Signs with a Side of Fries: The influence of outdoor advertising on retail food outlet purchases by adolescents

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A thesis submitted in partial fulfillment of the requirements for the Master of Arts degree in Geography

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Abstract

Most Canadian adolescents have diets high in fat, sodium, and free sugar. There are concerns among researchers and policymakers that food and beverage marketing has an adverse impact on adolescent dietary attitudes, knowledge, and behaviours. The food environment plays an important role in shaping diets and health. The food information environment, and more specifically outdoor food and beverage advertising, may have an effect on adolescent food and beverage purchases. This thesis investigates the associations between the availability of, accessibility to, or exposure to outdoor advertising and retail food outlets, coupled with attitudes related to food and beverage consumption, and purchases at retail food outlets by adolescents in a mid-sized Canadian census metropolitan area. Findings are relevant to policymakers and practitioners at all levels of government and improve on prior research related to retail food and beverage marketing.

KEYWORDS: Adolescent, Advertising, Billboards, City planning, Consumer nutrition environment, Exposure, Food environment, Food and beverages, Geography, Marketing
Lay Summary

Food and beverage consumption patterns are recognized as a major driver of short-term physical health, wellbeing, and academic performance among teenagers. Drinking and eating patterns can also influence a person’s long-term health and wellbeing. Moreover, recent changes to Canada’s Food Guide and regulatory efforts on advertising by all levels of government has placed eating and drinking behaviours, and food and beverage advertising, at the forefront of health research in Canada. This thesis explores how outdoor advertising may shape purchases at fast food outlets, restaurants, grocery stores, variety stores by teenagers in London, Ontario, Canada. A systematic review of previous studies on outdoor food and beverage advertising found no definitive link to dietary behaviours in any population. There are limited effects from a high availability of, accessibility to, or exposure to outdoor food and beverage advertising among teenagers in their home environment, with the strongest associations between fast food and variety store advertising and purchasing. Outdoor advertising around schools seems to have more of an effect on food and beverage purchasing than advertising near home or on the journey between home and school. The most important factor in purchasing for teenagers uncovered by this analysis is attitudes towards healthy eating, cooking, and packing lunch. Future research should focus on isolating the effects of outdoor advertising on purchasing behaviours with studies that use methods that measure exposure and engagement, rather than the accessibility or availability of advertising. All levels of government should pivot their efforts towards policies and programs that foster healthy eating behaviours, cooking skills, nutritional literacy, and equal access to healthy and nutritious food in schools rather than focusing on the regulation of food and beverage advertising.
Co-Authorship Statement

Each integrated manuscript in this thesis will be submitted for publication in a peer-reviewed journal. Alexander Wray is the primary author, and performed the data processing, data analysis, and writing of each chapter. Chapter 2 is independently authored with input from Dr. Jason Gilliland. Chapter 3 and 4 are primarily authored by Alexander Wray and include input from Angela Piaskoski, Dr. Gina Martin and Dr. Jason Gilliland. Data collection related to Chapters 3 and 4 was coordinated by Drew Bowman, Kate Schieman, Dr. Andrew Clark, and Dr. Jason Gilliland. Alexander Wray assisted with some of the fieldwork and data collection related to Chapters 3 and 4. All manuscripts in this thesis are formatted using APA style.
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As a small footnote, 2020 is the absolute worst and I get to say I lived through the COVID-19 pandemic while completing a Masters thesis. FUN.
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<tr>
<td>AAEE</td>
<td>Availability, Accessibility, Exposure, Engagement</td>
</tr>
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<td>AIC</td>
<td>Akaike Information Criterion</td>
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<td>AU</td>
<td>Australia</td>
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<td>BIC</td>
<td>Bayesian Information Criterion</td>
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<td>CA</td>
<td>Canada</td>
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<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>CMA</td>
<td>Census Metropolitan Area</td>
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<tr>
<td>F. USSR</td>
<td>Former United Soviet Socialist Republics</td>
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<td>GH</td>
<td>Ghana</td>
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<td>GIS</td>
<td>Geographic Information Systems</td>
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<td>Geographic Information Sciences</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>GT</td>
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<td>IRR</td>
<td>Incidence Rate Ratio</td>
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<td>JM</td>
<td>Jamaica</td>
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<tr>
<td>LPAT</td>
<td>Local Planning Appeals Tribunal</td>
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<td>MLHU</td>
<td>Middlesex-London Health Unit</td>
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<td>NZ</td>
<td>New Zealand</td>
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<td>OMB</td>
<td>Ontario Municipal Board</td>
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<td>UK</td>
<td>United Kingdom of Great Britain &amp; Northern Ireland</td>
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1. Introduction

The role of outdoor advertising in driving food purchasing among adolescents is inherently complex. As outdoor food and beverage billboards, signs, and posters are among the most predominant forms of advertising in public settings, they play an important role in daily exposures to food and beverage marketing. This constant interaction with advertising in the public realm could have implications for adolescent diet quality, and subsequently health outcomes in later life.

Food and beverage consumption patterns are linked to a wide range of chronic health conditions. Diet composition is generally recognized as a risk factor for heart disease, hypertension, cancers, and diabetes (Fitzmaurice et al., 2017; Lim et al., 2012; Micha et al., 2017). The etiological progression of these diseases from dietary factors are often determined by the nutritional content, portion size, and preparation method of foods and beverages that make up an individual’s diet (Forouzanfar et al., 2015). In addition, the food environment is recognized as a key determinant of diet behaviours and health outcomes (Caspi et al., 2012; Mackenbach et al., 2019; Sacks et al., 2019). A food environment is a group of food producers, processors, packagers, purveyors, and purchasers that interact in a demarcated spatial plane (Brown & Brewster, 2015). The study of food environments has traditionally focused on agricultural production, health outcomes, and socioeconomic conditions (Caspi et al., 2012; Wilkins et al., 2019). Recently, the Chief Public Health Officer of Canada (2017) has identified food environments as one of three major focus areas for building healthy and thriving communities.

Among Canadian adolescents, Diet has been identified as a major driver of physical health, mental wellbeing, social and cognitive development, and academic performance (Dobbins et al., 2017; Health Canada, 2017b, 2019b; Jessri et al., 2016; Potvin et al., 2012).

The advertising of high fat, sodium and free sugar foods and beverages remain relatively unrestricted in Canada, while tobacco and alcohol are tightly controlled by multiple levels of government (Health Canada, 2017b). Concerns have been raised in
recent Canadian studies that outdoor advertising may be a causal agent of observed diet-related health disparities among children and youth (Health Canada, 2017b; Potvin et al., 2012). In addition, a recent meta-analysis of dietary interventions found cognitive and behavioural strategies – marketing among other communication techniques – have the largest effect on diet quality (Cadario & Chandon, 2020). Canadian adolescents primarily have diets high in fat, sodium and free sugars with large portion sizes (Dobbins et al., 2017; Jessri et al., 2016). These types of diets are identified as a health risk in the 2019 revision to the Canadian Food Guide (Health Canada, 2019c). These types of diets among adolescents have been associated with lowering academic performance, negatively altering mood, and increasing the risk of chronic disease in later life (Health Canada, 2019b). While much research has been completed on the socio-economic factors that influence adolescent dietary behaviours, little research has explored the influence of the ‘information environment’ – outdoor advertising and the signage associated with retail food outlets – on their food and beverage choices (Glanz et al., 2005).

In the context of this thesis, the particular focus on the food environment will be limited to the retail food environment, which consists of four groups of retail food outlets:

- Fast food includes quick-service restaurants, coffee shops, ice cream parlours, food courts and cafeterias with seating where food is ordered from a counter, as well as local takeout and delivery-focused food and beverage outlets with limited or no seating.
- Slow food includes sit-down restaurants, bars, pubs, and other establishments that offer table-based service.
- Grocers includes typical grocery stores and supermarkets that sell fresh and packaged food, as well as farmers’ market stands, bakeries, and other food and beverage-based retail stores.
- Variety includes convenience and variety stores that are typically found in commercial plazas and gas stations selling packaged food and beverages.
This classification scheme follows from previous definitions set out by Tucker et al. (2008) in their research of food environments in the Middlesex-London region.

### 1.1 Research Context

Outdoor advertising emerged throughout North American and European urban areas in the late 1700s as a commercialization of exterior surfaces on highly-visible buildings (Treu, 2012). The introduction of cheap and reliable electricity in the early 1900s further drove this marketing technique to dominate urban landscapes (Cronin, 2010; Treu, 2012). Municipalities in response to this chaotic reshaping of urban life established bylaws around the turn of the 20th century that regulated the placement, size, proximity, and content of these advertisements to primarily commercial-retail zones (Ramsey, 1931). The post-WWII suburbanization of North America brought about a concentration of these commercial and retail zones away from residential areas (Treu, 2012; Wrigley & Lowe, 2014). These two factors in the development of North American cities results in a highly concentrated advertising landscape along the primary thoroughfares of many cities.

#### 1.1.1 The Canadian Outdoor Advertising Industry

The outdoor advertising industry in Canada had $1.3 billion in revenue for 2019 (Ozelkan, 2019). The industry has high barriers to entry and is relatively localized compared to the globalization that has occurred in other parts of the advertising sector. The rise of digital advertising and other new technologies in the past decade has lowered revenues overall. Product channels within the outdoor advertising industry can be broken into five channels: print billboards (38.5%), digital billboards (24.5%), transit advertising (22.4%), alternative advertising (10.4%), and street furniture (4.2%). These product channels are primarily controlled by Bell Media (20.1%), Jim Pattison Group (14.4%), Outfront Media (6.4%), and Lamar Advertising Company (5.5%) with other independent entities (53.6%) making up the majority of the market share, of which public transit agencies and airport authorities are the largest types of entities. Food and beverage related products are the second largest market in outdoor advertising, only surpassed by the
telecommunications, media, and technology category. This market in the industry is aptly summarized as follows:

Food and beverage companies and restaurants are expected to account for an estimated 14.4% of industry revenue in 2019. This segment accounts for individual products and its sellers, such as Pepsi; grocery stores, including Whole Foods Market; chain restaurants, such as McDonald's; and single-location restaurants. The sheer scope of this segment is a major factor in its high proportion of industry revenue. National chains often advertise on a large-scale basis and often place advertisements close to one of their locations. Single-location restaurants often advertise within a smaller radius of the restaurant itself and generally display promotions used to entice new customers, as opposed to building brand recognition, which is often the outcome expected from larger chains. As food and beverage manufacturers and chain restaurants have increasingly moved their advertising efforts into the digital arena, this segment has shrunk as a proportion of industry revenue but still remains dominant due to the geographic significance of food establishments. (Ozelkan, 2019, p. 21)

Outdoor advertising is an integral component of the retail food industry. While fast food and slow food entities may be the largest advertisers, grocery stores and variety stores often engage in localized advertising to reinforce their brand message and attract convenience-oriented consumers.

1.1.2 Schools and Outdoor Advertising in the London CMA

The London census metropolitan area (CMA) is a mid-sized Canadian region with 494,069 inhabitants, 220,452 households, and a population density of 185.6 per square kilometre (Statistics Canada, 2018). The region is characterized by the urban centre of London, with smaller centres of Strathroy, St. Thomas, and Port Stanley. The City of London, and outlying exurb of Strathroy, are typical examples of the North-American “super-block” development pattern, with an intermixed core area of pre-war small-block development, and then a ring of post-WWII large-block suburban development with strict divisions between land uses (Hodge & Gordon, 2008). The area is served by four public school boards: Thames Valley District School Board, London District Catholic School Board, Conseil scolaire Viamonde, and Conseil scolaire Catholique Providence. Many of the 24 high schools in the area are located in suburban or rural exurban areas, with the exception of three in London's
downtown core. All are located along major corridors or at major neighbourhood nodes (Figure 1-1).

Figure 1-1. Secondary schools, retail food outlets, and advertising in the London CMA

Moreover, outdoor advertising and retail food outlets in London tend to be concentrated along these major corridors from planning policies that guided commercial development to both the core area and regional shopping centres in the periphery (Cobban, 2003; Larsen & Gilliland, 2008; Novak & Gilliland, 2011). Thus, many schools tend to have a saturated retail food environment in close proximity
(Figure 1-2). Consequently, adolescents are constantly exposed to these sources in their school environment, and the routes taken between home and school.

Figure 1-2. Density of advertising around secondary schools in the London CMA

1.2 Theoretical Frameworks

The multidisciplinary nature of this thesis necessitates the use of multiple theories and frameworks. The broadest and most applicable theories are first described, following into more specific theories and frameworks that guide specific elements of the thesis. The thesis is generally guided by an adapted socio-ecological model of food environments, followed with a more specific model of interactions between the
community environment and nutritional behaviours. These two models are followed up with theorization about ‘exposures’ in the context of health geography research. Finally, more specific theories from psychology, economics, and geography are touched on to round out the theoretical framing of the thesis.

1.2.1 Socio-Ecological Model

The socio-ecological model is a widely used framework in environment and health research. The framework was pioneered by Bronfenbrenner (1992) as a broad theory on the relationship between ecological systems and childhood development. The model was further adapted by Story (2008) to food environments (Figure 1-3).

The model typically consists of concentric circles radiating out from individual to macro-levels of effects. In the context of this thesis, the individual, social, physical and environmental levels are used to illustrate the multiple levels of effects that make up dietary habits, behaviours, and practices. Briefly, at the core are individual factors such as age, gender, personal skills, values, and intrinsic motivations. At the next level, individuals are further influenced by their social connections such as friends, family, and peers. These social connections, and individual factors are
further impacts by the physical environment, which, in the context of food environments involves home, school, and the retail food environment (i.e. restaurants, variety stores, grocery stores, etc.). Finally, all these levels are shaped by policies, programs, infrastructure, and cultural norms at the macro-level.

1.2.2 Community Nutrition Environment

Glanz (2005) articulates a well-structured and useful framework of the food environment (Figure 1-4). The community nutrition environment model identifies seven drivers – institutional, community, organizational, consumer, information, psychosocial, perceptual – of dietary habits from political, environmental, and individual spheres of influence. The political sphere shapes dietary patterns through policies set by governments and food producers. The environmental sphere structures dietary patterns through the availability of food in a community, the organizational opportunities for food such as home, school, and work, the accessibility of food based on its pricing, promotion, and packaging, and the effects of media and advertising. Finally, the individual sphere affects dietary behaviour through psychosocial and perceptual interpretations of the environmental sphere. While there is a plethora of research about the institutional, community, organizational, consumer, psychosocial, and perceptual drivers of dietary behaviour, little research has explored the role of the information environment, particularly with a spatial lens. This information environment is primarily composed of retail food outlet signage and outdoor advertising on billboards, transit shelters, and other structures within a community.
1.2.3 Other Guiding Theories

There are three additional theories that are supportive of the primary theories guiding this thesis sourced from psychology, economics, and geography. First, advertising is generally a psychological process that intends to provoke an immediate or habitual response in a consumer for a product. Second, dietary research is convalescing around communicative approaches as the most effective intervention to change dietary behaviours. Finally, the field of geography has recently engaged with communication as a form of spatial processes and practices.

Joyce (1998) structures the psychological processes of advertising as a two-by-two matrix of involvement and reaction. Engagement with advertising consists of high or low involvement and is processed through either thinking or feeling. High involvement advertisements that provoke thought are considered to result in an informative response. High involvement advertising that use feeling result in an affective response. Low involvement ads that induce thinking have a habitual response, while those that promote feeling have a satisfaction-based response. Typically, food and beverage advertising would provoke either a habitual (i.e. groceries) or satisfactory (i.e. desserts) response in a consumer. Therefore, outdoor advertising should have an additive affect on purchasing behaviours, with higher totals of advertising exposure correlating with more purchases overall.
Dietary habits, along with many other behaviours, are increasingly recognized as led by irrational decisions with no single avenue for corrective action (Downs et al., 2009; Kahneman & Tversky, 1986; Khan, 2011). Many dietary interventions have failed to improve dietary quality by focusing on only one element of eating behaviour, such as literacy or availability of healthier foods and beverages (Cummins et al., 2005; Giskes et al., 2009; Johnson et al., 2012). Rather, food literacy and subsequent dietary behaviours can be effectively altered by reinforced learning through frequent ‘nudges’ at individual and environmental levels to make healthier choices (Cadario & Chandon, 2020; Egger & Swinburn, 1997; Khan, 2011; Story et al., 2008). Dietary patterns can be changed through social cues in various settings to push individuals towards better food and beverage purchases and consumptive decisions (Gittelsohn & Lee, 2013). Synthesized with the adapted socio-ecological model discussed previously, this theory guides the SmartAPPetite intervention; the source of this thesis’ data.

Adams and Jansson (2012) provide a useful interpretation of media and communication as geographic process and practice. They identify four quadrants of geographic thought – textures, structures, connections, representations – in communication, which I have adapted to outdoor food and beverage advertising represented by a billboard for McDonalds’ McCafe™ seasonal beverages (Figure 1-5).
Moving in a clockwise fashion starting from the top left of the figure, *textures* consist of the content of an advertisement that is rooted in a place. For example, the McDonald’s ad as a whole creates a texture of warmth and Fall as an edible season. Second, *structures* are the objects and practices that support or restrict the distribution of advertising in space. In the case of the McDonald’s ad, the placement of the billboard structure is controlled by regulations and physical limitations of the local environment. Third, *representations* are elements of an advertisement that have an identifiable association with a specific place. In the ad, maple leaves are used to represent Canadiana while the products themselves make representations about beverages that should be consumed during the Fall season. Finally, *connections* are elements of an advertisement that connects to another space or time. The ad connects the coffee products to the McDonald’s brand at a specific price until a particular time. Taken together these conceptualizations of geography and
media are useful to interpreting outdoor advertising as geographic products. In short, advertising is a deeply spatialized process that conforms to, and influences its’ environment.

1.2.4 Meanings of Exposure

This thesis traffics in many concepts and definitions of exposure to point-based geometries. Health-focused geographic research often explores how exposures to various elements of the built and natural environment affect health behaviours and outcomes. In conversations with my supervisor\(^1\) over the course of my graduate program, I have come to realize exposure is a broad term encompassing various spatial relationships which can be described in order of spatial specificity, from broadest to narrowest terms: availability, accessibility, exposure, and engagement. In the context of this thesis, these four types of space-time interactions can be used to understand interactions between food and beverage advertising and purchasing (Figure 1-6). I have provided definitions of these terms to contextualize concepts presented in subsequent chapters, building upon previous, yet underdeveloped work on the subject (Sadler et al., 2011; Sadler & Gilliland, 2015; Tillmann et al., 2018). In these definitions, I will refer to a source – typically described as the exposure source being measured (i.e. advertisements) – and a subject (i.e. teenagers) to illustrate the interaction in each term’s context. In the following chapters, I use these definitions to evaluate previous research on outdoor food and beverage advertising (Chapter 2), demonstrate examples of availability and accessibility using self-reported data (Chapter 3), and show an exposure-based spatial relationship using smartphone GPS-based data (Chapter 4).

\(^1\) Dr. Jason Gilliland is the source of these ideas. Over the course of my Masters degree, we have had many conversations about the multiplicity of meanings for ‘exposure’ in health geography. Reflecting on these discussions, I have further developed these ideas and applied them in Chapter 2, 3, and 4.
Availability is the broadest form of spatial relationship measuring simple connections between the source and subject’s surroundings (i.e. home, school, census tract, neighbourhood). Availability is often associated with descriptive spatial analyses that use a pre-defined or buffered container approach. For example, this type of relationship could be used to describe the number of ads within a neighbourhood, or the number of ads that fall within a Euclidian buffer around a school. Simply, studies that measure a threshold effect, or the presence/absence of a source in a subject region, are capturing an availability-based relationship.
Accessibility is a more advanced version of availability centred on an individual subject rather than group or areal unit, that is often mistaken for exposure. For example, a network service area or shortest network path, drawn around/between home and school, could be used to determine the number of ads that an opportunity exists for an exposure to occur between the subject and source based on features of the built and natural environment. More advanced versions of this type of spatial relationship capture the barriers and opportunities a subject may face in accessing (or being ‘exposed’ to) the source (i.e. an ad on their journey to school). Typically, the spatial analysis is focused at the individual level incorporating a spatial network, and ideally incorporates a cost-based or modal choice measure to reflect the route taken (i.e. journey between home and school), or decision made to visit a fixed location (i.e. a grocery store), that would connect the source and subject.

Exposure is a term which has traditionally been used to encapsulate all these spatial relationships. However, true exposure is measured at an individual level where contact or line of sight between the source and subject can be confirmed through GPS tracking, or self-reported information about past spatial behavior. For example, a self-reported travel diary by a subject could be used to determine exposure to a source (i.e. a specific ad for sugar sweetened beverages in a fixed location).

Engagement is an elevated version of exposure that is further complicated by determining if the subject and source had prolonged contact in space-time. For example, the use of GPS device set to one second logging intervals, or a camera mounted on the subject, would allow for a determination of the length of contact the subject had with a source (i.e. prolonged eye contact with an ad for food delivery). In short, exposure is an ill-defined term used to describe widely differing types of spatial relationships and interactions between sources and subjects.

1.3 Research Objectives and Questions

The overarching objective of this thesis is to uncover how outdoor advertising influences the availability of, accessibility to, and exposure to the retail food
environment among adolescents in the London, Ontario CMA. This research objective is further addressed through the following research questions:

1. What is known from previous research about the links between outdoor food and beverage advertising and purchasing at retail food outlets?

2. What is the availability of outdoor advertising and retail food outlets among children in the study area based on their home and school environments? What is the accessibility to outdoor food and beverage advertising along children’s journey between home and school? How do these spatial patterns of availability and accessibility relate to self-reported purchasing behaviours at retail food outlets?

3. What is children’s exposure to outdoor advertising and retail food outlets at an individual level, and how does that relate to self-reported purchasing behaviours at retail food outlets?

These research questions are addressed through a systematic review of outdoor food and beverage advertising studies that make use of spatial analysis techniques (Chapter 2), followed by two quantitative investigations of outdoor food and beverage advertising and self-reported purchasing habits (Chapter 3 & 4). This thesis intends to test correlations between various degrees of spatial interactions between outdoor food and beverage advertising and purchasing at retail food outlets among a diverse sample of adolescents from the London, Ontario CMA in Canada.

1.3.1 Rationale

The research gaps identified by the systematic review on outdoor advertising and dietary behaviour provide strong rationale for this thesis. Few studies have explored the links between outdoor food and beverage advertising and purchasing patterns, and even fewer have statistically evaluated relationships between the two, in comparison to the large volume of research about other advertising mediums. The original empirical studies (Chapter 3 & 4) in this thesis respond to the results from the systematic review (Chapter 2). Furthermore, the presence of an outdoor advertising dataset that captures both physical locations and content, coupled with
matching spatiotemporal data at the individual level, is an analysis opportunity that needs to be leveraged now to remain timely for research and policy in Canada.

This thesis connects elements of space-time behaviours with individual consumption beliefs and sociodemographic factors to potentially uncover correlations between advertising exposure and retail food outlet purchasing habits. Advertising, as the information component of the broader consumer nutrition environment, is an understudied component of the food system (Glanz et al., 2005). Moreover, the methodological techniques and theoretical framings of the studies are situated at the intersections of communication geography, health geography, and GIScience.

The federal government’s changes to Canada’s Food Guide also provide an ideal opportunity to illustrate how the food guide can be used to evaluate the nutritional content of advertising (Health Canada, 2019a). This analysis responds to practitioner interest in evaluating advertising content and addressing exposure to advertising among youth populations (Health Canada, 2017a). Thus, this thesis also aims to provide evidence for making meaningful advances to nutrition policy and practice in Canada.

1.4 The SmartAPPetite Study

The SmartAPPetite project is an intervention study designed to promote adolescents to engage in healthier dietary behaviours and make more local food purchases (Gilliland et al., 2015). The study is targeted to high school students (13-18 years old) in the Southwestern Ontario area. The study began recruiting in the 2018-19 school year and will continue to recruit cohorts until the 2021-22 school year. The study’s intervention is a smartphone application (SmartAPPetite) that provides time-based and geographically targeted messaging to participants. The intervention lasts for approximately 12 weeks, however interactions with the app are tracked for as long as the user continues to engage with the app. The messages delivered via the smartphone application provide dietary and lifestyle advice to nudge users towards making healthier decisions. Messages are sent three times a
day around the user’s defined mealtimes, and additional messages are sent when the user enters a geofenced area around a retail food outlet. In addition, students and their parents complete five surveys on their health behaviours, dietary patterns and knowledge, and retail food and beverage purchasing habits. Surveys are completed at baseline, during the 12-week intervention period, post-intervention at week 12, 1-month post intervention, and finally 5-months post-intervention.

This thesis does not evaluate the effectiveness of the SmartAPPetite intervention. Instead, it makes use of the survey data and smartphone GPS data collected from the 2018-19 cohort of the SmartAPPetite study. This cohort includes high school students from the London District Catholic School Board in London and Strathroy, Ontario. In addition, this thesis leverages data on outdoor advertising in the study area collected by Drew Bowman and the Human Environments Analysis Lab team in the summer of 2018 (Bowman et al., 2019). These three data sources are synthesized into an exploration of the role of outdoor advertising and the broader food environment in affecting adolescent dietary behaviour.

1.5 Thesis Process

Independent research and writing processes were used to craft this thesis. The database searches, collation of relevant studies, and analysis related to the systematic review (Chapter 2) was completed in March 2020. Photographs of outdoor food and beverage advertising were taken from July 2018 to September 2018 by members of the Human Environments Analysis Lab (see Bowman 2019). Quantitative survey and GPS data collection from the SmartAPPetite study began in September 2018 and concluded in May of 2019. Data cleaning, processing, and analysis for the quantitative component of this thesis was done from June 2019 to March 2020. Writing related to the quantitative studies occurred from April to July 2020 (Chapter 3 & 4). The introduction and discussion chapters were written and completed in the summer of 2020.
1.6 Thesis Format

This thesis takes on an integrated article format composed of three stand-alone manuscripts. There is one systematic review and two original research studies. The systematic review captures studies that use spatial analysis techniques related to outdoor food and beverage advertising. The review paper sets up the next two original research studies. The first examines the relationship between adolescent dietary behaviour and the availability of, and accessibility to, outdoor food and beverage advertising. The second study determines the effect of exposure to outdoor food and beverage advertising on dietary behaviour using observed GPS data. These two studies demonstrate similarities and differences in spatial analysis techniques – availability and accessibility versus exposure – using the same study population and environmental features. The thesis will build upon the research identified in the review with two quantitative analyses of diet behaviour and outdoor advertising.

Chapter 2 is a systematic review of peer-reviewed literature that applied spatial analysis techniques to studies of outdoor food and beverage advertising. Studies are reviewed based on the type of spatial analysis – availability, accessibility, exposure, and engagement – the approach used to code the content of food and beverage advertising, and the incorporation of health equity factors into the analyses. This review identifies research directions that are subsequently addressed by the two quantitative manuscripts.

Chapter 3 is an analysis of the connection between purchasing at retail food outlets by adolescents and the number of food and beverage ads that are available within an 800m buffer around home and school. In addition, a shortest network path calculation is used to estimate the number of ads a participant is accessible to on their journey to and from home to school.

Chapter 4 follows up from the analysis in the previous chapter by making use of observed GPS data from the SmartAPPetite smartphone application to estimate the
exposure to outdoor food and beverage advertising over a 12-week period as it relates to the number of self-reported purchases at retail food outlets.

**Chapter 5** provides a synthesis of the three manuscripts. This chapter describes the research contributions, methodological implications, research limitations, and future research and policy recommendations from this body of work.
1.7 References


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Wilkins, E., Radley, D., Morris, M., Hobbs, M., Christensen, A., Marwa, W. L., Morrin, A., & Griffiths, C. (2019). A systematic review employing the GeoFERN framework to examine methods, reporting quality and associations between
the retail food environment and obesity. *Health & Place, 57*, 186–199. https://doi.org/10.1016/j.healthplace.2019.02.007

2. Spatial perspectives on outdoor food and beverage advertising: A systematic review

BACKGROUND: The impact of food and beverage advertising on consumption is well-established. There is also growing evidence linking the distribution of food and beverage retailers in a neighbourhood to resident dietary behaviours; however, much less is known about the impacts of outdoor food and beverage advertising on dietary behaviours or health outcomes.

METHODS: A systematic review of studies related to outdoor food and beverage advertising was undertaken to determine the types of spatial analyses used to assess interactions with advertising, the coding approaches to the content of advertising, and the incorporation of health equity factors in the analyses. Searches were completed in ProQuest ABI/INFORM, PubMed, and Scopus.

RESULTS: The search process rendered 31 relevant studies from 552 unique results. Most studies are descriptive in nature, and while many are purporting to study exposure to outdoor food and beverage advertising, they capture much different spatial relationships and processes. Even the true exposure and engagement studies did not report a purchasing or health outcome variable. Few studies incorporated health equity variables in their analysis.

DISCUSSION: There is no clear link between outdoor food and beverage advertising and dietary behaviour. Also, health equity factors are not well incorporated into existing analyses. There is a need for further observational studies that include measures of health outcomes or health-related behaviours.
2.1 Background

Food and beverage consumption patterns are linked to a wide range of chronic health conditions. Diet composition is generally recognized as a risk factor for heart disease, hypertension, cancers, and diabetes (Fitzmaurice et al., 2017; Lim et al., 2012; Micha et al., 2017). The etiological progression of these diseases from dietary factors are often determined by the nutritional content, portion size, and preparation method of foods and beverages that make up an individual’s diet (GBD 2013 Risk Factors Collaborators, 2015; Schwingshackl et al., 2018). There is considerable research on how advertising affects dietary behaviour, and in turn health outcomes (Cohen & Lesser, 2016; Halford et al., 2004; Harris et al., 2009; Kinard & Webster, 2012). Moreover, a recent meta-analysis concluded that cognitive and behavioral-oriented communication strategies had the largest effect on diet quality (Cadario & Chandon, 2020). Thus, the study of how advertising and marketing of foods and beverages affects dietary behaviour is critical to overall population health and wellbeing.

The ‘community nutrition environment’ refers to the distribution of food outlets, in terms of the number, type, and location (Glanz et al., 2005). The ‘information environment’ is an important component of the broader nutrition environment, as it contains food advertising, which is known to affect knowledge, attitudes, and perceptions of certain foods or food sources. The food information environment has a broad reach, operating through various mediums (e.g., social media, television, print media, signage) and at multiple levels, including national, regional, neighbourhood, and store level (Glanz et al., 2005). While there is a plethora of research establishing how social media and television advertising influences consumer attitudes toward products (Baldwin et al., 2018; Halford et al., 2004; Harris et al., 2009; Henderson & Kelly, 2005), this field of research has largely been ‘aspatial’, neglecting the diverse characteristics of particular neighbourhoods or areas. Meanwhile, a large and growing body of spatial research has explored how community nutrition environments (e.g., proximity to fast food and convenience stores) can impact purchasing patterns, dietary behaviours, and health-related
outcomes of various resident groups in different communities (Gililand et al., 2012; He, Tucker, Gilliland, et al., 2012; He, Tucker, Irwin, et al., 2012; Sadler et al., 2016). Nevertheless, little is known about the spatial characteristics of outdoor food and beverage advertising and the influence it has on dietary behaviours or diet-related health outcomes (Cohen & Lesser, 2016; Health Canada, 2017). This systematic review will evaluate spatially constructed studies of outdoor food and beverage advertising. Given outdoor advertising is place-specific feature of the community nutrition environment, geographic-based approaches should be used in any analysis. Preliminary investigations revealed wide variations in approaches to analyzing food and beverage content on advertisements, and a lack of research in the area particularly on differences between populations.

2.1.1 Spatial Analysis Techniques

Advertising is a place-based process, influenced by geographic factors such as local regulations, culture, and built form (P. C. Adams, 2009). Outdoor advertising specifically has held an important position in the built environment, serving as a marker of place and marketing tool for a range of commercial enterprises, including vendors of food and beverages (Treu, 2012). Therefore, spatial relationships should be incorporated into studies of outdoor advertising and food environments.

In the context of this review, spatial relationships are classified into a typology of: availability, accessibility, exposure, and engagement (see Chapter 1.2.4). Environment and health studies by researchers of various disciplines (e.g., health geography, epidemiology, public health) generally misclassify their analysis as ‘exposure’, when they instead are capturing other spatial relationships. For the purpose of this review, and following from Chapter 1, availability is a term which best describes the number of ads within an area such as a neighbourhood, or a more ‘egocentric’ region, such as one that is defined by a certain distance of an individual (or location such as a house, school, or workplace), measured as a straight line or along a street and/or path in a circulation network. Accessibility can be considered an extension of availability that accounts for the barriers (i.e., cost, time, size, knowledge) and features of the built environment, such as the individual locations
of ads, and is typically measured with GIS techniques using shortest network paths. Exposure can only be determined where direct contact or line of sight can be established between a participant and the source of interest (i.e. a billboard), using GPS tracking or self-reported information about past spatial behaviour. Engagement represents prolonged and often purposeful exposure to a feature, rather than fleeting contact; engagement can be assessed through direct observation of an individual subject or the use of technology such as GPS, which can log the amount of time a participant spends in the line of sight of an outdoor ad.

### 2.1.2 Content Analysis of Advertising

There are a diverse range of approaches to coding the food and beverage content of outdoor advertising. The use of *a priori* classifications based on product type, thematic areas of interest, or the author’s judgement of whether the content is healthy or unhealthy is a straightforward approach. However, government and school board guidance on the nutritional content of products, and their recommended consumption as part of a complete diet could be another approach. The *World Health Organization Nutrient Profile Model, Canada’s Food Guide,* or *British Columbia Guidelines for Food and Beverage Sales in Schools* are examples of governmental guidance materials that could be transformed into a coding system to analyze the content of advertising (*British Columbia Ministry of Health, 2015; Health Canada, 2019; World Health Organization, 2003*). In addition, there are other tools and coding approaches that have been piloted for use generally with coding advertisements based on government policy or piloting with specific populations (*Borges & Jaime, 2019; Bowman et al., 2019; Henderson & Kelly, 2005; Poulos & Pasch, 2015*). The type of coding approach used in analyses of outdoor food and beverage advertising typically depends on the thematic area of interest, or the geographic context of the subject location.

### 2.1.3 Health Equity and Advertising

Equity-based factors at the neighbourhood level are routinely identified as the potential source of differences in advertising exposure, which in turn, may explain some of the disparities in health outcomes among different populations (*Michelle,
Equity in health-oriented research is frequently assessed using the PROGRESS-Plus framework, which includes place of residence, ethnicity, occupation, gender, religion, education, socioeconomic status, social capital, personal characteristics (i.e. age, disability), pathway effects from others (i.e. parents' behaviours), and time-dependent variables (i.e. amount of time with a serious illness) as factors in determining how individual and group-level disparities form in exposures, behaviours, and outcomes (O’Neill et al., 2014). Evaluating studies based on their incorporation of equity-based factors using the PROGRESS-Plus framework supports the identification of factors that should be included in future analyses.

2.2 Methods

A systematic review is a form of research synthesis used to comprehensively identify the available literature on a narrow and well-defined subject. Typically, only peer-reviewed and reputable ‘grey literature’ sources are included in the review. Systematic reviews can be used to gauge the effectiveness of an intervention, survey the use of particular methodologies and theories, and inform future research (Gough et al., 2012). The aim of this systematic review is to survey the use of different spatial analysis methods, and advertising content analysis strategies, to provide guidance for future work. Systematic reviews consist of five steps: 1) scoping the research question and developing the search strategy, 2) deciding the inclusion/exclusion criteria, 3) conducting the search and screening for studies to be included, 4) evaluating the quality of the studies gathered, and 5) synthesizing the results (Cooper et al., 2009; Petticrew & Roberts, 2006). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used as a guideline for reporting the findings of this review (Moher et al., 2009).

2.2.1 Search Strategy

Searches for peer-reviewed journal articles published in English prior to March 2020 were completed for 3 subject-specific databases: ABI/INFORM on ProQuest, PubMed, and Scopus. These databases were selected because respectively they
provide coverage of the business and management sciences, health sciences, and social sciences. Further, prior analysis of these databases revealed there is little overlap and connection between them compared to pairings of other databases (Wray & Minaker, 2019). The search strategy consisted of searching for sets of terms in the title, abstract, or keywords of each source (Table 2-1). Terms included groups of words related to outdoor advertising, and food or beverages, joined by an AND clause between the two groups. In the case of PubMed, searches were performed using the best matching Medical Sub-Headings (MeSH terms). ABI/INFORM and Scopus allows for searching using natural language.

2.2.2 Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were developed from the research question. The criteria were applied at each stage of the search process to eventually render the relevant studies for the review. Articles were included if they had an outcome or explanatory measure related to outdoor food and beverage advertising; and performed some form of spatial analysis. All other studies were excluded. Many studies were excluded because they only used an aspatial self-reported measure of outdoor food and beverage advertising.

2.2.3 Study Processing and Coding

The search results were first downloaded from the search database, and then uploaded to DistillerSR, a systematic review software package. A screening form was developed using the previously described inclusion/exclusion criteria to determine if a study was relevant to the review. Studies were first assessed using this screening form based on their title and abstract in DistillerSR. Full-text versions of the included studies at this stage were then retrieved, evaluated again using the same screening criteria, and then inputted into Zotero bibliographic software if relevant to the study.

The included studies were systematically coded using a standardized form. The following data was extracted from each study: bibliographic information, subject population, type of investigation, context, outcome measures, timing, setting, type of spatial analysis, the geographic unit of analysis, buffer sizes if applicable,
incorporation of PROGRESS-Plus equity factors, coding approach to the content of advertisements, sample size, effect size and confidence intervals if applicable, and overall conclusions.

2.3 Results

Most studies were identified through database searches (n=604) with a few studies additionally identified through searching the reference lists of included articles (n=3). Searches in ABI/INFORM returned 53 potential studies; PubMed returned 316 potential studies; and Scopus returned 235 potential studies. After duplicates were removed, 552 unique studies were screened on title and abstract resulting in the exclusion of 384 studies. The remaining 168 studies were assessed based on their full-text content with 137 being excluded for not being related to outdoor food and beverage advertising and/or not being a spatial-based analysis (Figure 2-1). Given the lack of studies that included an outcome variable, this analysis focuses on features of each analysis.
There were 31 studies determined to be relevant for the review (Table 2-1). Since 2015, the outdoor food and beverage advertising literature has grown with most studies being published in health-related journals. Studies were distributed across multiple age groups, with 2 studies focusing exclusively on adults (age 19 years or older), 6 studies focusing on only children (age 0-12 years), 3 studies on only adolescents (age 13-19 years), and 6 studies including both children and adolescents. All other studies (n=14) looked at their population in general terms. Results are further organized and presented by the type of spatial analysis, the coding system used for advertising content, and incorporation of PROGRESS-Plus health equity factors.
<table>
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<th>Sample Size</th>
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**2.3.1 Spatial Analysis**

Most studies (n=25) conducted a spatial analysis that assessed the availability of food and beverage advertising in at a regional (n=9), neighbourhood (n=9), or built environment feature (n=7) scale (J. Adams et al., 2011; Adjoian et al., 2019; Amanzadeh et al., 2015; Barquera et al., 2018; Basch et al., 2019; Bragg, Hardoby, et al., 2017; Bragg, Pageot, et al., 2017; Cassady et al., 2015; Fagerberg et al., 2019; Goryakin et al., 2015; Herrera & Pasch, 2018; Hillier et al., 2009; Isgor et al., 2016; Kelly et al., 2008, 2015; Lesser et al., 2013; Lucan et al., 2017; Maher et al., 2005; Moodley et al., 2015; Nelson et al., 2020; Parnell et al., 2019; Pinto et al., 2007; Sainsbury et al., 2017; Settle et al., 2014; Yancey et al., 2009). A small group of studies (n=4) determined the accessibility of advertising to children and adolescents based on their school, with all studies using a street network buffer or path-based spatial analysis technique (Egli et al., 2019; Godin et al., 2017; Velazquez et al., 2019; Walton et al., 2009). None of the studies incorporated cost-based measures in the development of their networks.

One study assessed exposure to food and beverage advertising using GPS-enabled video cameras with children (Liu et al., 2019). The analysis did not incorporate any variable to measure the level of engagement with an ad, relying on just the geographic data. Moreover, one study assessed engagement with food and beverage advertising (Signal et al., 2017), using the same methodology and population as the previous study. For studies that made use of Euclidian or network-based buffers, sizes ranged from 250m to 2000m, with the median at 800m.

**2.3.2 Coding Approaches**

The majority of studies make use of *a priori* classification approaches to coding the content of outdoor food and beverage advertising, either using a generic classification of healthy/unhealthy or product type (n=12), or thematic groupings,
such as pricing, cultural references, colour, or visual effectiveness, that are of interest to the authors (n=4). The next popular choice is to adapt existing national and sub-national guidance on foods and beverages, often contained in a country’s food guide, to create categories for coding advertising content based on their healthfulness or dietary grouping (n=9). The World Health Organization's standards are also commonly adapted in this way (n=4). The NOVA Classification system (n=1) and a bespoke nutrient profile model (n=1) were also used in some analyses.

2.3.3 Inclusion of Health Equity Factors

The most popular health equity factor included in analyses was socioeconomic status (n=23), with some studies making use of a multiple deprivation index score, which resulted in the inclusion of occupation (n=2), education (n=8), and social capital (n=1). The second most included equity factor was ethnicity (n=12), followed by personal characteristics such as age (n=7), gender (n=5), place of residence (n=5), and number of days in school (n=1). No studies considered religion or pathway dependency as a factor in their analyses, and five studies did not include any PROGRESS-Plus equity factor as a component of their analysis.

2.4 Discussion

Outdoor advertising remains a relatively understudied topic in the community nutrition environment literature. Many studies are mainly descriptive in their design with no outcome measures even at a group or neighbourhood level of analysis. Among these studies, there is no consensus on the approach to coding the nutritional content, healthfulness, or messaging of these advertisements. The labelling of food and beverages as 'healthy' or 'unhealthy' is a value-laden exercise rife with political and social actors. These actors form a web of constantly shifting evidence of risk that results in analyses that reduce complex social relationships with the food environment to simplistic models (Krieger, 1999). Therefore, future analyses should more critically reflect on the ascribing of value, risk, and harm to particular types of foods and beverages.
Studies of outdoor advertising have typically relied on descriptive methods with no health or behavioural outcome measure. Most studies simply audit a defined environment, and then compare the number of ads based on the ethnicity or socioeconomic status of a neighbourhood statistical unit (i.e. block group, dissemination area, census tract, electoral ward). These studies typically conclude that distributions of food and beverage advertising inherently have a disproportionate affect on low-income or visible minority populations; however, there are few studies that include health equity variables beyond socioeconomic status and ethnicity at a group or regional level.

There does appear to be an emerging link between the density of sugar-sweetened beverage advertising and resulting consumption (Basch et al., 2019; Lesser et al., 2013). In addition, there is some circumstantial evidence that unhealthy outdoor food and beverage advertising clusters around child-serving institutions (Barquera et al., 2018; Herrera & Pasch, 2018; Hillier et al., 2009; Kelly et al., 2015). However, none of the studies have effectively assessed the exposure-response relationship between outdoor advertising and dietary behaviour, as has been assessed for television and social media (Baldwin et al., 2018; Fleming-Milici & Harris, 2020; Halford et al., 2004; Harris et al., 2009).

There are only two (related) studies that have assessed the influence of exposure to outdoor food and beverage advertising, and diet-related outcomes. The KidsCam study used cameras and GPS trackers to record the daily interactions ~160 children had with their environments over four days in Wellington, New Zealand (Liu et al., 2019; Signal et al., 2017). Replication of these studies would be impractical and improbable given the ethical considerations of recording individual children in their daily life, in both public and private locations, and inadvertently recording non-participants in the study. These two studies did collect high-quality spatiotemporal data about exposures to, and engagement with, food and beverage advertising. Yet, they did not report affects on dietary behaviour or associated health outcomes from exposure to advertising, even though body mass index was reported as a descriptive variable collected as part of the study. However, the KidsCam study provides an
example of methodological innovations that could be adapted to the Canadian context to ensure non-participant privacy and avoiding recording in private spaces like the home. Cameras could be equipped with GPS units to automatically stop recording when entering a demarcated private space. In addition, Egli et al. (2019) provide an alternative approach by using Google Street View to estimate outdoor advertising exposure.

A troubling observation from this review is many studies operate from an epistemological basis that outdoor food and beverage advertising is inherently negative for diet-related behaviours and outcomes. However, much of the evidence cited in the background sections of these studies relies on the assumption that relationships observed in studies of other advertising mediums (i.e. television, digital, point-of-sale) are easily transferable to outdoor advertising such as billboards. The results from this review taken in aggregate would suggest that there is no evidence to support these claims. In short, there is no well-established link in the literature between outdoor food and beverage advertising and dietary behaviour among any population group.

Many local, provincial, and federal governments have attempted to regulate food and beverage advertising (Wilde, 2009). Some municipalities have even implemented strict land use policies in attempts to ban unhealthy food outlets from locating in areas with high rates of obesity (Stephens, 2007). However, follow-up analyses from these regulatory initiatives have found no effect on obesity rates in these communities years after the ban (Sturm & Hattori, 2015). People are not restricted to their home or school environment; they have wide-ranging activity spaces that can span many different settings in a community (Brown & Brewster, 2015). Claims about the effects of outdoor advertising on dietary behaviour must be supported by studies that capture exposure or engagement with food and beverage advertising content, and diet-related outcome measures. Research that uses individual-level data and isolates the effects of outdoor advertising would potentially support, or discourage, these types of regulatory initiatives.
Future research should be targeted towards undertaking observational studies that compare exposure to, or engagement with, outdoor food and beverage advertising with health-related outcome measures. These studies should incorporate more health equity variables to determine if there is variability by specific population group. The reliance on Euclidian buffers and statistical neighbourhood units in many analyses, also does not capture the full range of potential exposures in the community nutrition environment (Sadler et al., 2011; Sadler & Gilliland, 2015). Future spatial analyses should make use of network or observed GPS approaches to capturing accessibility, exposure, and engagement with advertising. Furthermore, there is a need for greater precision in describing spatial relationships between features of the built environment and subject individuals and/or groups in all types of geographic research. This review demonstrates that many studies purport to describe an exposure-response relationship, even though upon closer examination they describe much different spatial relationships and processes.
2.5 References


Brown, D. R., & Brewster, L. G. (2015). The food environment is a complex social network. Social Science & Medicine, 133, 202–204. https://doi.org/10.1016/j.socscimed.2015.03.058


Poulos, N. S., & Pasch, K. E. (2015). The Outdoor MEDIA DOT: The development and inter-rater reliability of a tool designed to measure food and beverage outlets and outdoor advertising. Health & Place, 34, 135–142. https://doi.org/10.1016/j.healthplace.2015.05.007


3. Availability and accessibility of outdoor advertising is related to the food and beverage purchasing habits of adolescents: A multi-level geospatial investigation

**BACKGROUND:** The information environment is an understudied component of the consumer nutrition environment. This study examines adolescents’ purchasing habits at retail food outlets based on the availability and accessibility of outdoor food and beverage advertising, considering individual demographics and consumption attitudes.

**METHODS:** Data were drawn from a baseline survey from a large intervention study involving adolescents (n=545) in four high schools of a mid-size Canadian region. An 800m buffer around each adolescent participant’s home, and shortest network path between home and school, were used to measure, respectively, the availability and accessibility of outdoor food and beverage advertising. A negative binomial regression model was used to estimate separately the relationships between outdoor advertising availability and accessibility, along with consumption attitudes, and retail food outlet purchasing.

**RESULTS:** The availability and accessibility of advertising is associated with fast food, slow food, and grocery purchasing patterns among adolescents. Consumption attitudes are also associated with food and beverage purchasing, in addition to cultural background and gender. There were no meaningful differences between the use of buffers (availability) or shortest network path (accessibility) in measuring potential exposure to advertising.

**DISCUSSION:** This study makes a novel contribution to research on outdoor advertising and purchasing. Policy and practitioner interest in regulating outdoor advertising would benefit from more marketing studies with purchasing or health-related outcome measures. Future studies should consider more complex spatial analysis techniques that capture exposure to, or engagement with, advertising.
3.1 Background

The food environment is a well-established contributor to population health and wellbeing. Accessibility to healthy and unhealthy retail food outlets is a widely recognized social determinant of health with wide-ranging ramifications across the lifecourse (Caspi et al., 2012; Health Canada, 2019b). Framing food environments in terms of the socio-ecological model of health suggests that individual, social, and environmental factors combine to affect dietary behaviours (Bronfenbrenner, 1992; Brown & Brewster, 2015; Story et al., 2008). Dietary behaviours have been linked to a wide range of chronic diseases including heart disease, liver disease, and multiple cancers (Fitzmaurice et al., 2017; Lim et al., 2012; Micha et al., 2017; World Health Organization, 2003). Among adolescents, diet has been linked to physical health, mental wellbeing, social and cognitive development, and academic performance (Dobbins et al., 2017; Jessri et al., 2016; Schwingshackl et al., 2018). The investigation of adolescent diets is important, as practices and behaviours formed during teenage years carry on through later life, having long-term impacts to health and wellbeing.

The food environment as it relates to consumption and purchasing can be classified into seven spheres of influence – institutional, community, organizational, consumer, information, psychosocial, and perceptual (Glanz et al., 2005). The spheres all contribute to food and beverage consumption behaviours, habits, and preferences (Caspi et al., 2012; He et al., 2012; Leiss et al., 2005; Steel, 2009; Wilkins et al., 2019). While there has been much research into many areas of the consumer nutrition environment, little research has focused on the information environment, particularly the role of outdoor advertising in shaping adolescent purchasing and consumption. Prior research has identified the local retail food environment as an important component of adolescent food purchasing and dietary behaviours (He et al., 2012; Sadler et al., 2016). Several studies have assumed a relationship exists between outdoor food and beverage advertising and purchasing or other health disparities (Barquera et al., 2018; Godin et al., 2017; Lesser et al., 2013; W. Liu et al., 2019; Signal et al., 2017; Velazquez et al., 2019). However, these studies have been
only descriptive of outdoor advertising distributions, and there remains little research of the link between outdoor food and beverage advertising and subsequent purchasing among any population group.

This study examines adolescents’ purchasing habits at retail food outlets in relation to (1) the availability of outdoor food and beverage advertising in the environments surrounding their home and school; and (2) the accessibility of outdoor advertising on the journey between home and school. This study also examines how diet-related consumption attitudes attenuate the relationship between outdoor food and beverage advertising availability and accessibility and purchasing habits.

3.2 Methods

The purpose of this analysis is two-fold. First, the associations of individual and environmental variables (i.e. outdoor food and beverage advertising) are examined with individual and sociocultural variables on purchasing at retail food outlets. Second, differences are identified in the results derived from the use of two common spatial analysis techniques – buffers and shortest network paths – in environmental health research.

References to ads or outdoor advertising in this analysis encompasses both traditional outdoor advertising on billboards, bus shelters, or street-level posters, as well as retail food outlets, as their design and placement on a property are typically an advertisement in their own right (Ozelkan, 2019; Treu, 2012). Retail food outlets and advertisements are categorized into four types: fast food, slow food, grocery, and variety (Tucker et al., 2008). Fast food includes quick-service restaurants, chains, coffee shops, food courts, and other outlets where food is ordered from a counter. This category also includes outlets with limited to no seating that are focused on takeout or delivery. Slow food includes sit-down restaurants, bars, pubs, and other establishments that offer table-based service. Grocery includes stores that sell fresh and package food, as well as farmers markets, bakeries, and other more focused food and beverage retail stores. Variety includes convenience and mart-type
outlets that are typically found on residential street corners or in commercial plazas and gas stations selling packaged food and beverages.

3.2.1 Data Collection

Participant data for this analysis is sourced from a large multi-year intervention study (www.smartappetite.ca) of adolescents in four schools in the census metropolitan area (CMA) of London, Ontario, a mid-size Canadian community with a population of 494,069 (Statistics Canada, 2018). The study was approved by Western University’s Non-Medical Research Ethics Board (NMREB #107034) as well as the research and assessment office of the London District Catholic School Board. This study included survey responses from the baseline timepoint of the 2018-19 survey for all participants who also reported a valid postal code in the study region. Surveys were conducted in schools with provided tablets or the participant’s own device (i.e., wi-fi enabled smartphone, tablet, or laptop). Surveys consisted of questions about health behaviours, knowledge, and attitudes with a particular focus on diet-related factors.

Data on all retail food outlets in the region were sourced from the local health unit’s food safety inspection database (Middlesex-London Health Unit, 2020). The retail food outlet data included the complete addresses of every outlet by type (e.g., fast food, grocery). Advertising data was collected through field audits during the summer and fall of 2018 by a team of researchers from the Human Environments Analysis Laboratory at Western University, relying on data on potential advertising locations from local municipalities in the region. Photographs were taken of each outdoor billboard, transit shelter, and street-level poster in the entire metropolitan area. These photographs were then coded by independent reviewers to determine the food and beverage content of each advertisement (Bowman et al., 2019).

3.2.2 Data Processing

Individual-level variables include age (13-19 years), gender (boy or girl), and cultural background (White compared to Asian, Black, Latinx, Middle Eastern, and other non-White groups) from the survey. Given the large proportion of missing data on household income, an area-level indicator for socio-economic status was
calculated as the percentage of households in the participant’s home postal code that fall below the median household income of the CMA (Statistics Canada, 2019). Three of the four schools involved in the analysis have a similar food environment (less than 3 outlets or billboards within 1200m), so this variable is transformed into a binary variable of one school with a saturated food environment (1) and grouping the three schools with a sparse food environment (0). Statements about consumption attitudes are coded on a Likert scale (1-5) from strongly agree to strongly disagree. For the primary outcome measure, participants self-report the number of purchases by retail food outlet type they make on average per week or month, which is then converted so that all measures are a per month average. Survey questions are found in Appendix C.

Spatial data was processed using ArcGIS Pro 2.5.1 (Esri, 2020). An 800m Euclidian buffer was derived around the centroid of each participant’s postal code to count the number of retail food outlets and advertisements that were available within 800 metres of a participant’s home. Further, a shortest network path was calculated between the centroid of the participant’s home postal code and the street entrance of their school using a road and major pathways network (DMTI Spatial, 2019). A buffer of 100m around this path was used to simulate visual accessibility to advertising and retail food outlets on the journey between home and school (Chmielewski & Tompalski, 2017).

3.2.3 Statistical Analysis
Poisson models are typically used with dependent count variables; however, food purchases were overdispersed in these data (Richards, 2008); therefore, a negative binomial regression model was selected for the analysis (Cameron & Trivedi, 2013). This choice of test is appropriate given the dependent variable of interest being count data, and the theoretical construct being a dose-response relationship between the dependent variable (i.e. purchases) and the explanatory variable (i.e. advertising) of interest (Cameron & Trivedi, 2013; Dupont, 2002; Long, 1997; Venables & Ripley, 2002). B. Liu et al. (2020) used this test in a similar analysis of exposure to fast food outlets and purchasing.
For each purchasing outcome (i.e. fast food, slow food, grocery, variety), which is treated as a continuous variable, a series of models were run to illustrate differences in spatial analysis techniques and theoretical constructs. The first group of models use the buffer calculation to represent advertising availability with individual-level sociodemographic variables. Another group of models was run to examine only the sociodemographic and participants’ consumption attitudes (Model 2). Finally, these two models were combined into one group of models (Model 3). Models are presented by their theoretical construct – advertising versus consumption attitudes versus both – grouped by their retail food outlet type and compared based on their spatial analysis method for the availability (i.e. buffers) and accessibility (i.e. shortest network path) of advertising.

All statistical analyses were completed using R Stats v3.6.3 (R Core Team, 2020). Negative binomial regression models were run using the glm.nb function in the MASS package (Venables & Ripley, 2002). A variable inflation factor analysis using the vif function in the CAR package was run to determine if there were any correlations between explanatory variables in all models (Fox & Weisberg, 2019). In addition, Akaike information criterion (AIC) scores and Bayesian information criterion (BIC) scores were used to compare the overall fit of the availability and accessibility models (Aho et al., 2014; Burnham & Anderson, 2004; Kuha, 2004).

### 3.3 Results

The analysis includes 545 participants from the 2018-19 sampling campaign of the larger intervention study and who reported a valid home postal code (Table 3-1). Students range in age from 13-19 years old, typical of most Ontario high schools. The sample includes more females (n=342) than males (n=201). There is a diverse group of ethnicities represented in the study, including Asian (n=65), Black (n=40), Latinx (n=44), Middle Eastern (n=39), and other non-white (n=46) cultural communities. School B (n=180) has a saturated food environment with a high density of retail food outlets, while Schools A, C, and D (n=365) have a sparse food environment, with a low density of retail food outlets nearby. The availability of
advertising and retail food outlets within 800m of a participant’s home tends to be made up of fast food and variety stores, with at least 70% of participants in close proximity to at least one fast food outlet, and 62% in proximity to at least one variety outlet. This trend of access to fast food (increase to 80%) and variety stores (increase to 76%) is further pronounced when looking at the journey between home and school, with more slow food outlets becoming more accessible, with 78% of participants accessible to at least one outlet.

Table 3-1. Sociodemographic and contextual factors among participants

<table>
<thead>
<tr>
<th>Demographic Factors</th>
<th>Motevar</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Category</td>
<td>n (%)</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>15 (3%)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>129 (23%)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>132 (24%)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>129 (23%)</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>115 (21%)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>17 (4%)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>2 (1%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>6 (1%)</td>
<td></td>
</tr>
<tr>
<td><strong>Gender identity (binary, ref. Female)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>201 (37%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>342 (62%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>2 (1%)</td>
<td></td>
</tr>
<tr>
<td><strong>Cultural background (categorical, ref. White)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>65 (12%)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>40 (7%)</td>
<td></td>
</tr>
<tr>
<td>Latinx</td>
<td>44 (8%)</td>
<td></td>
</tr>
<tr>
<td>Middle Eastern</td>
<td>39 (7%)</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>307 (56%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>46 (8%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>4 (2%)</td>
<td></td>
</tr>
<tr>
<td><strong>Availability or accessibility of advertising (continuous)(^1)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Ads Buffer (800m)</td>
<td>SNP (100m)</td>
</tr>
<tr>
<td>Fast Food</td>
<td>0</td>
<td>166 (30%)</td>
</tr>
<tr>
<td>Slow Food</td>
<td>&gt;1</td>
<td>379 (70%)</td>
</tr>
<tr>
<td>Grocery</td>
<td>0</td>
<td>246 (45%)</td>
</tr>
<tr>
<td>Variety</td>
<td>&gt;1</td>
<td>299 (55%)</td>
</tr>
<tr>
<td>All types</td>
<td>0</td>
<td>353 (65%)</td>
</tr>
<tr>
<td>Missing</td>
<td>&gt;1</td>
<td>192 (35%)</td>
</tr>
<tr>
<td><strong>% Households below median income (continuous)(^1)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 20%</td>
<td>13 (2%)</td>
<td></td>
</tr>
<tr>
<td>20 – 39%</td>
<td>161 (30%)</td>
<td></td>
</tr>
<tr>
<td>40 – 59%</td>
<td>183 (34%)</td>
<td></td>
</tr>
<tr>
<td>60 – 79%</td>
<td>143 (26%)</td>
<td></td>
</tr>
<tr>
<td>&gt; 80%</td>
<td>45 (8%)</td>
<td></td>
</tr>
<tr>
<td><strong>School (binary, School B vs. all other schools)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School A (HC)</td>
<td>75 (14%)</td>
<td></td>
</tr>
<tr>
<td>School B</td>
<td>180 (33%)</td>
<td></td>
</tr>
<tr>
<td>School C</td>
<td>209 (38%)</td>
<td></td>
</tr>
<tr>
<td>School D</td>
<td>81 (15%)</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Variables are presented in categorical formats in this table to illustrate distributions among participants, and are treated as continuous variables in the analysis.
Table 3-2. Food and beverage consumption attitudes among participants

<table>
<thead>
<tr>
<th>Consumption Attitudes</th>
<th>Statement</th>
<th>Indicator</th>
<th>Statistic</th>
<th>cont’d.</th>
<th>Statement</th>
<th>Indicator</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eating healthy food is important to me</td>
<td>Mean response (1-5)</td>
<td>1.84</td>
<td></td>
<td>I have no problem understanding food labels</td>
<td>Mean response (1-5)</td>
<td>2.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard deviation</td>
<td>0.67</td>
<td></td>
<td></td>
<td>Standard deviation</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Valid n</td>
<td>542</td>
<td></td>
<td></td>
<td>Valid n</td>
<td>542</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missing n</td>
<td>3</td>
<td></td>
<td></td>
<td>Missing n</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>I like to cook</td>
<td>Mean response (1-5)</td>
<td>2.26</td>
<td></td>
<td>Cooking meals helps me eat healthier</td>
<td>Mean response (1-5)</td>
<td>2.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard deviation</td>
<td>0.93</td>
<td></td>
<td></td>
<td>Standard deviation</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Valid n</td>
<td>538</td>
<td></td>
<td></td>
<td>Valid n</td>
<td>542</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missing n</td>
<td>7</td>
<td></td>
<td></td>
<td>Missing n</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Preparing lunch at home saves money</td>
<td>Mean response (1-5)</td>
<td>1.74</td>
<td></td>
<td>Preparing lunch at home takes too much time</td>
<td>Mean response (1-5)</td>
<td>2.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard deviation</td>
<td>0.74</td>
<td></td>
<td></td>
<td>Standard deviation</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Valid n</td>
<td>541</td>
<td></td>
<td></td>
<td>Valid n</td>
<td>542</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missing n</td>
<td>4</td>
<td></td>
<td></td>
<td>Missing n</td>
<td>3</td>
</tr>
</tbody>
</table>

Participants reported a range of attitudes about eating, cooking, and packing lunch for school (Table 3-2). Most agree that eating healthy food is important and preparing lunch at home saves money; however, some students expressed preparing lunch at home takes too much time. Moreover, some students expressed strong interest in cooking, recognizing its health benefits, and many are confident in their ability to understand food and beverage labels.

3.3.1 Model 1: Advertising Models

The first set of models combines sociodemographic and contextual variables with advertising availability and accessibility (Table 3-3 & Table 3-4). In the case of fast food purchases, fast food ads have a marginally positive relationship (Incident Rate Ratio (IRR)=1.02 [95% CI=1.00,1.05]) while variety ads have a significant negative relationship (IRR=0.94 [0.90,0.99]) when using buffers around the home. These associations are not present in the shortest network path model. Saturated school participants make more fast food purchases than their peers at other schools in both models: buffer (IRR=1.26 [1.06,1.51]) and shortest network path (IRR=1.40 [1.12,1.75]). In the case of slow food purchases, fast food ads have a positive relationship (IRR=1.04 [1.01,1.07]) in the buffer model, but a marginally significant
negative relationship (IRR=0.98 [0.95,1.00]) in the network model. Variety ads have a significant negative association (IRR=0.90 [0.85,0.96]) with slow food purchases in only the buffer model. Boys purchase less slow food than girls (IRRBuffer=0.79 [0.66,0.96]; IRRNetwork=0.81 [0.67,0.98]), and Latinx participants are estimated to have a significantly higher count of slow food purchases in both models (IRRBuffer=1.79 [1.31,2.45]; IRRNetwork=1.72 [1.25,2.37]). The school environment does not significantly relate to slow food purchases in either model.

Table 3-3. Sociodemographic and advertising model for fast food and slow food purchases (Model 1)

<table>
<thead>
<tr>
<th>Dependent Variable, IRR (95% CI):</th>
<th>Fast Food Purchases</th>
<th>Slow Food Purchases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buffers</td>
<td>Network</td>
</tr>
<tr>
<td>Fast food ads</td>
<td>1.02*</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>(1.00,1.05)</td>
<td>(0.97,1.01)</td>
</tr>
<tr>
<td>Slow food ads</td>
<td>0.98^</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>(0.94,1.01)</td>
<td>(0.98,1.04)</td>
</tr>
<tr>
<td>Grocery ads</td>
<td>0.99</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>(0.89,1.10)</td>
<td>(0.97,1.14)</td>
</tr>
<tr>
<td>Variety ads</td>
<td>0.94***</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.90,0.99)</td>
<td>(0.97,1.04)</td>
</tr>
<tr>
<td>Gender, Male</td>
<td>0.89^</td>
<td>0.88^</td>
</tr>
<tr>
<td></td>
<td>(0.76,1.04)</td>
<td>(0.75,1.03)</td>
</tr>
<tr>
<td>Age</td>
<td>1.01</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>(0.95,1.08)</td>
<td>(0.96,1.08)</td>
</tr>
<tr>
<td>Asian (ref. White)</td>
<td>0.86</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>(0.67,1.10)</td>
<td>(0.68,1.12)</td>
</tr>
<tr>
<td>Black</td>
<td>1.16</td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>(0.86,1.55)</td>
<td>(0.85,1.54)</td>
</tr>
<tr>
<td>Latinx</td>
<td>0.92</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>(0.68,1.25)</td>
<td>(0.65,1.19)</td>
</tr>
<tr>
<td>Middle Eastern</td>
<td>0.84</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>(0.61,1.15)</td>
<td>(0.65,1.21)</td>
</tr>
<tr>
<td>Other non-white</td>
<td>1.15</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>(0.87,1.51)</td>
<td>(0.86,1.49)</td>
</tr>
<tr>
<td>% Low income</td>
<td>1.61*</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>(0.96,2.69)</td>
<td>(0.75,2.03)</td>
</tr>
<tr>
<td>Saturated school</td>
<td>1.26***</td>
<td>1.40***</td>
</tr>
<tr>
<td></td>
<td>(1.06,1.51)</td>
<td>(1.12,1.75)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.54***</td>
<td>3.61***</td>
</tr>
<tr>
<td></td>
<td>(1.34,9.37)</td>
<td>(1.35,9.62)</td>
</tr>
<tr>
<td>Observations</td>
<td>494</td>
<td>494</td>
</tr>
<tr>
<td>Cragg-Uhler R²</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>McFadden R²</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Akaike Inf. Crit.</td>
<td>2674.31</td>
<td>2680.18</td>
</tr>
<tr>
<td>Bayes Inf. Crit.</td>
<td>2737.35</td>
<td>2743.21</td>
</tr>
</tbody>
</table>

Note: ^p<0.2; *p<0.1; **p<0.05; ***p<0.01
Table 3-4. Sociodemographic and advertising model for grocery and variety purchases (Model 1)

<table>
<thead>
<tr>
<th></th>
<th>Grocery Purchases</th>
<th></th>
<th>Variety Purchases</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buffers</td>
<td>Network</td>
<td>Buffers</td>
<td>Network</td>
</tr>
<tr>
<td>Fast food ads</td>
<td>1.01</td>
<td>1.02*</td>
<td>1.02*</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.99,1.03)</td>
<td>(1.00,1.04)</td>
<td>(0.99,1.05)</td>
<td>(0.98,1.03)</td>
</tr>
<tr>
<td>Slow food ads</td>
<td>0.98*</td>
<td>0.97***</td>
<td>0.98</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.95,1.00)</td>
<td>(0.95,0.99)</td>
<td>(0.93,1.02)</td>
<td>(0.97,1.03)</td>
</tr>
<tr>
<td>Grocery ads</td>
<td>0.97</td>
<td>0.95^</td>
<td>0.97</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>(0.89,1.06)</td>
<td>(0.89,1.02)</td>
<td>(0.85,1.11)</td>
<td>(0.89,1.09)</td>
</tr>
<tr>
<td>Variety ads</td>
<td>1.02</td>
<td>1.01</td>
<td>0.97</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.98,1.06)</td>
<td>(0.99,1.04)</td>
<td>(0.91,1.03)</td>
<td>(0.96,1.04)</td>
</tr>
<tr>
<td>Gender, Male</td>
<td>0.87**</td>
<td>0.86**</td>
<td>1.10</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>(0.77,1.00)</td>
<td>(0.76,0.98)</td>
<td>(0.90,1.35)</td>
<td>(0.91,1.35)</td>
</tr>
<tr>
<td>Age</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>(0.93,1.03)</td>
<td>(0.93,1.03)</td>
<td>(0.91,1.06)</td>
<td>(0.91,1.06)</td>
</tr>
<tr>
<td>Asian (ref. White)</td>
<td>1.04</td>
<td>1.04</td>
<td>1.30*</td>
<td>1.33</td>
</tr>
<tr>
<td></td>
<td>(0.84,1.27)</td>
<td>(0.85,1.28)</td>
<td>(0.95,1.77)</td>
<td>(0.98,1.82)</td>
</tr>
<tr>
<td>Black</td>
<td>0.98</td>
<td>0.94</td>
<td>1.51**</td>
<td>1.47**</td>
</tr>
<tr>
<td></td>
<td>(0.76,1.25)</td>
<td>(0.74,1.21)</td>
<td>(1.04,2.20)</td>
<td>(1.01,2.13)</td>
</tr>
<tr>
<td>Latinx</td>
<td>1.08</td>
<td>1.06</td>
<td>1.57**</td>
<td>1.49**</td>
</tr>
<tr>
<td></td>
<td>(0.84,1.39)</td>
<td>(0.82,1.36)</td>
<td>(1.08,2.29)</td>
<td>(1.02,2.19)</td>
</tr>
<tr>
<td>Middle Eastern</td>
<td>1.28**</td>
<td>1.30**</td>
<td>1.18</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>(1.00,1.63)</td>
<td>(1.02,1.65)</td>
<td>(0.79,1.74)</td>
<td>(0.82,1.77)</td>
</tr>
<tr>
<td>Other non-white</td>
<td>0.87</td>
<td>0.83^</td>
<td>1.56***</td>
<td>1.54***</td>
</tr>
<tr>
<td></td>
<td>(0.69,1.10)</td>
<td>(0.66,1.05)</td>
<td>(1.11,1.21)</td>
<td>(1.10,1.21)</td>
</tr>
<tr>
<td>% Low income</td>
<td>0.59***</td>
<td>0.82</td>
<td>0.86</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>(0.39,0.90)</td>
<td>(0.55,1.22)</td>
<td>(0.45,1.65)</td>
<td>(0.45,1.58)</td>
</tr>
<tr>
<td>Saturated school</td>
<td>1.00</td>
<td>0.86*</td>
<td>1.35***</td>
<td>1.31*</td>
</tr>
<tr>
<td></td>
<td>(0.86,1.16)</td>
<td>(0.71,1.03)</td>
<td>(1.07,1.69)</td>
<td>(0.99,1.73)</td>
</tr>
<tr>
<td>Constant</td>
<td>9.69***</td>
<td>8.26***</td>
<td>3.64**</td>
<td>3.51***</td>
</tr>
<tr>
<td></td>
<td>(4.35,21.39)</td>
<td>(3.70,18.40)</td>
<td>(10.6,12.46)</td>
<td>(10.2,12.07)</td>
</tr>
</tbody>
</table>

Observations: 493 493 487 487

crugg-Uhler R²: 0.05 0.06 0.05 0.04
McFadden R²: 0.01 0.01 0.01 0.01
Akaike Inf. Crit.: 2581.89 2576.43 2284.98 2287.09
Bayes Inf. Crit.: 2644.89 2639.44 2347.81 2349.91

Note: ^p<0.2; *p<0.1; **p<0.05; ***p<0.01
3.3.2 Model 2: Consumption Attitudes

The second group of models examines the influence of sociodemographic factors and consumption attitudes on purchases (Table 3-5). Participants who express that eating healthy food is important to them are significantly less likely (IRR=1.20 [1.07,1.35]) to purchase fast food. Participants who expressed they were confident with food labels are more likely to make a slow food (IRR=0.89 [0.80,0.99]) or grocery purchase (IRR=0.93 [0.86,1.00]). Those who like to cook are less likely to make fast food (IRR=1.10 [1.01,1.20]) and slow food purchases (IRR=1.15 [1.04,1.28]). Those who prepare their lunch to save money are less likely to make fast food purchases (IRR=1.13 [1.02,1.25]), while those who said they did not have enough time to prepare their lunch for school are significantly more likely to make fast food (IRR=0.88 [0.82,0.94]) and variety store purchases (IRR=0.89 [0.82,0.98]), and less likely to make grocery purchases (IRR=1.06 [1.00,1.13]). School and cultural background had similar relationships to the previous set of models across all types of purchases.
### Table 3-5. Sociodemographic and consumption attitudes model for all types (Model 2)

<table>
<thead>
<tr>
<th></th>
<th>Fast Food</th>
<th>Slow Food</th>
<th>Grocery</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy eating</td>
<td>1.20***</td>
<td>1.10</td>
<td>0.98</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(1.07,1.35)</td>
<td>(0.95,1.27)</td>
<td>(0.89,1.09)</td>
<td>(0.86,1.17)</td>
</tr>
<tr>
<td>Know labels</td>
<td>0.97</td>
<td>0.89**</td>
<td>0.93**</td>
<td>0.92^</td>
</tr>
<tr>
<td></td>
<td>(0.89,1.06)</td>
<td>(0.80,0.99)</td>
<td>(0.86,1.00)</td>
<td>(0.82,1.03)</td>
</tr>
<tr>
<td>Like to cook</td>
<td>1.10**</td>
<td>1.15***</td>
<td>0.99</td>
<td>1.04</td>
</tr>
<tr>
<td></td>
<td>(1.01,1.20)</td>
<td>(1.04,1.28)</td>
<td>(0.92,1.07)</td>
<td>(0.93,1.17)</td>
</tr>
<tr>
<td>Cook for health</td>
<td>0.98</td>
<td>0.91*</td>
<td>1.06*</td>
<td>1.04</td>
</tr>
<tr>
<td></td>
<td>(0.89,1.07)</td>
<td>(0.81,1.01)</td>
<td>(0.98,1.14)</td>
<td>(0.93,1.17)</td>
</tr>
<tr>
<td>Cook to save</td>
<td>1.13**</td>
<td>1.01</td>
<td>1.05</td>
<td>1.12*</td>
</tr>
<tr>
<td></td>
<td>(1.02,1.25)</td>
<td>(0.89,1.15)</td>
<td>(0.96,1.15)</td>
<td>(0.98,1.28)</td>
</tr>
<tr>
<td>No time to cook</td>
<td>0.88***</td>
<td>0.94^</td>
<td>1.06**</td>
<td>0.89***</td>
</tr>
<tr>
<td></td>
<td>(0.82,0.94)</td>
<td>(0.87,1.02)</td>
<td>(1.00,1.13)</td>
<td>(0.82,0.98)</td>
</tr>
<tr>
<td>Gender, Male</td>
<td>0.89^</td>
<td>0.77***</td>
<td>0.83***</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>(0.76,1.04)</td>
<td>(0.63,0.94)</td>
<td>(0.73,0.95)</td>
<td>(0.88,1.32)</td>
</tr>
<tr>
<td>Age</td>
<td>1.00</td>
<td>0.95^</td>
<td>0.99</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>(0.94,1.06)</td>
<td>(0.88,1.02)</td>
<td>(0.94,1.05)</td>
<td>(0.90,1.05)</td>
</tr>
<tr>
<td>Asian (ref. White)</td>
<td>0.87</td>
<td>1.11</td>
<td>1.02</td>
<td>1.30*</td>
</tr>
<tr>
<td></td>
<td>(0.68,1.12)</td>
<td>(0.83,1.49)</td>
<td>(0.83,1.26)</td>
<td>(0.95,1.77)</td>
</tr>
<tr>
<td>Black</td>
<td>1.17</td>
<td>0.72^</td>
<td>0.98</td>
<td>1.53**</td>
</tr>
<tr>
<td></td>
<td>(0.87,1.56)</td>
<td>(0.48,1.09)</td>
<td>(0.76,1.26)</td>
<td>(1.05,2.23)</td>
</tr>
<tr>
<td>Latinx</td>
<td>0.88</td>
<td>1.66***</td>
<td>1.09</td>
<td>1.53**</td>
</tr>
<tr>
<td></td>
<td>(0.65,1.18)</td>
<td>(1.21,1.26)</td>
<td>(0.85,1.40)</td>
<td>(1.05,2.22)</td>
</tr>
<tr>
<td>Middle Eastern</td>
<td>0.91</td>
<td>0.84</td>
<td>1.34**</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>(0.67,1.23)</td>
<td>(0.58,1.22)</td>
<td>(1.06,1.70)</td>
<td>(0.83,1.78)</td>
</tr>
<tr>
<td>Other non-white</td>
<td>1.16</td>
<td>0.87</td>
<td>0.86</td>
<td>1.53***</td>
</tr>
<tr>
<td></td>
<td>(0.89,1.51)</td>
<td>(0.62,1.23)</td>
<td>(0.68,1.10)</td>
<td>(1.09,2.15)</td>
</tr>
<tr>
<td>% Low income</td>
<td>1.18</td>
<td>1.11</td>
<td>0.70*</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>(0.74,1.87)</td>
<td>(0.63,1.95)</td>
<td>(0.47,1.03)</td>
<td>(0.44,1.46)</td>
</tr>
<tr>
<td>Saturated school</td>
<td>1.23***</td>
<td>0.98</td>
<td>1.03</td>
<td>1.36***</td>
</tr>
<tr>
<td></td>
<td>(1.04,1.46)</td>
<td>(0.80,1.21)</td>
<td>(0.89,1.20)</td>
<td>(1.09,1.69)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.64**</td>
<td>4.24**</td>
<td>5.96***</td>
<td>4.57**</td>
</tr>
<tr>
<td></td>
<td>(1.26,10.54)</td>
<td>(1.16,15.46)</td>
<td>(2.41,14.71)</td>
<td>(1.15,18.11)</td>
</tr>
</tbody>
</table>

**Note:** Models are not comparable on AIC or BIC. ^p<0.2; *p<0.1; **p<0.05; ***p<0.01

^IRR values are inverted due to coding of variables

### 3.3.3 Model 3: Combined Factors

The combined models of advertising and consumption attitudes showed similar results compared to the previous two models, with the associations of advertising becoming weaker overall. Fast food and slow food purchases are more highly
correlated with consumption attitudes than the availability or accessibility of advertising (Table 3-6). The availability of variety ads has a negative association (IRR=0.94 [0.90,0.99]), with fast food purchasing, while those who placed importance on healthy eating are significantly less likely to make a fast food purchase (IRR_{Buffer}=1.22 [1.08,1.37]; IRR_{Network}=1.21 [1.07,1.36]). Those who expressed an affinity for cooking and packed their lunch to save money are less likely to make a fast food purchase, while those who said they did not have enough time to pack lunch are significantly more likely to purchase fast food (IRR_{Buffer}=0.88 [0.82,0.95]; IRR_{Network}=0.88 [0.82,0.94]). Participants who attend the school with a saturated retail food environment are more likely to purchase fast food (IRR_{Buffer}=1.23 [1.03,1.46]; IRR_{Network}=1.25 [1.00,1.55]) than their peers in sparse school food environments across both models (Figure 3-1). In the case of slow food purchases, the availability of fast food ads has a positive correlation (IRR=1.03 [1.00,1.07]) while variety store ads have a negative correlation (IRR=0.91 [0.85,0.97]) only in the buffer model. Participants who like to cook are significantly less likely (IRR=1.14 [1.03,1.26]) to make a slow food purchase. Boys are significantly less likely than girls to make a slow food purchase (IRR=0.78 [0.64,0.96]), while Latinx populations are significantly more likely (IRR_{Buffer}=1.80 [1.32,2.46]; IRR_{Network}=1.72 [1.25,2.36]) to purchase from a slow food outlet.

Grocery and variety purchases are more associated with sociodemographic factors than consumption attitudes and advertising availability or accessibility (Table 3-7). Slow food ads have a negative association (IRR=0.97 [0.95,0.99]) with grocery purchasing. Participants who are confident with food labels are 7% more likely to make a grocery purchase, and those who do not have enough time to pack lunch are 6% less likely to make a grocery purchase. Boys are 16% less likely to make a grocery purchase than girls. Variety store purchases are more affected by cultural background with Black, Latinx, and other non-white populations more likely to make a purchase (Table 3-7). Those who do not have time to pack their lunch are 10% more likely to make a variety purchase.
Figure 3-1. Food information environment around each school
Table 3-6. Combined model for fast food and slow food purchases (Model 3)

<table>
<thead>
<tr>
<th>Dependent Variable, IRR (95% CI):</th>
<th>Fast Food Purchases</th>
<th>Slow Food Purchases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buffers</td>
<td>Network</td>
</tr>
<tr>
<td>Fast food ads</td>
<td>1.02^</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.99,1.04)</td>
<td>(0.98,1.02)</td>
</tr>
<tr>
<td>Slow food ads</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>(0.95,1.02)</td>
<td>(0.97,1.02)</td>
</tr>
<tr>
<td>Grocery ads</td>
<td>0.97</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>(0.87,1.08)</td>
<td>(0.94,1.10)</td>
</tr>
<tr>
<td>Variety ads</td>
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<td>1.00</td>
</tr>
<tr>
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<td>(0.97,1.03)</td>
</tr>
<tr>
<td>Healthy eating</td>
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<td>1.21***</td>
</tr>
<tr>
<td></td>
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<td>(1.07,1.36)</td>
</tr>
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</tr>
<tr>
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<td>(0.89,1.06)</td>
</tr>
<tr>
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<td>1.10**</td>
</tr>
<tr>
<td></td>
<td>(1.00,1.09)</td>
<td>(1.01,1.19)</td>
</tr>
<tr>
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<td>0.98</td>
</tr>
<tr>
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<td>(0.89,1.07)</td>
</tr>
<tr>
<td>Cook to save</td>
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<td>1.12**</td>
</tr>
<tr>
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<td>(1.01,1.24)</td>
<td>(1.01,1.25)</td>
</tr>
<tr>
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<td>0.88***</td>
</tr>
<tr>
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<td>(0.82,0.94)</td>
</tr>
<tr>
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<td>0.89^</td>
</tr>
<tr>
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<tr>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
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<td>0.92</td>
</tr>
<tr>
<td></td>
<td>(0.68,1.25)</td>
<td>(0.68,1.25)</td>
</tr>
<tr>
<td>Other non-white</td>
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<td>1.15</td>
</tr>
<tr>
<td></td>
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<td>(0.88,1.50)</td>
</tr>
<tr>
<td>% Low income</td>
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</tr>
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<td>(0.91,1.249)</td>
<td>(0.72,1.87)</td>
</tr>
<tr>
<td>Saturated school</td>
<td>1.23**</td>
<td>1.25**</td>
</tr>
<tr>
<td></td>
<td>(1.03,1.46)</td>
<td>(1.00,1.55)</td>
</tr>
<tr>
<td>Constant</td>
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<td>3.71**</td>
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<tr>
<td></td>
<td>(1.20,9.96)</td>
<td>(1.27,10.83)</td>
</tr>
</tbody>
</table>

Observations | 489 | 489 | 482 | 482
Cragg-Uhler R² | 0.13 | 0.12 | 0.10 | 0.10
McFadden R² | 0.03 | 0.02 | 0.03 | 0.03
Akaike Inf. Crit. | 2622.81 | 2630.55 | 1685.37 | 1687.43
Bayes Inf. Crit. | 2710.85 | 2718.59 | 1773.10 | 1775.16

Note: ^p<0.2; *p<0.1; **p<0.05; ***p<0.01

1 IRR values are inverted due to coding of variables.
Table 3-7. Combined model for grocery and variety purchases (Model 3)

<table>
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<tr>
<th></th>
<th>Grocery Purchases</th>
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<th>Variety Purchases</th>
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<td>Buffers</td>
<td>Network</td>
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<td>1.01^</td>
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<td>(0.95,1.00)</td>
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</tr>
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<td>1.02</td>
<td>0.98</td>
<td>1.00</td>
</tr>
<tr>
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<td>(0.99,1.04)</td>
<td>(0.92,1.04)</td>
<td>(0.96,1.04)</td>
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<tr>
<td>Healthy eating ¹</td>
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<td>1.01</td>
<td>1.01</td>
</tr>
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<td>(0.87,1.18)</td>
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<tr>
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<td>0.92**</td>
<td>0.92^</td>
<td>0.92^</td>
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<td>(0.82,1.03)</td>
</tr>
<tr>
<td>Like to cook ¹</td>
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<td>1.00</td>
<td>1.04</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
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<td>(0.93,1.07)</td>
<td>(0.93,1.16)</td>
<td>(0.93,1.17)</td>
</tr>
<tr>
<td>Cook for health ³</td>
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<td>1.05^</td>
<td>1.05</td>
<td>1.04</td>
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<td>(0.93,1.17)</td>
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<tr>
<td>Cook to save ¹</td>
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<td>1.06</td>
<td>1.11^</td>
<td>1.12*</td>
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<td>(0.97,1.27)</td>
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<tr>
<td>No time to cook ³</td>
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<td>1.06**</td>
<td>0.90**</td>
<td>0.89***</td>
</tr>
<tr>
<td></td>
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<td>(1.00,1.13)</td>
<td>(0.82,0.98)</td>
<td>(0.82,0.98)</td>
</tr>
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<td>0.82***</td>
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<td>1.08</td>
</tr>
<tr>
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<td>(0.72,0.94)</td>
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<td>(0.88,1.32)</td>
</tr>
<tr>
<td>Age</td>
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<td>0.99</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
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<td>(0.94,1.04)</td>
<td>(0.90,1.05)</td>
<td>(0.89,1.05)</td>
</tr>
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<td>Asian (ref. White)</td>
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<td>1.03</td>
<td>1.28*</td>
<td>1.31*</td>
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<td>(0.84,1.27)</td>
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<td>1.55**</td>
<td>1.50**</td>
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<tr>
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<td>(1.02,2.19)</td>
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<td>1.59***</td>
<td>1.53**</td>
</tr>
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<td>(0.83,1.37)</td>
<td>(1.09,2.32)</td>
<td>(1.04,2.25)</td>
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<td>1.22</td>
</tr>
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<td>(1.00,1.61)</td>
<td>(0.81,1.78)</td>
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<td>1.55***</td>
<td>1.53**</td>
</tr>
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<td>0.85</td>
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<td>1.34***</td>
<td>1.26^</td>
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<td>4.55**</td>
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<td>(2.25,13.64)</td>
<td>(1.15,18.08)</td>
<td>(1.13,18.03)</td>
</tr>
<tr>
<td>Observations</td>
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<td>488</td>
<td>482</td>
<td>482</td>
</tr>
<tr>
<td>Cragg-Uhler R²</td>
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<td>0.08</td>
<td>0.07</td>
<td>0.07</td>
</tr>
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<td>McFadden R²</td>
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<td>0.01</td>
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<td>Akaike Inf. Crit.</td>
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</tr>
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<td>Bayes Inf. Crit.</td>
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<td>2642.07</td>
<td>2353.75</td>
<td>2354.55</td>
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</tbody>
</table>

Note: ^p<0.2; *p<0.1; **p<0.05; ***p<0.01
¹IRR values are inverted due to coding of variables
Sensitivity analyses revealed no significant differences based on the search radius for the buffer (400m, 800m, 1200m) or shortest network path (50m, 100m, 150m) calculations in Model 1 or 3. Variable inflation factor analyses showed no signs of multicollinearity in any of the three models.

In summary, the availability and accessibility of retail food advertisements have slight associations with purchasing at fast food, slow food, grocery, and variety outlets. However, a participant’s consumption attitudes appear to have a stronger association, in addition to cultural background and gender, with all types of purchases. Turning to model performance, the comparison of AIC and BIC scores in all models show no meaningful difference between the use of buffers or shortest network path in measuring potential exposure to advertising.

### 3.4 Discussion

Food and beverage purchasing among adolescents is affected by a range of individual, social, and environmental factors. Gender and cultural background coupled with individual beliefs about eating and cooking were found to relate significantly to food purchasing. The availability of advertising in the home neighbourhood environment and accessibility of advertising on the journey between home and school has a less meaningful association with slow food and grocery purchasing than compared to the associations with consumption attitudes. Additionally, the food information environment surrounding school correlates positively with adolescents’ fast food and variety purchasing patterns. Previous studies have found the food environment around schools may impact purchasing and diet (Barquera et al., 2018; Egli et al., 2019; He et al., 2012; Hillier et al., 2009; Velazquez et al., 2019); while, this study supports that there is also a substantial association with purchasing. This study builds upon the prior literature by delivering an analysis that includes a purchasing/diet-related outcome variable.

Students attending the school with a saturated food advertising environment have a level of purchasing 1.23-1.34 times greater than students attending a school with a sparse food information environment. This difference between schools suggests that
the food information environment surrounding schools has an influence on purchasing, with the high availability of fast food and variety advertising around schools influencing students’ consumption patterns in comparison to their peers. The low coefficient of determination ($R^2$) in all models would suggest the independent variables do not have strong predictive power of purchasing. Perhaps other independent predictors not accounted for in this model, such as food knowledge and parental behaviours have a larger influence on purchasing. Given dietary preferences, attitudes, behaviours are formed in childhood and adolescence, certainly parental and other social groups may have a large effect on purchasing behaviour (Dobbins et al., 2017; Jessri et al., 2016). Moreover, in the models, consumption attitudes also associate with purchasing patterns for many adolescents. Many of the relationships between particular beliefs and types of purchases follow well-established relationships in the literature (Kinard & Webster, 2012; Leiss et al., 2005; Parkin, 2006; Pedersen et al., 2015; Salvy et al., 2012; Stok et al., 2016). For example, students who express they do not have enough time to pack their lunch for school purchase more fast food or variety products and make less grocery purchases. Moreover, students who understand food labels and like to cook make more grocery purchases and less fast food or slow food purchases. Gender and cultural differences found in the analysis align with many other studies on boys making less purchases than girls, and sociocultural factors influencing purchasing behaviours (Amanzadeh et al., 2015; Bragg, Hardoby, et al., 2017; Bragg, Pageot, et al., 2017; Cassady et al., 2015; Godin et al., 2017; He et al., 2012; Herrera & Pasch, 2018; Moodley et al., 2015; Pinto et al., 2007; Reis et al., 2020; Yancey et al., 2009). On the whole, boys are less likely than girls to make slow food and grocery purchases which may be the result of gender-based norms around food and shopping (Parkin, 2006; Steel, 2009). Related, associations based on cultural background could be the result of cultural norms in some groups around the types of retail food outlets that are frequented, or clustering of non-white participants in particular areas may result in a proxy effect for their local food environment, likely because cultural communities self-select into neighbourhoods with culturally-
relevant outlets and amenities (Mendez et al., 2006; Owusu, 1999; Painter & Yu, 2010).

The lack of differences in AIC and BIC scores between the buffer and network models suggests that the spatial construct of measuring potential advertising exposure in terms of availability or accessibility has little influence on the overall fit of the model. However, many explanatory variables with significant correlations in the buffer-based model (i.e., availability) were reduced in the shortest network path model (i.e., accessibility). For example, the proportion of households below the median household income had a significant negative association with grocery purchases in the buffer model. However, the shortest network path model showed no association. This difference in strength of correlations demonstrates the importance of considering geographic scale and the spatial construct being measured in the analysis. In the case of grocery stores, many are located in periphery commercial areas along main arterial avenues isolated from most residential neighbourhoods (Larsen & Gilliland, 2008). Thus, many participants have low availability in their immediate home environment, but high accessibility on the journey between home and school as they have to take major arterial roads to reach their school, if they live far from their school. Moreover, adolescents may be more likely to shop for groceries with their parents or stopping along the way home from school.

3.4.1 Limitations
There are three key limitations to this study. First, the synthesis of data from multiple sources with data collection at slightly different times may result in a spatiotemporal mismatch between the dependent and explanatory variables. The advertising and food environment data was captured from May to October 2018, while the survey data was collected in September 2018. Given the phrasing of the survey question for the dependent variable as a participant’s typical behaviour rather than a recall of the past week of purchases, the impact of this mismatch should be minimal however, as most outdoor advertising campaigns typically last 4 weeks and advertisers in the food and beverage industry typically return to the
same locations, usually just altering the product or promotion being advertised on the sign (Ozelkan, 2019). Second, this study may misclassify some of the spatial relationships due to not using the adolescents’ exact home address. Although, postal code centroids are the most used address proxy in Canadian environment and health research; use of postal code centroids to represent the adolescent participants’ home locations may misclassify potential exposures, particularly in rural locations where postal code areas are much larger than urban areas. Nevertheless, previous research has shown postal codes to be acceptable address proxies in Canadian urban and suburban areas (Healy & Gilliland, 2012). Third, the study may be impacted using self-reported measures rather than observed data. Although self-reported measures are more common than ‘objective’ measures in dietary research, they are known to be affected by biases related to social desirability and performativity, for example with adolescent participants wanting to impress their peers and perform ‘well’ on the survey questions (Hebert et al., 2008). Unfortunately, the collection of observed data in relation to purchasing is incredibly challenging and laborious (e.g., plate photography, direct observation by researchers during mealtimes) and otherwise difficult without the use of invasive, and potentially unethical, data collection technologies (e.g., wearable cameras).

3.4.2 Conclusions
This study is an improvement over the existing literature which has attempted to link outdoor advertising exposure with food and beverage purchasing and other health-related behaviours. The use of a purchasing measure as the outcome variable confirms the assumptions made about outdoor advertising in prior studies, and improves upon them by separately analysing fast food, slow food, grocery, and variety purchasing habits. Further, the inclusion of measures related to consumption attitudes is a novel addition to research about outdoor food and beverage advertising. In addition, the comparison of two spatial analysis techniques demonstrates the importance of selecting the appropriate geographic measure in environmental health research.
These findings provide much needed evidence to support growing policy interest at the federal level in regulating and addressing negative health effects from advertising (Health Canada, 2017, 2019a). Moreover, educational and municipal governance bodies have shown interest in limiting exposure to ‘unhealthily’ food and beverage advertising in the school environment (Tam, 2017). Future research should use more complex spatial analysis techniques to ascertain the effects of true exposure and engagement with outdoor advertising on purchasing rather than potential exposure. Such advances would best be served through the use of direct spatio-temporal measurements of activities, mobility, and exposure in everyday environments through the use of GPS logging. Given the number of relationships in this study that were marginally significant, further studies with a larger sample size may enable broader conclusions to be drawn about the impacts of outdoor advertising on purchasing. This research area is continuing to evolve and cannot rely on general advertising research to draw conclusions about the effects of outdoor food and beverage advertising on subsequent consumption.
3.5 References


4. Observed exposure to outdoor food and beverage advertising among adolescents: Associations with self-reported purchasing habits

BACKGROUND: Adolescent food and beverage consumption behaviours are influenced by a range of factors, including age, gender, and individual attitudes, as well as the composition of the local food environment. There is considerable evidence that the availability of retail food outlets in local areas influences adolescent food and beverage purchasing. However, little research has examined the influence of outdoor food and beverage advertising on purchasing.

METHODS: Exposure to outdoor advertising and retail food outlets was measured using observed GPS data collected over a 12-week period from 154 adolescents at three secondary schools in a mid-size metropolitan area. A negative binomial regression model was used to compare the effects of advertising exposure, consumption attitudes, and sociodemographic factors on food and beverage purchasing.

RESULTS: The results of the model were inconclusive for the food information environment. A relationship between exposure to outdoor advertising and purchasing cannot be proven or disproven. Students with more healthy consumption attitudes were significantly more likely to make fast food purchases. Students being located at a (sub)urban school resulted in lower overall fast food and variety purchases, compared to students at rural schools.

DISCUSSION: The urbanicity of a school is related to purchasing habits. The lack of significant findings for the food information environment from this analysis is likely due to the small sample size, spatiotemporal mismatch, and biases from using observational and self-reported data. However, this study demonstrates there is need for more research on the effects of outdoor advertising on adolescent food and beverage purchasing, particularly in the context of other analyses.
4.1 Background

Adolescent food and beverage consumption patterns can have wide-ranging effects on their physical health, mental wellbeing, social status, and academic performance (Health Canada, 2019; Lim et al., 2012; Micha et al., 2017; World Health Organization, 2016). Many Canadian adolescents have diets which are high in fat, sodium, and free sugars (Dobbins et al., 2017; Jessri et al., 2016). There is some concern that outdoor advertising may be a cause of poor diets among Canadian children and youth (Health Canada, 2017; Potvin Kent et al., 2012). Adolescents in particular seem to be affected by the retail food landscape, with greater availability of fast food and variety stores translating to higher rates of consumption (He et al., 2012; Laska et al., 2010; Sadler et al., 2016; Tucker et al., 2008). These trends may be the result of fast food and variety stores congregating in close proximity to child and youth-serving places, but also may be from outdoor food and beverage advertising having permeated throughout the landscapes of many Canadian communities (Hillier et al., 2009; Novak & Gilliland, 2011; Treu, 2012; Velazquez et al., 2019). Although outdoor advertising is one small component of the broader ‘consumer nutrition environment’ (Glanz et al., 2005), research on other food and beverage advertising channels, such as television and social media, has found effects on adolescent purchasing (Baldwin et al., 2018; Fleming-Milici & Harris, 2020; Halford et al., 2004; Harris et al., 2009; Henderson & Kelly, 2005). Outdoor advertising may or may not be an effective channel for the marketing of food and beverage products to adolescents.

Food and beverage consumption can be framed in terms of individual, social, environmental, and policy level factors (Story et al., 2008). Individual factors include impacts from age, gender, and dietary attitudes. Social factors include influences from relatives, cultural communities and peer groups. Environmental factors included factors such as neighbourhood form and the distribution of food outlets. Policy level factors include national food and beverage policies as well as municipal land use zoning and bylaws restricting what activities can locate in certain places. These factors can also be conceptualized in terms of the consumer nutrition
environment (Glanz et al., 2005). There is a plethora of cross-sectional and intervention research about many aspects of the consumer nutrition environment (Caspi et al., 2012; Elliott, 2014; Mackenbach et al., 2019; Pitt et al., 2017), yet the food information environment is understudied in relation to food behaviours and other components of the consumer nutrition environment, even from a cross-sectional perspective.

Prior studies of the information environment, specifically, outdoor advertising have either been descriptive in nature with no outcome measure, or only use aggregated measures of advertising availability at a neighbourhood or regional level (Adams et al., 2011; Adjoian et al., 2019; Fagerberg et al., 2019; Isgor et al., 2016; Kelly et al., 2008; Sainsbury et al., 2017; Settle et al., 2014; Yancey et al., 2009). While the KidsCam study in New Zealand collected novel information about exposure and engagement with outdoor advertising, none of their publications reported a health-related outcome measure, and moreover, the use of wearable cameras with minors in public and private settings presents unique challenges around ethical and effective data collection (W. Liu et al., 2019; Signal et al., 2017). In addition, Sadler et al.’s (2016) and B. Liu et al.’s (2020) analysis of retail food outlet exposures as compared to the number of food and beverage purchases and other consumption preferences, demonstrates the emerging role of using observed GPS data to determine exposure and engagement with the consumer nutrition environment. The use of observed GPS data to determine exposures in the information environment is an ideal next step in the study of adolescent food and beverage purchasing behaviours. Therefore, this study compares exposure to outdoor food and beverage advertising with subsequent purchases among adolescents in three high schools of a mid-size city in Canada.

4.2 Methods

The analysis makes use of observed GPS data to estimate the number of food and beverage ads a participant was exposed to during the study period. This study
builds upon prior analyses of how purchasing is influenced by the availability and accessibility of outdoor food and beverage advertising (Chapter 3).

4.2.1 Data Collection

Participant data for this analysis are sourced from a large multi-year intervention study (www.smartappetite.ca) of adolescents in a mid-size Canadian community. The study was approved by Western University’s Non-Medical Research Ethics Board (NMREB #107034) as well as the research and assessment office of the London District Catholic School Board. Survey responses from the baseline timepoint of the 2018-19 sampling campaign from that study are used in this analysis. More details on the SmartAPPetite intervention study are reported in Chapter 1. In addition, retail food outlet data was sourced from the local health unit’s food safety inspection database (Middlesex-London Health Unit, 2020). The retail food outlet data included the complete street-level addresses of every outlet, already coded by type (e.g., fast food, grocery). Advertising data was collected through a field audit in the summer and fall of 2018 by a team of researchers from the Human Environments Analysis Laboratory at Western University. Photographs were taken of each outdoor billboard, transit shelter, and street-level poster in the study area. These photographs were then coded by independent reviewers to determine the food and beverage content of each advertisement. For more information on this data, see Bowman et al. (2019).

GPS points are taken from participants that regularly used (>100 points logged) the SmartAPPetite smartphone application during the 12-week intervention period of the study. The app sends healthy diet and lifestyle messages to users three times a day before their self-determined mealtimes, and when a user is in close proximity (>125m) to a retail food outlet. These messages are designed to ‘nudge’ the participant towards making healthier choices at retail food outlets, such as choosing water over soda or adding more vegetables to their order (Gilliland et al., 2015; Johnson et al., 2012). GPS points are collected every 120 seconds or when a user enters the geofenced area surrounding a retail food outlet. They are only collected
while the user is engaging with the app or has the app running in the background of their device.

4.2.2 Data Processing

Individual-level variables include age, gender, and ethnicity from the participant survey. A neighbourhood level socioeconomic status variable was calculated for each participant using the % of households in the participant’s postal code which fall below the median household income in the census metropolitan area (Statistics Canada, 2019). Two of the three schools involved in the analysis are located in a more low density/rural location, so this variable was transformed into a binary variable of one school that is in a higher density urban context (1) and grouping the two schools that are in a rural context (0). Statements about consumption attitudes were coded on a Likert scale (1-5) from strongly agree to strongly disagree. For the primary outcome measure, participants self-report the number of purchases they make on average per week or month at retail food outlets, which is then standardized into a per month average. Survey questions are presented in Appendix C.

References to ads or outdoor advertising in this analysis encompasses both traditional outdoor advertising on billboards, bus shelters, or street-level posters, and retail food outlets as their design and placement on a property are typically an advertisement in their own right (Ozelkan, 2019; Treu, 2012). Retail food outlets and advertisements are categorized into four types: fast food, slow food, grocery, and variety (Tucker et al., 2008). Fast food includes quick-service restaurants, chains, coffee shops, food courts, and other outlets where food is ordered from a counter. This category also includes outlets with limited to no seating that are focused on takeout or delivery. Slow food includes sit-down restaurants, bars, pubs, and other establishments that offer table-based service. Grocery includes stores that sell fresh and package food, as well as farmers markets, bakeries, and other more focused food and beverage retail stores. Variety includes convenience stores and mart-type outlets that are typically found at street corners in residential
neighbourhoods and in commercial plazas and gas stations selling packaged food and beverages.

Spatial data was processed using ArcGIS Pro 2.5.1 (Esri, 2020). Participants with less than 100 valid GPS points recorded by the smartphone application were excluded from the sample (included n=154, excluded n=211) given less than 100 points would represent an average of <1 location recorded every day during the data collection period. Chi-square tests on gender and ethnicity, and two-tailed sample t-tests on age showed no significant differences between the included and excluded participants. Euclidean buffers around outlets (150m), billboards (150m), bus shelters (75m), and street posters (75m) were used to simulate visual acuity to these exposure sources (Chmielewski & Tompalski, 2017). Impressions were then generated by counting the number of GPS points a participant had within the buffer of a specific ad, totalling the number of impressions across all ads, rendering an exposure value.

4.2.3 Statistical Analysis

Negative binomial regression models were used given the overdispersion of zero values in the dependent variable, the dependent variable being a count, and the analysis being an incident-response relationship between the exposure variable of number of ad impressions and dependent variable of making a purchase at a specific type of retail food outlet (Dupont, 2002; Long, 1997; Venables & Ripley, 2002). The model was run for each type of retail food outlet purchase to check for interaction effects between types of food and beverage advertising exposure. These exposure values were not standardized based on the total number of GPS points recorded for each participant, given it would normalize them away from matching the overdispersion of these variables.

All statistics were calculated using R Stats v3.6.3 (R Core Team, 2020). Negative binomial regression models were run using the glm.nb function in the MASS package (Venables & Ripley, 2002). A variable inflation factor analysis using the vif function in the CAR package was run to check for multicollinearity (Fox & Weisberg, 2019).
4.3 Results

The analysis includes 154 students who participated in the 2018-19 sampling campaign of the larger intervention study, and regularly made use of the SmartAPPetite mobile application for 12 weeks (Table 4-1). Students range in age from 13-18 years old, typical of most Ontario high schools. The sample contains more females (n=98) than males (n=56). There is a diverse group of participants in this sample between white (n=89) and non-white (n=65) ethnic backgrounds. One school was located in an urban area (n=85), while two schools were located in rural areas (n=69). Most students had at least one impression of a fast food (91%), slow food (84%), or variety (75%) ad during the data collection period, while only around half (58%) experienced a grocery advertisement (Table 4-1). This pattern is likely due to the concentration of grocers in regional shopping centres, and participants having limited interaction with these types of outlets (Figure 4-1).

Participants reported varying attitudes about eating, cooking, and preparing lunch for school (Table 4-2). Many agreed that eating healthy food is important and preparing lunch at home saves money, though time could be a constraint for some students to pack a lunch for school. Moreover, some students expressed strong interest in cooking, recognizing its health benefits, and many are confident about reading food and beverage product labels.

Advertising impressions have no association with self-reported purchases (Table 4-3). Fast food purchases are positively associated with expressing an interest in eating healthy food, and negatively affected by being in the urban school. Slow food purchases had no significant relationship with explanatory factors. Grocery purchases are positively associated with expressing an interest in healthy eating, but inversely affected by expressing that cooking meals helps keep the participant healthy. Variety purchases show the same inverse effect for cooking meals to stay healthy and are negatively associated with being in an urban school. No signs of multicollinearity were detected in the models. The model was run separate times for each retail food outlet type.
Table 4-1. Demographics and contextual information about participants

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Category</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (binary, female)</td>
<td>Male</td>
<td>56 (36%)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>98 (64%)</td>
</tr>
<tr>
<td></td>
<td>Missing</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Ethnicity (binary, White)</td>
<td>White</td>
<td>89 (58%)</td>
</tr>
<tr>
<td></td>
<td>Non-White</td>
<td>65 (42%)</td>
</tr>
<tr>
<td></td>
<td>Missing</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contextual</th>
<th>Category</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>13</td>
<td>2 (1%)</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>34 (22%)</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>37 (24%)</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>41 (27%)</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>34 (22%)</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>5 (3%)</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Missing</td>
<td>1 (1%)</td>
</tr>
</tbody>
</table>

| % below CMA median income by postal code (continuous) | < 20% | 8 (5%) |
| 20 – 39% | 55 (36%) |
| 40 – 59% | 51 (33%) |
| 60 – 79% | 34 (22%) |
| > 80% | 6 (4%) |

| School (binary, urban vs. rural) | Urban | 85 (59%) |
| | Rural | 69 (41%) |

<table>
<thead>
<tr>
<th>Advertising impressions by observed GPS (continuous)</th>
<th>Type</th>
<th>Ads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Food</td>
<td>0</td>
<td>14 (9%)</td>
</tr>
<tr>
<td>&gt;=1</td>
<td>140 (91%)</td>
<td></td>
</tr>
<tr>
<td>Slow Food</td>
<td>0</td>
<td>25 (16%)</td>
</tr>
<tr>
<td>&gt;=1</td>
<td>129 (84%)</td>
<td></td>
</tr>
<tr>
<td>Grocery</td>
<td>0</td>
<td>64 (42%)</td>
</tr>
<tr>
<td>&gt;=1</td>
<td>90 (58%)</td>
<td></td>
</tr>
<tr>
<td>Variety</td>
<td>0</td>
<td>38 (25%)</td>
</tr>
<tr>
<td>&gt;=1</td>
<td>116 (75%)</td>
<td></td>
</tr>
<tr>
<td>All types</td>
<td>0</td>
<td>8 (5%)</td>
</tr>
<tr>
<td>&gt;=1</td>
<td>146 (95%)</td>
<td></td>
</tr>
</tbody>
</table>

1Variables are presented in categorical formats in this table to illustrate distributions among participants, and are treated as continuous variables in the analysis.
Figure 4-1. Grocery outlets and secondary schools in the London, Ontario CMA
Table 4.2. Consumption attitudes among participants

<table>
<thead>
<tr>
<th>Consumption Attitudes</th>
<th>Indicator</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating healthy food is important to me</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean response (1-5)</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Valid n</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Missing n</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>I like to cook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean response (1-5)</td>
<td>2.30</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Valid n</td>
<td>153</td>
<td></td>
</tr>
<tr>
<td>Missing n</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Preparing lunch at home saves money</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean response (1-5)</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Valid n</td>
<td>153</td>
<td></td>
</tr>
<tr>
<td>Missing n</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I have no problem understanding food labels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean response (1-5)</td>
<td>2.03</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Valid n</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Missing n</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cooking meals helps me eat healthier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean response (1-5)</td>
<td>2.33</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Valid n</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Missing n</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Preparing lunch at home takes too much time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean response (1-5)</td>
<td>2.74</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Valid n</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Missing n</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Table 4-3. Exposure model results for all retail food outlet types

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>Purchases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fast Food</td>
</tr>
<tr>
<td>Fast food ads</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(1.00,1.00)</td>
</tr>
<tr>
<td>Slow food ads</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(1.00,1.00)</td>
</tr>
<tr>
<td>Grocery ads</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(1.00,1.00)</td>
</tr>
<tr>
<td>Variety ads</td>
<td>1.00*</td>
</tr>
<tr>
<td></td>
<td>(1.00,1.00)</td>
</tr>
<tr>
<td>Healthy eating 1</td>
<td>0.78**</td>
</tr>
<tr>
<td></td>
<td>(0.64,0.96)</td>
</tr>
<tr>
<td>Know labels 1</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.87,1.16)</td>
</tr>
<tr>
<td>Like to cook 1</td>
<td>1.11^</td>
</tr>
<tr>
<td></td>
<td>(0.96,1.28)</td>
</tr>
<tr>
<td>Cook for health 1</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>(0.88,1.19)</td>
</tr>
<tr>
<td>Cook to save 1</td>
<td>1.16*</td>
</tr>
<tr>
<td></td>
<td>(0.98,1.38)</td>
</tr>
<tr>
<td>No time to cook 1</td>
<td>0.90*</td>
</tr>
<tr>
<td></td>
<td>(0.80,1.01)</td>
</tr>
<tr>
<td>Gender, Male</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>(0.77,1.33)</td>
</tr>
<tr>
<td>Age</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>(0.86,1.07)</td>
</tr>
<tr>
<td>Non-White</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>(0.74,1.29)</td>
</tr>
<tr>
<td>% Low income</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>(0.30,1.39)</td>
</tr>
<tr>
<td>School, Urban</td>
<td>0.76**</td>
</tr>
<tr>
<td></td>
<td>(0.58,0.98)</td>
</tr>
<tr>
<td>Constant</td>
<td>14.30***</td>
</tr>
<tr>
<td></td>
<td>(1.72,118.75)</td>
</tr>
<tr>
<td>Observations</td>
<td>144</td>
</tr>
<tr>
<td>Cragg-Uhler R²</td>
<td>0.15</td>
</tr>
<tr>
<td>McFadden R²</td>
<td>0.03</td>
</tr>
<tr>
<td>Akaike Inf. Crit.</td>
<td>738.18</td>
</tr>
<tr>
<td>Bayes Inf. Crit.</td>
<td>788.67</td>
</tr>
</tbody>
</table>

Note: Models are not comparable on AIC or BIC. ^p<0.2; *p<0.1; **p<0.05; ***p<0.01
1IRR values are inverted due to coding of variables
4.4 Discussion

The results suggest an inconclusive relationship between exposures to outdoor advertising and purchasing among adolescents. The null effect sizes suggest there is not enough explanatory power to detect a relationship between exposure and purchasing, and the lack of significance limits the ability to conclude that no relationship exists. Prior work on the availability and accessibility of advertising as it relates to purchasing with a larger sample of participants suggests there is greater odds of making a purchase with the more ads that are spatially available or accessible to the participant (Chapter 3). Moreover, the significant effects of school location and consumption attitudes align with results from those prior analyses, and findings from other studies (He et al., 2012; Reis et al., 2020; Sadler et al., 2016).

However, in this analysis there is an inverse effect for being located at an urban school on fast food and variety store purchases compared to the availability and accessibility-based analysis in Chapter 3. This difference may be because students attending this school live in close proximity to this school and may be able to travel home for lunch, compared to students who are more isolated at the two rural schools.

The different effects in some consumption attitudes compared to the availability/accessibility analysis in Chapter 3 may be from participant’s sharing an idealized version of their healthy eating behaviours. The low $R^2$ value also indicates there are other important predictor variables that could be accounted for in future analyses. Food knowledge, parenting styles (i.e. taking children shopping for groceries, or treating fast food and slow food as a celebratory experience), and other participants’ socialization around food and beverages at a young age could all shape later purchasing behaviours in adolescence (Elliot et al., 2014). Typically, adolescents who express consumption attitudes that revolve around healthy eating and cooking their own meals make less fast food and variety purchases (Health Canada, 2019; Micha et al., 2017). This stated attitude towards food and beverages may not match true behaviour. Moreover, participants may be visiting unhealthy outlets (i.e. fast food) but still selecting ‘healthy’ options. Many fast food outlets do
offer ‘healthier’ options on their menus, thus potentially still resulting in these students making less ‘unhealthy’ purchases, as defined by federal nutritional policy.

This study improves upon previous research on this topic area. Unlike the KidsCam study, this analysis reports a diet-related outcome variable (W. Liu et al., 2019; Signal et al., 2017). Further, it makes use of GPS data that covers a longer time period than prior GPS-based analyses of exposure and engagement in the food environment (B. Liu et al., 2020; Sadler et al., 2016). The methods deployed in this study could be combined with methodological innovations by Egli et al. (2019) and Signal et al. (2017) to collect more data about exposure and engagement with environmental opportunities and hazards.

There is considerable interest at all levels of government and among food-related professionals in ascertaining and potentially regulating the effects of outdoor advertising on adolescent food and beverage consumption (Health Canada, 2017; Tam, 2017). The federal government has indicated with recent legislation that marketing to children should be more strictly regulated, especially related to food and beverage advertising. There are also debates at the local level on more strictly regulating the placement of fast food and variety outlets in proximity to schools and limiting outdoor advertising of ‘unhealthy’ foods and beverages (Tam, 2017). While the results of this analysis are inconclusive, the findings, as well as other analyses and practitioner interest, suggest future research is desirable.

4.4.1 Limitations

This study has four limitations. First, the study has a relatively small sample size of only 154 participants, with the median number of impressions (i.e. being within 75-100m of a retail food ad or outlet) per participant at only 35 over a 12-week period. The smartphone application used to collect GPS data did have difficulties in routinely logging participant’s locations over the 12-week sampling campaign, due to the app having to be running in the background or actively open to record locations. Second, there is a spatiotemporal mismatch between the survey data used to capture purchasing habits, and the explanatory variables of advertising exposure. Survey data was collected in September 2018, while advertisements were
photographed and mapped from July to October 2018. Exposures to these advertisements were then measured using GPS data collected from October to December 2018. Thus, there is little temporal overlap between the outcome measure and explanatory variables. Third, the use of self-reported measures for the outcome variable and observed data for the exposure variable could result in a construct bias. The self-reported measures capture participants’ habits, while the GPS data captures participants’ behaviours over a 12-week period. Given the effects of seasonality, socialization during the school year, and continual personal growth among adolescents, there is potentially a construct bias between the exposure and outcome variable related to consumption patterns. Fourth, participants were actively participating in a behavioural intervention targeted at dietary change during the 12-week period used for the exposure data. Therefore, the use of pre-intervention survey data for the outcome variable, and in-situ intervention data for the exposure variables, may have resulted in observing different behaviours than the habits expressed prior to the intervention. A recent systematic review and meta-analysis which found interventions aimed at reducing the effects of advertising and marketing were more effective than other types of dietary and lifestyle intervention (Cadario & Chandon, 2020). Given the intervention was communication-based, it would be reasonable to conclude there may have been some in-situ effect on adolescent consumption behaviours. Thus, this study may be observing a change in participant’s spatial decision-making as related to exposures to the retail food environment.

4.4.2 Conclusions
The inconclusive results of this study do not disprove or prove that outdoor food and beverage advertising affects adolescent purchasing. The small sample size and spatiotemporal mismatch between variables is potentially reducing the explanatory power of advertising on purchasing among the participants in this study. However, this study demonstrates that observed GPS data should be used in future studies of retail food environment exposures and purchasing. Coupling observed GPS data with third-party street imagery and ecological momentary assessment capture
techniques Future iterations of this investigation should use an outcome variable based on observed GPS data to measure engagement with a retail food outlet, rather than a self-reported purchase. Few studies of food environments and purchasing have used observed GPS, and much of the evidence remains inconclusive due to underpowered samples, methodological limitations, or not reporting an outcome variable. There remains considerable interest at all levels of government, and among registered dieticians, urban planners, and other child welfare groups in understanding the role of food environments in shaping adolescent consumption, specifically the role of the food information environment. Therefore, more cross-sectional, experimental, and intervention-type research is needed in this area.
4.5 References


5. Synthesis and Conclusion

This chapter synthesizes findings from this thesis containing three unpublished manuscripts. First, a systematic review of geographic studies found no conclusive evidence of associations between outdoor advertising and purchasing in any population group. Second, a quantitative analysis determined the availability and accessibility of outdoor advertising has a small association with purchasing in a sample of adolescents from a mid-size Canadian metropolitan area. Third, following from this study, a second quantitative analysis found no conclusive evidence of any association between exposure to outdoor advertising and purchasing among a smaller sample of the same group of adolescents. Overall, these three manuscripts form a body of work on the relationship between outdoor advertising and purchasing of food and beverages, centred in geographic analysis.

5.1 Summary of Studies

The systematic review manuscript identified and summarized 31 studies of outdoor food and beverage advertising that incorporated some form of spatial analysis (Chapter 2). Many of these studies were descriptive of spatial patterns of advertising only, with only two studies focussing on sugar-sweetened beverages reporting a consumption or purchasing-related outcome measure associated with spatial patterns (Godin et al., 2017; Lesser et al., 2013). While many studies claimed to be investigating 'exposure' to outdoor advertising, in geographic terms these studies were typically only investigating the 'availability' of, or 'accessibility' to, outdoor advertising and retail food outlets. Moreover, while many studies seem to frame outdoor food and beverage advertising as a causal factor in consumption and purchasing, none of these studies cite previous evidence, nor provide any new evidence, to confirm such a relationship exists. The background information contained in these studies instead relied on evidence about television and social media marketing, rather than citing any previous evidence related to outdoor advertising. This problematic assumption results in the descriptive studies having
paternalistic framings of the distribution of unhealthy advertising in low-income and ethnic minority communities as a source of health disparities.

The only associative relationship emerging from the literature is the availability of sugar-sweetened beverage advertising correlating with a slight increase in consumption of those beverages (Basch et al., 2019; Godin et al., 2017; Lesser et al., 2013; Moodley et al., 2015). Even among the more advanced exposure and engagement studies of outdoor food and beverage advertising, the authors fail to report a single outcome measure related to purchasing, consumption, or general health effects (W. Liu et al., 2019; Signal et al., 2017). Instead, the authors immediately drew conclusions that more regulation was needed given the number of times children were being exposed to advertising but did not provide any evidence of an association with consumption behaviours or health outcomes. Overall, there is limited evidence of an association between outdoor advertising and purchasing in any population group.

The first quantitative manuscript (Chapter 3) follows from the systematic review by investigating how the availability and accessibility of food and beverage outdoor advertising relates to purchasing. This study involved a sample of adolescents from four high schools in the census metropolitan area of London, Ontario, Canada. Outdoor advertising around home, and on the journey between home and school, had small significant effects on fast food, slow food, and variety store purchasing. From a methodological perspective, there were no significant differences between models using an availability (i.e. buffers) metric to those using an accessibility (i.e. shortest network path) metric. However, there are larger and more significant effects from gender, personal attitudes on food and beverage consumption, and the school neighbourhood environment on purchasing than outdoor advertising availability and accessibility.

Boys were less likely to make all types of purchases than girls. This result aligns with other studies of adolescent food and beverage purchasing behaviours (He et al., 2012; Kinard & Webster, 2012; Parkin, 2006; Sadler et al., 2016; Tucker et al., 2008). Personal attitudes regarding healthy eating, cooking, and packing lunch for school
had much larger effects on purchasing. Students who expressed interest in healthy eating and an affinity for cooking made less fast food and slow food purchases. Those who expressed they did not have time to pack a lunch at home for school were more likely to make fast food and variety store purchases, and slightly less likely to make grocery store purchases. Further, cultural background sometimes associated with a strong increase in purchases. These patterns may be the result of cultural associations with particular types of food, and how it is prepared, served, and sold. These effects may also be spurious correlations from a self-selection bias whereby non-white participants already interested in food were more likely to participate in the study, or an unaccounted mediating variable such as residential clustering of certain ethnocultural groups near commercial areas that serve their cultural community (Mendez et al., 2006; Painter & Yu, 2010).

The school neighbourhood environment seems to have a considerable effect on purchasing. One of the four schools in the study has an overly saturated food environment, with many fast food and variety outlets, and related advertising, within a short walking distance (Map 3-1). Students from this school were ~20-30% more likely to make a fast food or variety store food and beverage purchase in the past month than students from the other three schools. Therefore, it would appear the availability and accessibility of advertising and food outlets in the school environment have a more significant effect on purchasing than in the home neighbourhood setting or on the journey between home and school.

The second quantitative manuscript (Chapter 4) follows from the first by replicating the analysis but using a new geospatial measure of exposure to outdoor food and beverage advertising among a smaller sample of students from only three schools. This exposure variable was constructed from observed GPS activity tracking data collected over a 12-week period. While this study suffers from some methodological limitations, it is the first exposure-oriented spatial analysis of outdoor food and beverage advertising with a consumption related outcome variable. Effects from consumption attitudes were similar to the analyses presented in Chapter 3. Interestingly, a different school, still located in an urban area, showed a protective
effect on fast food and variety store purchasing compared to rural schools. This difference could be because students in the more urban schools can go home for lunch, while students in the more isolated rural schools may have to buy lunch from a fast food or variety type-outlet, including the school cafeteria, if they do not pack a lunch. The results from this analysis were inconclusive about the effects of outdoor advertising on purchasing.

5.2 Research Contributions

There are three broad research contributions from this thesis. First, the two quantitative chapters contribute to a very sparse field of geographic research on outdoor advertising and purchasing. Second, these studies make incremental contributions to understanding the various drivers of adolescent food and beverage purchasing habits from different types of food retailers. Third, this analysis incorporates data at four different levels of the socio-ecological model, improving upon previous investigations of relationships between retail food environments and consumption patterns.

The two quantitative studies examine how outdoor advertising relates to purchasing among adolescents using geographic techniques. These studies were undertaken in direct response to the gaps identified in the systematic review chapter. Furthermore, these studies use geographic methods which are relatively common in the literature (e.g., buffers to assess availability), as well as geospatial techniques which are still highly novel in the literature, such as using GPS activity tracking to assess exposure to outdoor advertising. Additionally, most prior studies have been descriptive, focusing solely on the geographical patterns of food and beverage advertising, with very little cross-sectional, longitudinal, or intervention-based evidence on the impacts of advertising. In the case of the analyses of availability and accessibility in this thesis, small effects were observed for fast food and variety store related advertising on purchasing, but not for grocery stores. This finding highlights differences in the relationship between advertising and purchasing for different types of food retailers, which is another important
contribution to this body of literature which is overly concentrated on fast food. No consistent income-based disparities were found in the models, countering the prevailing dogma in prior research that assumes a clustering of unhealthy advertising in poor communities leads to worse health behaviours and outcomes. Instead, these studies illustrate that food and beverage consumption behaviours are more akin to a social network with relationships that may transcend simplistic container-based approaches to categorizing the availability and accessibility of a harmful exposure (Brown & Brewster, 2015; Sturm & Hattori, 2015). This body of work contributes to the literature more evidence that overly simplistic analyses of food environments ignore many other factors that influence food and beverage consumption and purchasing decisions.

The body of work in this thesis suggests that individual and contextual factors have larger effects on purchasing by adolescents than the availability or accessibility of outdoor advertising. These findings match research and wisdom on gender-based and cultural differences in food and beverage consumption (Adams, 2009; Leiss et al., 2005; Parkin, 2006; Steel, 2009). Moreover, personal attitudes about healthy eating, cooking, and packing lunch had consistent effects on purchasing across all three models. There has been considerable research on the behavioural aspects of adolescent food and beverage consumption, and the studies in this thesis make an incremental contribution to that evidence base (Cadario & Chandon, 2020; He et al., 2012; Health Canada, 2019b; Johnson et al., 2012; Kinard & Webster, 2012; Leiss et al., 2005; Montgomery et al., 2020; Pedersen et al., 2015; Potvin Kent et al., 2012; Tucker et al., 2008). Overall, outdoor advertising is less important than individual and contextual factors in explaining adolescent food and beverage purchasing habits.

Individual, social, and environmental factors are all important elements of understanding health behaviours and outcomes (Bronfenbrenner, 1992). In the context of food environments, these factors interact to encourage or discourage specific behaviours, habits, and preferences (Brown & Brewster, 2015; Story et al., 2008). Environmental factors frame the realm of possibilities for individual and
social factors, while in turn, these factors shape the opportunity structures that make up the environmental context (Macintyre et al., 2002). Very few studies of outdoor food and beverage advertising incorporate individual and social factors into their analyses, and even fewer combine them into analyses with environmental and contextual variables. Thus, the systematic review demonstrates a gap in many studies of outdoor advertising and improves upon the existing literature by using a combined model of individual, social, and environmental variables in the quantitative chapters.

5.3 Methodological Contributions

This thesis makes two methodological contributions to the fields of health geography. First, it presents a novel typology of measuring spatial relationships, and applies it to interactions between outdoor advertising and purchasing among adolescents. Second, the body of work demonstrates the use of conceptual GIS estimation and observed GPS techniques in an applied environmental health research context.

The spatial relationships typology described in Chapter 1, and subsequently applied in Chapters 2 through 4 provides a novel interpretation of interactions between exposure sources and subjects in geographic research. The systematic review found many studies claim to analyze an exposure relationship, when instead they describe an availability or accessibility relationship. The first quantitative study describes the spatial interactions between outdoor food and beverage advertising and purchasing in terms of availability and accessibility. In that analysis, no significant differences were found in the overall fit between the availability and accessibility model. However, there were instances were the correlations decreased in their effect size, or statistical significance moving from availability to accessibility. Turning to the second quantitative analysis using observed GPS data, this model made use of a variable measuring exposure to outdoor food and beverage advertising. There were no conclusive findings from this study. These results follow other investigations of the ‘edge effect’, the ‘modifiable areal unit problem’ and the ‘uncertain geographic
context problem’, whereby changes in how contextual units or spatial patterns of behaviour are measured can result in varying outcomes (Healy & Gilliland, 2012; Kwan, 2012; Sadler et al., 2011; Tillmann et al., 2018). Overall, this typology is a novel contribution to framing traditional spatial exposure-oriented research in sub-fields of geography and spatial epidemiology.

The systematic review uncovered two studies that measured an exposure and engagement relationship (W. Liu et al., 2019; Signal et al., 2017). Unfortunately, the data collection methods used in these studies are impractical and would likely be considered unethical in the Canadian context. The use of GPS-enabled cameras in both public and private life raises too many ethical concerns about inadvertently capturing non-participants and sensitive situations. In addition, the excessive amount of data collected using this technique in comparison to the desired analytic result means other methods would be more suitable. Instead, Chapter 4 presents an example of a study that uses observed smartphone GPS data, and separate photographs of advertisements to capture similar information. This data was used to measure effects of exposure to outdoor advertising, however, a higher refresh rate for logging GPS points engagement with advertising and retail food outlets could have been easily measured, similar to other analyses (B. Liu et al., 2020). Moreover, this approach could be improved by using GPS cameras that automatically stop recording if a participant enters a demarcated private space (i.e. the home), or leveraging third-party street view and researcher collected photography of advertisements (Egli et al., 2019; Bowman et al., 2019). Essentially, the data collection and analysis process piloted in this thesis should inform more advanced investigations of exposure and engagement-based spatial interactions in food environment research.

5.4 Limitations

There are three limitations that cut across the quantitative studies in this thesis. These limitations include self-reported measure bias, spatiotemporal mismatches, and an uncontrolled self-selection bias. Briefly, the systematic review faces the
typical limitations of potentially having overly restrictive exclusion criteria, too narrow of a focus, and coding bias from having one reviewer screen, code and interpret the relevant studies (Cooper et al., 2009; Petticrew & Roberts, 2006). Nevertheless, search terms were discussed with a supervisor and a subject librarian, and these limitations do not necessarily impact the validity of the review.

A potential self-report bias exists with the purchasing and consumption attitude measures from the survey. There is a well-known bias, among adolescent populations in particular, with self-reported measures of dietary behaviours given social status and performance pressures (Hebert et al., 2008; Montgomery et al., 2020). Nevertheless, self-report measures are the most commonly used in studies of dietary behaviours, as other methods tend to be too laborious or intrusive. There is also a slight spatiotemporal mismatch by about a month between the data collected for outdoor advertising and the survey data. This mismatch should have only minimal effect on the analysis given outdoor food and beverage advertising campaigns typically last about 4 weeks, and usually the same locations remain as some form of food and beverage marketing source, often for the same retail food outlet brand (Ozelkan, 2019). Finally, there is a chance of self-selection bias where participants who are interested in food and healthy eating are more likely to participate in the study. Further, the outdoor advertising exposure measure used in Chapter 4 may be capturing an uncontrolled intervention effect as the GPS points were collected during the same time period as participants participating in the larger study’s intervention. Overall, these broad limitations may explain some of the inconclusive findings, and more specific limitations are described within each chapter.

5.5 Implications of Policy and Practice

This body of research is timely for policy and practice in Canada. There have been many policy and regulatory changes at the federal and local level related to dietary behaviours, food environments, and food and beverage marketing. Health Canada has recently updated the Canada Food Guide, and published recommendations on
limiting unhealthy food and beverage marketing to children and youth. Some Ontario municipalities have also embarked on new policy and regulatory initiatives to foster more healthy food environments. Given the inconclusive nature of the results, and the limited effects of outdoor advertising on purchasing, I will not make sweeping claims about policy recommendations from this research. Instead, I will describe the various policy debates that are relevant to this research area.

The Canada Food Guide sets out dietary and lifestyle recommendations related to the consumption of foods and beverages in Canada. The previous food guide focused almost exclusively on nutritional content, while the new food guide has incorporated more lifestyle-focused advice (Health Canada, 2019b). Key changes include recommending diets lower in fat, sodium, and free sugars; eating more fruits and vegetables; cooking at home more often; using food labels to make informed choices; and being aware of the effects of food marketing (Health Canada, 2019a). This last recommendation is exclusively focused on advertising channels other than outdoor advertising, with no mention of billboards or retail food outlets as sources of marketing exposure. However, upon turning to more specific recommendations about limiting marketing to children and youth, outdoor advertising and retail food outlets become more prominent in the policy guidance (Health Canada, 2017). While the proposed Child Health Promotion Act failed to pass Parliament in 2019, there remains considerable interest in legislation that would restrict the marketing of high fat, sodium, and free sugar products to children and youth (Health Canada, 2019c). Thus, this research is situated in a national context that is currently debating the merits of stricter regulation of food and beverage marketing based on its health effects.

Local land use regulations are commonly proposed as a tool to address disparities in food environments, and exposure to unhealthy retail food outlets (Caspi et al., 2012; Larsen & Gilliland, 2008; Paquet, 2019; Wilkins et al., 2019). London has established an official plan policy framework that prioritizes the creation of accessible food environments, aiming to improve access to healthy nutritious food through incentivizing the development of small format grocers and farmers markets in areas
where residential neighbourhoods interface with commercial zones. There is also significant commitment to ensuring food affordability in the official plan and addressing issues in the availability of fruits and vegetables across the city in accompanying strategy documents (City of London Planning, 2018; EcoEthonomics, 2016). These policies have been appealed to the Local Planning Appeals Tribunal (LPAT), also previously and presently known as the Ontario Municipal Board (OMB) (Lansink v. London (City), 2018). Currently, an issues list to guide the hearing has yet to be published, so the official plan policies have yet to be translated into actionable zoning bylaw conditions. These policies should lay the groundwork for addressing the concentration of fast food and variety stores around some schools and increasing the availability of fresh food outside of major commercial areas.

Kitchener, Ontario provides a comparable mid-sized city context that could provide lessons for London’s approach to improving food environments. The City of Kitchener has adopted a set of progressive policies designed to place healthy retail food outlets within one kilometre of every residential parcel over the next three decades. These policies include requirements for smaller format grocery stores, limiting the number of fast food and drive-thru outlets in urban cores, and requiring a health impact assessment of most commercial and employment-related development proposals (City of Kitchener Planning, 2014). The plan’s policies have translated into the proposed amendments to the zoning bylaw by opening residential designations to some retail food outlet uses, lowering parking requirements, and establishing maximum areal limits on the size of most grocery outlets. These policies and the zoning bylaw have been appealed to the LPAT by a powerful group of the dominant Canadian fast food and grocery store chains – Loblaws, Sobeys, Tim Hortons, McDonald’s, Wendy’s, Burger King, A&W – on jurisdictional grounds (Ormston v Kitchener (City), 2018). In filings to the tribunal, the chains have claimed the city has no authority to legislate health matters under the provincial planning legal framework.

The LPAT/OMB decision, and (likely) subsequent judicial review by the Ontario Superior Court, on these matters may follow the McLachlin interpretation of
municipal power as articulated in the Supreme Court of Canada’s decision on 114957 Canada Ltee (Spraytech, Societe d’arrosage) v Hudson (Town) (2001). This legal interpretation of municipal planning power to uphold Kitchener and London’s official plan policies and zoning bylaws would likely set off a chain reaction of legislative and regulatory changes related to health impact assessments of food related commercial uses. Therefore, research on the effects of retail food outlets and outdoor food and beverage advertising could form an important component of evaluating future signage, commercial, and institutional development applications.

5.6 Recommendations for Future Research

The broad recommendation for future research from this thesis is more research is needed on the effects of outdoor food and beverage advertising on subsequent consumption and purchasing in all populations. While there are many descriptive studies of outdoor food and beverage advertising, there are very few cross-sectional or intervention-based studies. Moreover, studies would benefit from using spatial analysis techniques that capture exposure and engagement relationships rather than availability and accessibility (Sadler et al., 2016; Sadler & Gilliland, 2015). The move from aggregative models to more individual-focused measures in environmental health research is a laudable goal, as many relationships observed at the aggregate level tend to not hold at more fine-grained levels of analysis (Markevych et al., 2017; Sadler et al., 2011; Tillmann et al., 2018; Wray & Minaker, 2019). While there is evidence of television and social media marketing having an influence on food and beverage purchasing (Baldwin et al., 2018; Fleming-Milici & Harris, 2020; Halford et al., 2004; Harris et al., 2009), there are a handful of studies that have ascertained the effects of outdoor advertising. It remains an inconclusive relationship.

Science is imbued with uncertainty. It is often deficient, and it is certainly complex in the case of topics within health geography. However, health geographers cannot retreat into simple positivist or critical spheres of framing their research on food environments. Yet, there is a moral responsibility to prevent adverse health
outcomes from harmful exposures. Policy will continue to be produced on food environments, consumption, and dietary behaviours regardless of research engagement. Following in the tradition of Lindblom’s (1959) analytic technique of muddling through successive comparisons, and further supported by the writings of Hill (1965), Frank, Gibson and Macpherson (1987), Hennekens and Buring (1987), and Ozonoff (1994); I layout four principles to guide the next stages of research on outdoor food and beverage advertising:

- **Stability** – future studies must consider the confidence in or strength of the associations between outdoor advertising and consumption, relying on quantitative and/or qualitative evidence that a relationship exists between the exposure and response variables.
- **Plausibility** – future research should consider the likelihood of relationships between outdoor advertising and purchasing, as compared to alternative drivers such as gender, cultural community, or individual beliefs on food and beverage consumption.
- **Consistency** – any research findings should be evaluated based on their consistency with findings on other advertising channels, and consistency across various types of models and geographic levels of analysis.
- **Temporality** – future research should consider the causal sequence between exposure and engagement with outdoor advertising, and subsequent visits to retail food outlets.

These four principles will hopefully guide this research area towards more conclusive cross-sectional and intervention-type designs that may confirm or refute the existence of a relationship between outdoor food and beverage advertising and purchasing. Given the considerable policy interest in improving diet-related health outcomes, it is important that research confirm or refute these proposals lest the majority of public resources be allocated to correcting only a minor driver of unhealthy food and beverage consumption.
5.7 Conclusion

Adolescent food and beverage consumption and purchasing is influenced by a range of factors. These include gender, ethnicity, personal attitudes about food and beverage consumption, and the accessibility and availability of retail food outlets in home and school neighbourhood environments. While analyses found inconclusive evidence of exposure to outdoor advertising affecting purchasing, the availability and accessibility of advertising in the information environment seems to have a small association with purchasing among adolescents. In short, outdoor advertising may play a slight role in adolescent food and beverage purchasing.

Given the legislative and policy context in Canada, there is building demand for research on outdoor food and beverage advertising and purchasing, particularly among children and youth. Future researchers should work to develop a robust evidence base composed of cross-sectional, longitudinal, and intervention studies that measure the range of spatial interactions in the food information environment.
5.8 References


Brown, D. R., & Brewster, L. G. (2015). The food environment is a complex social network. Social Science & Medicine, 133, 202–204. https://doi.org/10.1016/j.socscimed.2015.03.058


Lansink v. London (City), No. PL170100 (Ontario Municipal Board March 6, 2018).


114957 Canada Ltee (Spraytech, Societe d’arrosage) v Hudson (Town), [2001] 2 SCR 241 ___ (Supreme Court of Canada 2001), On appeal from Quebec.


Ormston v Kitchener (City), No. PL150200 (Ontario Municipal Board January 19, 2018).


Appendix A

The following documents are included in this appendix:

- NMREB continuing ethics certificates for the SmartAPPetite study
Dear Dr. Jason Gilliland,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WBEM application form for the amendment, as of the date noted above.

Documents Approved:

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REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

*Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).*

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Dear Dr. Jason Gilliland,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

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Please do not hesitate to contact us if you have any questions.
Appendix B

The following documents are included in this appendix:

- Control Letter of Information & Assent for Students <18
- Control Letter of Information & Consent for Students >18
- Control Letter of Information & Consent for Parents
- Intervention Letter of Information & Assent for Students <18
- Intervention Letter of Information & Consent for Students >18
- Intervention Letter of Information & Consent for Parents
Research Project: SmartAPPetite Adolescent Study

Control Letter of Assent for >18

To whom it may concern,

Have you ever wanted to learn more about how to choose healthy foods, prepare healthy meals, or buy healthy options at restaurants?

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University are working with high school students like you to promote healthy living and healthy eating. We invite you to participate in a message-based nutrition intervention called SmartAPPetite. SmartAPPetite aims to provide users with teen-specific knowledge on healthy living and healthy eating.

This study will take place in your high school this year, where your school will participate in the study without using the app to provide a baseline understanding of student knowledge about nutrition. We will offer the app to you after the third survey.

What are we going to study?

The purpose of this study is to evaluate our message-based intervention, SmartAPPetite, to improve healthy food access, food knowledge, and dietary behaviours of high school students.

What would you have to do?

Complete the Youth Survey. You will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks about you, your food knowledge, eating habits, and food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help remember the type and amount of food you ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

You will receive a $10 gift card for completing the first survey, and $15 gift cards for completing each of the second and third surveys. Therefore, you will receive $40 in gift cards total for participating in this study. The amount received is taxable it is your responsibility to report this amount for income tax purposes.
Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. You will earn up to 7 entries into the draw by registering for the study and completing each survey (1 entry for registering, 2 entries for each survey completed). Students who withdraw from the study will not lose any earned entries.

Do you have to participate?

No - you only have to participate if you would like to. You are also allowed to stop at any time or refuse to answer any questions. We will never share your information with anyone else, not even your parents. You are allowed to see your information at any time. The researchers from Western University will be happy to answer any questions or concerns you have. All study activities occur during school time, or when necessary, on your own time.

What are the benefits and risks if I participate?

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the app's impact on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens.

There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about you. We are also asking for your email address and postal code. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers.

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password-protected computer in a secure facility at the University of Western Ontario.
Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this assent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is de-identified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your assent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted]. If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below.

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Youth Study

Assent Form

I have had all of my questions answered and agree to participate in this study.

Print Name: ____________________________ ____________________________

First name Last name

Student’s Email Address: ________________________________

Today's Date: ____________________________
Research Project: SmartAPPetite Adolescent Study

Control Letter of Information for >18

Dear Participant,

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as diabetes, cardiovascular disease, cancer, obesity, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study. The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Your school has been selected to participate in the study without using the app to provide a baseline understanding of student knowledge about nutrition. We will offer the app to all students in the school after the third survey. Any high school-aged adolescents who can speak and read English are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your participation in our research.

Do we have to participate in this study? Your participation in this study is completely voluntary. You do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If you decide to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted] and any data collected from you will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?

If you agree to participate, you will be asked to Complete the Youth Survey. The youth survey is a 40-minute online survey you will complete 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks you about yourself, your food knowledge, your eating habits,
and your food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help you remember the type and amount of food that you ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

Compensation

You will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. Students will earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students who withdraw from the study will not lose any earned entries.

What are the benefits and risks if I participate?

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the app's impact on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens.

There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about you. We are also asking for your email address and postal code. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers.

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password-protected computer in a secure facility at the University of Western Ontario.
Representatives of The University of Western Ontario's Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is de-identified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your consent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University's Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University's Office of Human Research Ethics at [redacted].

If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Youth Study

Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, you agree to participate in this study, and have had all questions answered to your satisfaction.

I am 18 years of age or older, and agree to participate in this study.

Student’s name: ____________________________

Student’s School: __________________________

Student’s 2nd Period Teacher: __________________________

Date: __________________________
Research Project: SmartAPPetite Adolescent Study

Control Letter of Information for Parents

Dear Parent/Guardian,

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a study using a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as diabetes, cardiovascular disease, cancer, obesity, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study. The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Your child’s school has been selected to participate in the study without using the app to provide a baseline understanding of student knowledge about nutrition. We will offer the app to all students in the school after the third survey. Any high school-aged adolescents who can speak and read English (and their parents) are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your child’s participation in our research.

Do we have to participate in this study? Your participation in this study is completely voluntary. You and your child do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If you or your child decide to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted], any data collected from you or your child will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?

If you agree to participate, you will be asked to:

Complete the Parent Survey. This short 10-minute survey will ask questions about your family’s meal and shopping behaviours, as well as other information about your family
socio-economic status. The Parent Survey is completely voluntary - your child can still join the study themselves if you decide not to fill out the Parent Survey; however, as the survey gives us critical information from the point of view of parents, we would really appreciate your participation.

If your child agrees to participate, they will be asked to:

*Complete the Youth Survey.* Your child will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks your child about themselves, their food knowledge, their eating habits, and food purchasing behaviours. Part 2 is a 24-hour recall diary, for which your child will be led through a guided online survey to help them remember the type and amount of food they ate the previous day. Surveys are completed in person at your student’s school during class time. Should your student be absent or need to remain in class, they still have the option to complete the survey later on their own time.

**Compensation**

If you participate in the parent survey, you will receive a $10 gift card. Your child will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give your child a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. Students will earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students who withdraw from the study will not lose any earned entries.

**What are the benefits and risks if my child participates?**

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens.

There is little risk to your child if he/she participates in this study, but there is a slight chance that you or your child may be uncomfortable sharing details of your family, such as economic status or eating patterns. We are also asking for your email address and postal
code. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers.

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You or your child will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is de-identified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your consent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed
according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University’s Office of Human Research Ethics at [redacted].

If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Youth Study

Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, your agreement to allow your child to participate in this study, and have had all questions answered to your satisfaction.

By providing the following information, I agree for my child to participate in this study.

Student’s Name: ________________________________

Student’s School: ________________________________

Student’s 2nd Period Teacher: ________________________________

Parent’s Name: ________________________________

Do you agree to participate in the brief 10-minute parent survey, for which you will receive a $10 gift card for Amazon as a thank you for participating?

☐ Yes ☐ No

IF YES → The survey will ask the following question before auto directing the parent to the parent survey on a new Qualtrics survey.

If you would like to receive a $10 Gift Card from Amazon as a thank you for participating in the survey, please provide your email address and we will email it to you within 4 weeks. Your email address will not be used for any other purpose then stated above.

___________________________________________________________
Enter your email address

___________________________________________________________
Verify your email address

IF NO → The consent form will be submitted to allow their child to participate in the study.
Research Project: SmartAPPetite Adolescent Study

Intervention Letter of Assent for <18

To whom it may concern,

Have you ever wanted to learn more about how to choose healthy foods, prepare healthy meals, or buy healthy options at restaurants? Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University are working with high school students like you to promote healthy living and healthy eating. We invite you to participate in a message-based nutrition intervention called SmartAPPetite. SmartAPPetite aims to provide users with teen-specific knowledge on healthy living and healthy eating. This study will take place in your high school this year.

What are we going to study?

The purpose of this study is to evaluate our message-based intervention, SmartAPPetite, to improve healthy food access, food knowledge, and dietary behaviours of high school students.

What would you have to do?

*Complete the Youth Survey.* You will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks about you, your food knowledge, eating habits, and food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help remember the type and amount of food you ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

*You will receive a $10 gift card for completing the first survey, and $15 gift cards for completing each of the second and third surveys.* Therefore, you will receive $40 in gift cards total for participating in this study. The amount received is taxable it is your responsibility to report this amount for income tax purposes.

*Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school.* You will earn up to 7 entries into the draw by registering for the study and completing each survey (1 entry for registering, 2 entries for each survey completed). You can also earn an additional entry each
time you open AND rate a message in the app (limit one entry per message). Students who withdraw from the study will not lose any earned entries.

**Receive SmartAPPetite Intervention for 10 Weeks.**

*If you have a smartphone or tablet device (with data or WiFi connectivity)*, you will be asked to download the free SmartAPPetite app and sign up for an account with your email address. You will receive up to 3 healthy eating and healthy lifestyle messages per day for 10 weeks. Each message will include a tip about healthy eating and healthy lifestyle for teens, and often a recipe related to the tip, and a list of local, healthy food vendors based on their geographic location. The app also provides GPS-enabled messaging to inform the user if they are close to any local vendors of healthy food.

*If you do not have a smartphone or tablet device* you will have the option of receiving a daily message through email for 10 weeks. These messages will include tips about healthy eating and healthy lifestyle about teens, related recipes, and local vendors of healthy food items close to their school.

**Focus Group.** Upon completion of the study, you may be asked to take part in a focus group to provide feedback about SmartAPPetite and discuss suggestions for improvement. Focus groups will be conducted during your lunch break at school, and you will be provided a healthy nutritious lunch during the session. Further information about focus groups will be provided in a separate document. All focus groups will be audiorecorded to ensure we catch the whole conversation. If you do not want to be audio recorded then do not participate in the focus group portion of the study. Please be advised that although the researchers will take every precaution to maintain confidentiality of the data, the nature of focus groups prevents the researchers from guaranteeing confidentiality. The researchers will remind participants to respect the privacy of your fellow participants and not repeat what is said in the focus group to others. If the results are published, your name will not be used.

**Do you have to participate?**

No - you only have to participate if you would like to. You are also allowed to stop at any time or refuse to answer any questions. We will never share your information with anyone else, not even your parents. You are allowed to see your information at any time. The researchers from Western University will be happy to answer any questions or concerns.
you have. All study activities occur during school time, or when necessary, on your own time.

What are the benefits and risks if I participate?

By participating in this research, you will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens. Potential anticipated benefits to the participants include: increased awareness of the health benefits of healthy and local foods; increased food literacy and knowledge of how to incorporate healthy, local, and seasonal foods into their household menus; increased fruit and vegetable consumption; healthier diets and better overall health.

There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about yourself. We are also asking for your email address, postal code, and the app is GPS-enabled. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers. However, any locational information collected is strictly confidential and approved research team members will only be able to access the information after the completion of the study. You also have the option to turn-off GPS location services within the application at any time.

There is a chance that you may incur additional data charges in the use of the app. Research team members will show you how to control when the app uses data (cellular or wifi), and if you have any questions please contact us at [redacted].

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research.
Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this assent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is de-identified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your assent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University's Office of Human Research Ethics at [redacted].

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Youth Study

Assent Form

I have had all of my questions answered and agree to participate in this study.

Print Name: __________________________

First name  Last name

Date: ______________

Student’s Email Address: _____________________________

Student’s Age: _________________________

Please indicate which way you would like to participate in the SmartAPPetite project:

0 Through a smartphone or tablet

0 By email

Focus Groups:

0 Please check the box if you would like to participate in the focus groups at the end of the study
Research Project: SmartAPPetite Adolescent Study

Intervention Letter of Information for >18

Dear Student,

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as obesity, diabetes, cardiovascular disease, cancer, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study. The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Any high school-aged adolescents who can speak and read English are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your participation in our research.

Do we have to participate in this study? Your participation in this study is completely voluntary. You do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If either you or your parent decides to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted], any data collected from you will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?

If you agree to participate, you will be asked to:

Complete the Youth Survey. You will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks you about yourself,
your food knowledge, your eating habits, and your food purchasing behaviours. Part 2 is a 24-hour recall diary, for which you will be led through a guided online survey to help you remember the type and amount of food they ate the previous day. Surveys are completed in person at your school during class time. Should you be absent or need to remain in class, you still have the option to complete the survey later on your time.

*Receive SmartAPPetite Intervention for 10 Weeks.*

*If you have a smartphone or tablet device (with data or WiFi connectivity),* you will be asked to download the free SmartAPPetite app and sign up for an account with your email address. You will receive up to 3 healthy eating and healthy lifestyle messages per day for 10 weeks. Each message will include a tip about healthy eating and healthy lifestyle for teens, and often a recipe related to the tip, and a list of local, healthy food vendors based on their geographic location. The app also provides GPS-enabled messaging to inform the user if they are close to any local vendors of healthy food. To participate in this study, your email address must be provided to our team so that we can connect you to your SmartAPPetite app.

*If you do not have a smartphone or tablet device* you will have the option of receiving a daily message through email for 10 weeks. These messages will include tips about healthy eating and healthy lifestyle about teens, related recipes, and local vendors of healthy food items close to their school. To participate in this study, your email address must be provided to our team so that we can send you email-based SmartAPPetite messages.

*Focus Group.* Upon completion of the study, you may be asked to take part in a focus group to provide feedback about SmartAPPetite and discuss suggestions for improvement. Focus groups will be conducted during your lunch break at school, and you will be provided a healthy nutritious lunch during the session. Further information about focus groups will be provided in a separate document. All focus groups will be audio-recorded to ensure we catch the whole conversation. If you do not want to be audio-recorded you may not participate in the focus group portion of the study. Please be advised that although the researchers will take every precaution to maintain confidentiality of the data, the nature of focus groups prevents the researchers from guaranteeing confidentiality. The researchers will remind participants to respect the privacy of your fellow participants and not repeat what is said in the focus group to others. If the results are published, direct quotes may be used, but your name will not be used.
Compensation

You will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give you a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. Students will earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students will also earn an additional entry each time they open AND rate a message in the app (limit one entry per message). Students who withdraw from the study will not lose any earned entries.

What are the benefits and risks if I participate?

By participating in this research, you will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens. Potential anticipated benefits to the participants include: increased awareness of the health benefits of healthy and local foods; increased food literacy and knowledge of how to incorporate healthy, local, and seasonal foods into their household menus; increased fruit and vegetable consumption; healthier diets and better overall health.

There is little risk if you participate in this study, but there is a slight chance that you may be uncomfortable sharing details about yourself. We are also asking for your email address, postal code, and the app is GPS-enabled. Geographic locational information, such as postal code, helps us establish the geographical impact of food choices and accessibility to food vendors and retailers. However, any locational information collected is strictly confidential and approved research team members will only be able to access the information after the completion of the study. You also have the option to turn-off GPS location services within the application at any time.

There is a chance that you may incur additional data charges in the use of the app. Research team members will show you how to control when the app uses data (cellular or wifi), and if you have any questions please contact us at [redacted].

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.
You will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that participants will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any paper files are housed securely in a locked institutional storage room. All data is de-identified and aggregated prior to publication. We will keep your data for a minimum of 7 years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your consent to participate and ask that your data be destroyed by contacting one of the researchers within this time period. It is not possible to withdraw your data from a report that has been already submitted to publishers, however you may withdraw your data from being used in all future reports. All data will be destroyed according to University of Waterloo, Wilfrid Laurier University, and Western University policies.

Who do I contact if I have any other questions?
The study has also been cleared by Western University's Non-Medical Research Ethics Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034 please contact Western University's Office of Human Research Ethics at [redacted].

If you have any further questions about the SmartAPPetite project we encourage you to please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:

[redacted]
Research Project: SmartAPPetite Adolescent Study

Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, you agree to participate in this study, and have had all questions answered to your satisfaction.

1. Study Participation:

Would you like to participate in this study?

☐ Yes ☐ No

2. Group Discussion:

Would you like to participate in the audio-recorded group discussion, where anonymous direct quotes from the group discussions may be used by the research team in publications?

☐ Yes ☐ No

I am 18 years of age or older, and agree to participate in this study.

Student’s name: ____________________________

Student’s School: __________________________

Student’s 2nd Period Teacher: __________________

Date: ________
Research Project: SmartAPPetite Adolescent Study

Intervention Letter of Information for Parents

Dear Parent/Guardian,

Dr. Jason Gilliland from Western University, Dr. Leia Minaker from the University of Waterloo, and Dr. Sean Doherty from Wilfrid Laurier University invite you to participate in a nutrition and healthy living smartphone app (e.g., android, iOS, email) called SmartAPPetite. SmartAPPetite provides users with scientifically valid information on how to eat healthy, and healthy living in general. This app has been created to help address the increase in diet related chronic disease, such as obesity, diabetes, cardiovascular disease, cancer, dental disease, and osteoporosis. This study will involve high school-aged youth from schools across Southwestern Ontario between 2018 and 2021.

Purpose of this Study. The purpose of this study is to evaluate the effectiveness of a message-based nutritional intervention program called SmartAPPetite, which aims to improve healthy food access, food literacy, and dietary behaviours in an adolescent population. Any high school-aged adolescents who can speak and read English (and their parents) are welcome to take part in our research. The purpose of this letter is to provide you with the information required for you to make an informed decision regarding your child’s participation in our research.

Do we have to participate in this study? Your participation in this study is completely voluntary. You and your child do not have to participate. You can each refuse to answer any survey questions, and can choose to leave the study at any time. If you or your child decides to leave the study at any time (even AFTER the study has been completed) please contact the project team at [redacted] and any data collected from you or your child will be immediately destroyed and excluded from the analysis. All study activities occur during school time, or when necessary, on your own time.

What will happen in this study?

If you agree to participate, you will be asked to:

Complete the Parent Survey. This short 10-minute survey will ask questions about your family's meal and shopping behaviours, as well as other information about your family socio-economic status. The Parent Survey is completely voluntary - your child can still join the study themselves if you decide not to fill out the Parent Survey; however, as the survey
gives us critical information from the point of view of parents, we would really appreciate your participation. The survey is completed on your own time.

If your child agrees to participate, they will be asked to:

*Complete the Youth Survey.* Your child will be asked to complete a 40-minute online survey 3-times: one now, one in 8- to 10-weeks, and one in 6-months. Part 1 asks your child about themselves, their food knowledge, their eating habits, and food purchasing behaviours. Part 2 is a 24-hour recall diary, for which your child will be led through a guided online survey to help them remember the type and amount of food they ate the previous day. Surveys are completed in person at your student’s school during class time. Should they be absent or need to remain in class, they still have the option to complete the survey later on their own time.

*Receive SmartAPPetite Intervention for 10 Weeks.*

*If your child has a smartphone or tablet device (with data or WiFi connectivity)*, they will be asked to download the free SmartAPPetite app and sign up for an account with their email address. They will receive up to 3 healthy eating and/or healthy lifestyle messages per day for 10 weeks. Each message will include a tip about healthy eating and healthy lifestyle for teens, and often a recipe related to the tip, and a list of local, healthy food vendors based on their geographic location. The app also provides GPS-enabled messaging to inform the user if they are close to any local vendors of healthy food. To participate in this study, your child’s email address must be provided to our team so that we can create a SmartAPPetite app account for your child.

*If my child does not have an smartphone or tablet device*, they will have the option of receiving a daily message through email for 10 weeks. These messages will include tips about healthy eating and/or healthy lifestyle for teens, related recipes, and local vendors of healthy food items close to their school. To participate in this study, your child’s email address must be provided to our team so that we can send them email-based SmartAPPetite messages.

*Focus Group.* Upon completion of the study, your child may be asked to take part in a focus group to provide feedback about SmartAPPetite and discuss suggestions for improvement. Focus groups will be conducted during your students’ lunch break at school, and they will be provided a healthy nutritious lunch during the session. Further information about focus
groups will be provided in a separate document. All focus groups will be audio-recorded to ensure we catch the whole conversation. If you do not want your child to be audio-recorded, they may not participate in the focus group portion of the study. Please be advised that although the researchers will take every precaution to maintain confidentiality of the data, the nature of focus groups prevents the researchers from guaranteeing confidentiality. The researchers will remind participants to respect the privacy of your fellow participants and not repeat what is said in the focus group to others. If the results are published, direct quotes may be used, but your child’s name will not be used.

Compensation

If you participate in the parent survey, you will receive a $10 gift card. Your child will receive gift cards as follows: $10 for first survey, $15 for second and third survey (total of $40 in gift cards). The amount received is taxable it is your responsibility to report this amount for income tax purposes.

Participation in this study will also give your child a chance to win a MacBook Air, which we will be giving away in a grand prize draw to one student from each school. Students will earn up to 7 entries into the draw by registering for the study (1 entry) and completing each survey (2 entries each). Students will also earn an additional entry each time they open AND rate a message in the app (limit one entry per message). Students who withdraw from the study will not lose any earned entries.

What are the benefits and risks if my child participates?

By participating in this research, students and parents will help us evaluate the effectiveness of the SmartAPPetite project. By better understanding the impact of the app has on teen food habits, purchasing, and knowledge, we can use the app as a population intervention for teens. Potential anticipated benefits to the participants include: increased awareness of the health benefits of healthy and local foods; increased food literacy and knowledge of how to incorporate healthy, local, and seasonal foods into their household menus; increased fruit and vegetable consumption; healthier diets and better overall health.

There is little risk to your child if he/she participates in this study, but there is a slight chance that you or your child may be uncomfortable sharing details of your family, such as economic status, eating patterns. We are also asking for your email address, postal code, and the app is GPS-enabled. Geographic locational information, such as postal code, helps us
establish the geographical impact of food choices and accessibility to food vendors and retailers. However, any locational information collected is strictly confidential and approved research team members will only be able to access the information after the completion of the study. Participants also have the option to turn-off GPS location services within the application at any time.

There is a chance that your child may incur additional data charges on their device by using the app. Research team members will show your child how to control when the app uses data (cellular or wifi), and if you have any questions please contact one of the research team members at [redacted].

We are minimizing the risks you may feel as follows:

All information collected in this study is kept strictly confidential.

You or your child will not be personally identified or identifiable by name in any of the documents related to the study, except for the consent form. This will be accomplished by assigning a unique identification code.

Materials and data files will ONLY be viewed by members of the research team and will be stored in a locked filing cabinet until transferred onto a password protected computer in a secure facility at the University of Western Ontario.

Representatives of The University of Western Ontario’s Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research. Data will be kept until the conclusion of data analysis and publications from this study are completed. The results of this study will only be presented for groups so that children will never be individually identifiable. While we do our best to protect your information there is no guarantee that we will be able to do so. If data is collected during the project which may be required to report by law, we have a duty to report. You do not waive any legal rights by signing this consent form.

You will be completing the study by an online survey operated by Qualtrics. When information is transmitted or stored on the internet privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers).

Only researchers associated with this study will have access to the study records through an encrypted connection on a password-protected server with two factor authentication. Any
paper files are housed securely in a locked institutional storage room. All data is de-
identified and aggregated prior to publication. We will keep your data for a minimum of 7
years in accordance with Canadian Institutes of Health Research policy.

You can withdraw your consent to participate and ask that your data be destroyed by
contacting one of the researchers within this time period. It is not possible to withdraw
your data from a report that has been already submitted to publishers, however you may
withdraw your data from being used in all future reports. All data will be destroyed
according to University of Waterloo, Wilfrid Laurier University, and Western University
policies.

Who do I contact if I have any other questions?

The study has also been cleared by Western University’s Non-Medical Research Ethics
Board (NMREB#107034). For matters pertaining to ethics clearance NMREB#107034
please contact Western University’s Office of Human Research Ethics at [redacted].

If you have any further questions about the SmartAPPetite project we encourage you to
please contact a research team member listed below or the research team at [redacted].

The Lead Investigators of this project include:

[redacted].
Research Project: SmartAPPetite Adolescent Study

Consent Form

Completion of the following consent form indicates that you have read the Letter of Information, your agreement to allow your child to participate in this study, and have had all questions answered to your satisfaction.

1. Study Participation:

Would you like your child to participate in this study?

☐ Yes ☐ No

2. Group Discussion:

Would you like your child to participate in the audio-recorded group discussion, where anonymous direct quotes from the group discussions may be used by the research team in publications?

☐ Yes ☐ No

By providing the following information, I agree for my child to participate in this study.

Student’s Name: ____________________________

Student’s School: ____________________________

Student’s 2nd Period Teacher: ____________________________

Parent’s Name: ____________________________

Do you agree to participate in the brief 10-minute parent survey, for which you will receive a $10 gift card for Amazon as a thank you for participating?

☐ Yes ☐ No
Appendix C

The following documents are included in this appendix:

- SmartAPPetite adolescent survey questions used in Chapter 3 and 4
SmartAPPetite Adolescent Survey Questions

A1) I am a: Male / Female / I identify as: ________

A2) What is your current age? 13 14 15 16 17 18 19

A5) Postal code at your main home: ________ (e.g. N6A 5K6)

A6) What is your ethnicity? (Select all that apply)

- White/Caucasian
- South Asian (e.g., East Indian, Pakistani, Sri Lankan)
- East Asian (e.g., Chinese, Japanese, Korean)
- Middle Eastern (e.g., Egyptian, Iranian, Lebanese)
- Latin American (e.g., Mexican, Columbian, Peruvian)
- Indigenous (i.e., First Nations, Métis, or Inuit)
- Black (e.g., African, Caribbean)
- Other (Please Specify): ______________________

C5) During a typical week, how often do you purchase food from the following types of locations?

a. Supermarket or grocery store
Times per Month: ________ OR Times per Week: ________

b. Convenience store, corner store, gas station, or pharmacy
Times per Month: ________ OR Times per Week: ________

c. Fast food restaurant or coffee shop
Times per Month: ________ OR Times per Week: ________

d. Full-service/sit-down restaurant
Times per Month: ________ OR Times per Week: ________

C6) Please rate your level of agreement on a scale of strongly agree (1) to strongly disagree (5) with the following statements:

- Eating healthy food is important to me
- I like to cook
- Cooking or preparing meals helps me eat more healthy
- Cooking or preparing lunch at home helps me save money
- Cooking or preparing lunch to take to school takes too much time
- I have no problem reading or understanding food labels
Curriculum Vitae

Name: Alexander J. D. “AJ” Wray

Post-secondary Education and Degrees:

Western University
London, Ontario, Canada
September 2018 – August 2020 (Conferred Fall 2020) M.A. Geography (focus: Environment, Development and Health)

Western University
London, Ontario, Canada
September 2018 – April 2020, M.A.
Western Certificate in University Teaching and Learning

University of Waterloo
Waterloo, Ontario, Canada
2013 – 2018 Dip.EA.
Environmental Assessment

University of Waterloo
Waterloo, Ontario, Canada
2013 – 2018 B.E.S. (Hons) Co-operative Planning (focus: Land Development Planning)

International experiences during degree:

The University of Tokyo
Bunkyo City, Tokyo, Japan
February 2017, Department of Urban Engineering
Kakehashi Friendship Ties Exchange Program

Politecnico di Milano
Milano, Milan, Italy
April 2014, Barcelona Field School
International Network for Traditional Building, Architecture, and Urbanism Exchange Program

Honours and Awards:

Institute of Population and Public Health Canadian Public Health Association 2020 Conference Travel Award (Canadian Institutes of Health Research) (2020)

Children’s Health Research Institute Travel Award (Lawson Foundation) (2020)

School of Graduate and Postdoctoral Studies Wall of Fame Award (Western University) (2020)

E.G. Pleva Prize for Excellence as a Graduate Teaching Assistant (Dept. of Geography, Western University) (2019)
Student Achievement Award (Esri Canada GIS Centre of Excellence, Western University) (2019)

Esri Canada GIS Scholarship (Faculty of Social Science, Western University) (2019)

Ontario Graduate Scholarship (Ontario Ministry of Colleges and Universities) (2019)

Joseph Armand Bombardier Canada Graduate Scholarship – Masters (Social Sciences and Humanities Research Council of Canada) (2018)

Federation of Students Leadership Award (Federation of Students, University of Waterloo) (2018)

Faculty of Environment Co-op Work Term Award (University of Waterloo) (2018)

Faculty of Environment Dean’s Honours List (University of Waterloo) (2018)

Jim Kalbfleisch Award (University of Waterloo) (2017)

Alyson Woloshyn Leadership Award (University of Waterloo) (2016)

Southwest Ontario District Scholarship (Ontario Professional Planners Institute) (2014)

President’s Entrance Scholarship (University of Waterloo) (2013)

University of Waterloo Planning Alumni of Toronto Award (University of Waterloo) (2013)

Colonel McLaughlin Graduate Scholarship (Durham District School Board) (2013)

Ontario Principals’ Award for Student Leadership (Ontario Principals’ Council) (2013)

Ontario Power Generation Award (Durham District School Board) (2013)

Ontario Secondary School Teachers Federation and Durham District School Board Award for Personal Excellence in the Community (Ontario Secondary School Teachers Federation District 13) (2012)

**Related Work Experience:**

President & Board Member

Town and Gown Association of Ontario

September 2018 – present
Project Coordinator
Food Retail Environment Study for Health and Economic Resiliency (FRESHER), Human Environments Analysis Lab
May 2020 – present

Research Assistant
Human Environments Analysis Lab
September 2018 – present

Teaching Assistant
Western University (Geography)
September 2018 – April 2020

Research Assistant
University of Waterloo (Planning)
September 2016 – August 2018

Teaching Assistant
University of Waterloo (Planning)
January 2017 – April 2018

Student Planner
Region of Waterloo (Planning Research & Analytics)
January 2016 – April 2016

Assistant Project Officer
Ontario Ministry of Environment and Climate Change (Environmental Assessment Services)
May 2015 – August 2015

Research Assistant
Ontario Ministry of Environment and Climate Change (Water User and Toxics Reporting)
May 2014 – August 2014

**Conference and Community Presentations:**


Wray A, & Gilliland J. 2019, April 26. Where has all the food gone? A review of food environment policies and bylaws of Canadian metropolitan areas. Presented at the Urban Affairs Association 49th Annual Meeting, Los Angeles, California, United States of America.


Publications:  


