajarine, N. (2014). The community and consumer food environment and children's diet: A systematic review. *BMC Public Health, 14*, 522.

Epsg.io. (2018). *NAD83/Alberta10-TM(Forest)-EPSG:3400*. https://epsg.io/3400. (Accessed 7 October 2019).

Forouzanfar, M. H., Afshin, A., Alexander, L. T., Anderson, H. R., Bhutta, Z. A., Biryukov, S., … Murray, C. J. L. (2016). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: A systematic analysis for the global burden of disease study 2015. *Lancet, 388*, 1659–1724.

French, S. A., Tangney, C. C., Crane, M. M., Wang, Y., & Appelhans, B. M. (2019). Nutrition quality of food purchases varies by household income: The SHoPPER study. *BMC Public Health, 19*, 231.

Ghahramani, S. (2000). *Fundamentals of probability* (Vol. 2). New Jersey: Prentice Hall.

Gittelsohn, J., & Kumar, M. B. (2007). Preventing childhood obesity and diabetes: Is it time to move out of the school? *Pediatric Diabetes, 8*, 55–69.

Glanz, K., Sallis, J. F., Saelens, B. E., & Frank, L. D. (2005). Healthy nutrition environments: Concepts and measures. *American Journal of Health Promotion, 19*, 330–333.

Götz, N., & Holmén, J. (2018). Mental maps: Geographical and historical perspectives. *Journal of Cultural Geography, 35*, 157–161.

Government of Alberta. (2012). *The Alberta nutrition guidelines for children and youth*. https://open.alberta.ca/dataset/1c291796-4eb0-4073-be8e-bce2d331f9ce/resource/3319786c-1df1-43ca-8693-067f733682dc/download/nutrition-guidelines-ab-children-youth.pdf. (Accessed 14 October 2020).

Government of Alberta. (2019). *Student population statistics*. https://www.alberta.ca/student-population-statistics.aspx?utm_source=redirector. (Accessed 7 May 2020).

Government of Canada. (2019). *Canada's food guide*. https://food-guide.canada.ca/en/. (Accessed 14 October 2020).

Health Canada. (2012). *Do Canadian children meet their nutrient requirements through food intake alone?*. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/fn-an/alt_formats/pdf/surveill/nutrition/commun/art-nutr-child-enf-eng.pdf. (Accessed 14 October 2020).

Hollands, G. J., Carter, P., Anwer, S., King, S. E., Jebb, S. A., Ogilvie, D., & Marteau, T. M. (2019). Altering the availability or proximity of food, alcohol, and tobacco products to change their selection and consumption. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD012573.pub2

Institute of Medicine. (2006). *Food marketing to children and youth: Threat or opportunity?* Washington, DC: National Academies Press.

King, G., Rigby, P., & Batorowicz, B. (2013). Conceptualizing participation in context for children and youth with disabilities: An activity setting perspective. *Disability & Rehabilitation, 35*, 1578–1585.

Lacy, S., & Riffe, D. (1996). Sampling error and selecting intercoder reliability samples for nominal content categories. *Journalism & Mass Communication Quarterly, 73*, 963–973.

Mah, C. L., Cook, B., Rideout, K., & Minaker, L. M. (2016). Policy options for healthier retail food environments in city-regions. *Canadian Journal of Public Health, 107*, eS64–eS67.

Mair, J. S., Pierce, M. W., Teret, S. P., & Ashe, M. (2005). *The use of zoning to restrict fast food outlets: A potential strategy to combat obesity*. https://www.jhsph.edu/research/centers-and-institutes/center-for-law-and-the-publics-health/research/ZoningFastFoodOutlets.pdf. (Accessed 14 October 2020).

Menu Stat. (2021). *Menus Stat interactive restaurant nutrition database [webpage]*. http://menustat.org/#/home. (Accessed 12 February 2021).

Minaker, L. M., Shuh, A., Olstad, D. L., Engler-Stringer, R., Black, J. L., & Mah, C. L. (2016). Retail food environments research in Canada: A scoping review. *Canadian Journal of Public Health, 107*(Suppl 1), 5344.

Minaker, L. M., Raine, K. D., & Cash, S. B. (2009). Measuring the food service environment: Development and implementation of assessment tools. *Canadian Journal of Public Health, 100*, 421–426.

Minaker, L., Fisher, P., Raine, K., & Frank, L. (2011). Measuring the food environment: From theory to planning practice. *Journal of Agriculture, Food Systems and Community Development, 2*, 65–82.

Minaker, L. M. (2013). *Evaluating food environment assessment methodologies: A multi-level examination of associations between food environments and individual outcomes [Thesis]*. University of Alberta.

Minaker, L. M. (2016). Retail food environments in Canada: Maximizing the impact of research, policy and practice. *Canadian Journal of Public Health, 107*(Suppl 1), 5632.

Ministry of Education, & Ministry of Health. (2005). *Guidelines for food and beverage sales in B.C. Schools*. https://www.health.gov.bc.ca/library/publications/year/2005/guidelines_sales.pdf. (Accessed 30 September 2020).

Moubarac, J.-C. (2017). *Ultra-processed foods in Canada: Consumption, impact on diet quality and policy implications*. Montréal: University of Montréal.

Olstad, D. L., Raine, K. D., & Nykiforuk, C. I. J. (2014). Development of a report card on healthy food environments and nutrition for children in Canada. *Preventive Medicine, 69*, 287–295.

Park, H.-K. (2008). Nutrition policy in South Korea. *Asia Pacific Journal of Clinical Nutrition, 17*, 343–345.

Pauzé, E., Ekeh, O., & Potvin Kent, M. (2020). The extent and nature of food and beverage company sponsorship of children's sports clubs in Canada: A pilot study. *International Journal of Environmental Research and Public Health, 17*, 3023.

Prowse, R. J. L., Naylor, P.-J., Olstad, D. L., Carson, V., Storey, K., Mâsse, L. C., … Raine, K. D. (2018). Food marketing in recreational sport settings in Canada: A cross-sectional audit in different policy environments using the Food and beverage Marketing Assessment Tool for Settings (FoodMATS). *International Journal of Behavioral Nutrition & Physical Activity, 15*, 39.

QGIS Development Team. (2019). *QGIS geographic information system*. Open Source Geospatial Foundation Project. http://qgis.osgeo.org. (Accessed 1 August 2019).

Ravensbergen, L., Buliung, R., Wilson, K., & Faulkner, G. (2016). Socioeconomic inequalities in children's accessibility to food retailing: Examining the roles of mobility and time. *Social Science & Medicine, 153*, 81–89.

Ritson, M. (2009). *UK News: Takeway is shut 'to combat pupil obesity'*. https://www.express.co.uk/news/uk/96145/Takeway-is-shut-to-combat-pupil-obesity. (Accessed 14 October 2020).

Roberts, K., Shields, M., de Groh, M., Aziz, A., & Gilbort, J. (2012). Overweight and obesity in children and adolescents: Results from the 2009 to 2011 Canadian health measures survey. *Health Reports, 23*, 37–41.

Rose, G. (2001). Sick individuals and sick populations. *International Journal of Epidemiology, 30*, 427–432.

Rose, D., Bodor, J. N., Swalm, C. M., Rice, J. C., Farley, T. A., & Hutchinson, P. L. (2009). *Deserts in new orleans? Illustrations of urban food access and implications for policy*. Ann Arbor: National Poverty Center Working Paper.

Sadler, R. C., Clark, A. F., Wilk, P., O'Connor, C., & Gilliland, J. A. (2016). Using GPS and activity tracking to reveal the influence of adolescents' food environment exposure on junk food purchasing. *Canadian Journal of Public Health, 107*, eS14–eS20.

Sadler, R. C., & Gilliland, J. A. (2015). Comparing children's GPS tracks with geospatial proxies for exposure to junk food. *Spatio-temporal Epidemiol., 14*, 55–61.

Scaglioni, S., De Cosmi, V., Ciappolino, V., Parazzini, F., Brambilla, P., & Agostoni, C. (2018). Factors influencing children's eating behaviours. *Nutrients, 10*, 706.

Senate of Canada. (2019). *1st session, 42nd parliament* (Vol. 150). Issue 294; Thursday, May 30, 2019 https://sencanada.ca/en/content/sen/chamber/421/debates/294db_2019-05-30-e?language=e (Accessed 26 July 2020).

Signal, L. N., Stanley, J., Smith, M., Barr, M. B., Chambers, T. J., Zhou, J., & Ni Mhurchu, C. (2017). Children's everyday exposure to food marketing: An objective

analysis using wearable cameras. *International Journal of Behavioral Nutrition and Physical Activity, 14*, 137.

Sim, S., Veugelers, P., Prowse, R., Nykiforuk, C. I. J., & Maximova, K. (2020). Unhealthy food options in the school environment are associated with diet quality and body weights of elementary school children in Canada. *Public Health Nutrition*, 1–10. https://doi.org/10.1017/S1368980020004437. In press.

Slater, J. (2017). Food literacy: A critical tool in a complex foodscape. *Journal of Family and Consumer Sciences, 109*, 14–20.

Slater, J. J., & Mudryj, A. N. (2016). Self-perceived eating habits and food skills of Canadians. *Journal of Nutrition Education and Behavior, 48*, 486–495.e1.

Standing Senate Committee on Social Affairs, Science and Technology. (2016). *Obesity: A whole-of-society approach for a healthier Canada.* Ottawa: Senate of Canada.

Statistics Canada. (2017a). *Table 105-2026. Measured children and youth body mass index (BMI) (Cole classification), by age group and sex, Canada and provinces.* Canadian Community Health Survey. www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1052026&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid. (Accessed 25 August 2019).

Statistics Canada. (2017b). *Download, census profile, 2016 census (V742-median total income of households in 2015 ($))*. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/download-telecharger/comp/page_dl-tc.cfm?Lang=E. (Accessed 28 August 2019).

Statistics Canada. (2018). *Population estimates on July 1st, by age and sex*. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501&pickMembers%5B0%5D=1.10&pickMembers%5B1%5D=2.1. (Accessed 17 July 2019).

Swinburn, B., Kraak, V., Rutter, H., Vandevijvere, S., Lobstein, T., Sacks, G., & Magnusson, R. (2015). Strengthening of accountability systems to create healthy food environments and reduce global obesity. *Lancet, 385*, 2534–2545.

Swinburn, B., Sacks, G., Vandevijvere, S., Kumanyika, S., Lobstein, T., Neal, B., & Walker, C. (2013). INFORMAS (international network for food and obesity/non-communicable diseases research, monitoring and action support): Overview and key principles. *Obesity Reviews, 14*, 1–12.

Taber, D. R., Chriqui, J. F., Powell, L. M., & Chaloupka, F. J. (2012). Banning all sugar-sweetened beverages in middle schools. *Archives of Pediatrics and Adolescent Medicine, 166*, 256.

The Conference Board of Canada. (2013). *What's to eat? Improving food literacy in Canada*. https://opha.on.ca/getmedia/0dde51a8-d0a0-47f2-b567-8d385ac095f8/Improving-Food-Literacy-in-Canada.pdf.aspx?ext=.pdf. (Accessed 15 October 2020).

Thornton, L. E., Lamb, K. E., & White, S. R. (2020). The use and misuse of ratio and proportion exposure measures in food environment research. *International Journal of Behavioral Nutrition and Physical Activity, 17*, 118.

Tugault-Lafleur, C. N., Barr, S. I., & Black, J. L. (2019). Examining differences in school hour and school day dietary quality among Canadian children between 2004 and 2015. *Public Health Nutrition, 1–12*.

Tugault-Lafleur, C., & Black, J. (2019). Differences in the quantity and types of foods and beverages consumed by Canadians between 2004 and 2015. *Nutrients, 11*, 526.

United States Department of Agriculture. (2009). *Access to affordable and nutritious food: Measuring and understanding food deserts and their consequences, report to congress*. https://www.ers.usda.gov/webdocs/publications/42711/12716_ap036_1_.pdf. (Accessed 25 May 2020).

Venter, C., & Harris, G. (2009). The development of childhood dietary preferences and their implications for later adult health. *Nutrition Bulletin, 34*, 391–394.

Williams, J., Scarborough, P., Matthews, A., Cowburn, G., Foster, C., Roberts, N., & Rayner, M. (2014). A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. *Obesity Reviews, 15*, 359–374.

World Health Organization. (2016). *Report of the commission on ending childhood obesity*. https://apps.who.int/iris/bitstream/handle/10665/204176/9789241510066_eng.pdf?sequence=1. (Accessed 14 October 2020).