University of Alberta

Evaluating food environment assessment methodologies: a multi-level examination of associations between food environments and individual outcomes

By

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I dedicate this dissertation to my partner, Jacob J. Shelley, without whose support, critical insights, and outstanding child-rearing abilities, I could not have completed this dissertation as swiftly.

Abstract

Background: The food environment (FE) is being increasingly recognized as an important and modifiable determinant of diet quality and weight status. Hundreds of FE measures exist, resulting in a lack of comparability between studies. This is particularly problematic given that evaluating FEs' impact on population health requires valid and reliable FE measures.

Methods: A population-based, stratified random sample was recruited from southern Ontario (N=4902 individuals within 2228 households). Socio-demographic data, and self-reported weight, height and waist circumference (WC) were collected from household members. Diet quality was assessed using diet record data collected from a subset of participants (n=1170 individuals within 690 households). The main food shopper in each household reported perceptions of their neighbourhood FE. Seven objective measures characterized the FE of 421 food stores and 912 restaurants in the study region. Euclidean-distance buffers around each household were created at 250m, 500m, 1000m, and 1500m; FE scores from each measure were aggregated within each buffer. These datasets were used to investigate three different research issues. In Chapter 3, construct validity of four of the measures was examined using a multitrait-multimethod matrix (MTMM). In Chapter 4, multiple regression analyses determined the extent to which objective measures predicted residents' perceptions; multilevel multiple regression analyses determined the extent to which perceptions and objective measures predicted individuals' body mass index (BMI), WC and diet quality. In Chapter 5, mediation analyses were conducted to determine whether residents' perceptions explained associations between objective measures and outcomes.

Results: MTMM results revealed that common FE measures purportedly assessing the same constructs may in fact be measuring different constructs, and that food availability and food quality may not be separate and distinct constructs as previously thought. Perceptions were not highly correlated with objective FE measures. Regression analyses results revealed that many objective measures predict residents' perceptions. Objective measures (notably food access and food affordability measures) predicted BMI and WC while perceptual variables did not. Mediation analyses findings revealed that perceptions do not mediate associations between objective measures and diet quality, BMI, or WC.

Conclusion: MTMM results suggest a method effect, in that what is actually being measured seems to differ by assessment method employed, which has implications for research and practice. Findings may support FE policies or programs focused on objective (rather than perceived) FE features, since objective features better predict weight outcomes and perceptions do not mediate these associations. Specifically, strategies to restrict convenience store access and improve the affordability of nutritious foods relative to non-nutritious foods seem to be supported by these findings.

Acknowledgements

I dedicated this dissertation to my spouse, Jacob, to whom I am especially grateful for helping me to learn how to balance work, school and family, and to recognize that our choice to begin a family while we were both in school was crazy but worth it. This dissertation is the result of four years' work spread over five years, since I gave birth to two of my three babies during my PhD. Having children while in school forced me to consider my priorities, which now involve more than succeeding academically. I would thus like to additionally acknowledge my three children: Jordan, Marley, and Evelyn. Jordan, thank you for your kind and empathetic spirit, and for all the hugs when I have felt stressed out. Marley, thank you for always bringing a smile to my face with your quirky antics. Evelyn, thank you for keeping me on my toes and for always being ready for a game of patty cake or "this little piggy".

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Chapter 1: Introduction to food environments

1. Introduction

The food environment has been defined as “a group of factors including the types of retail food outlets and the availability, quality, and price of different kinds of foods, such as prepared foods, fresh produce, and other groceries, in a given geographical area” ((2)p. 61). Federal, provincial, and territorial governments are interested in the effects of food environment features on the dietary behaviours and health of the population, as evidenced by the 2012 report, *Measuring the Food Environment* (3) commissioned by the Office of Nutrition Policy and Promotion at Health Canada. Indeed, federal, provincial and territorial Ministers of Health and of Health Promotion/Healthy Living have suggested that increasing the availability and accessibility of nutritious foods, particularly among vulnerable populations, is a policy intervention that may hold promise in reducing childhood obesity (4). Since healthy diets are essential for maintaining health and preventing chronic disease, municipal and regional governments in Canada are beginning to consider policies that would limit residents’ exposure to less nutritious foods, or programs that would increase access to nutritious foods within food outlets. For example, several municipalities in Quebec are considering restricting access to non-nutritious foods through zoning regulations prohibiting fast food outlets from opening within walking distance of schools (3); Toronto Public Health is currently conducting a study to determine the feasibility of a Healthy Corner Stores program that would increase access to nutritious foods in underserved Toronto neighbourhoods (personal communication, Brian Cook, Toronto Public Health).

Although governments at all levels are interested in addressing inequalities in food environments and several jurisdictions have taken steps to implement policies or programs aimed at improving food environments, extant research shows inconsistent associations between food environments and residents’ diet-related health outcomes, such as diet quality, weight status, and chronic diseases (5-9). In part, this is due to inconsistent food environment assessment methods, an incomplete understanding of how different assessment methods are related, and an unclear picture of how food environments “get under the skin” of local residents.

1.1 Pressing issues requiring further study

Literature reviews (5-8, 10-12) have identified several gaps, including three pressing issues requiring further study. First, over 500 measures of the food environment exist (13), and there is little consistency between assessment methods in the published literature, making generalizations or comparisons across studies very difficult. The use of inconsistent assessment methods is particularly problematic, given that food environment policies cannot be rigorously assessed without valid and reliable food environment measures.

Second, researchers have inconsistently operationalized the relevant geographic scale at which food environment features are hypothesized to act, obscuring the relationship between food environments and residents' diet-related outcomes. This is because relationships at one scale may not exist at other scales (14, 15). Considerations of geographic scale have important implications for policies or programs aimed at improving food environments. For example, while the impact of food environment characteristics at one scale may be relevant for residents' diet-related outcomes, the same geographic scale may not correspond to administrative neighbourhood boundaries within which policy makers can act.

Third, the relationship between objective measures and residents' perceptions of their food environments is unclear; most studies have not found objective measures to be highly correlated with residents' perceptions (16-18), although perceptions have been hypothesized to mediate the association between objective food environment measures and residents' diet-related outcomes (1). The relationship between objective and perceived food environment measures is particularly important for theory development (e.g., how are food environments associated with residents' perceptions and diet-related health outcomes within an ecological framework?), methodological refinement (e.g., which objective measures are most strongly correlated with residents' perceptions?), and also for policy or programs (e.g., should programs focus on improving objective accessibility of nutritious foods, or on increasing residents' awareness of local, nutritious foods?). As will be discussed in Chapter 2, many conceptual frameworks have been presented. The frameworks differ in terms of theoretical emphasis on different types of constructs, the categorization of different variables into different ecological levels, and mechanisms by which food environments are hypothesized to affect residents' health. Since extant food environment literature often relies on implicit assumptions to guide researchers' choice of food environment assessment measures, the research described in this dissertation explicitly tests Glanz and colleagues' frequently-cited conceptual model (18) in particular with the goal of refining it, which is an important step in this nascent field.

The research presented in this dissertation contributes to knowledge advancement in each of these identified knowledge gaps. First, seven different objective food environment assessment tools and one perceptual food environment assessment tool were employed, making it possible to compare tools within the same population. Second, the research uses buffer zones at different geographic scales, ranging from 250 to 1500m, to examine how geographic scale influences construct validity and may be differentially associated with diet-related outcomes. Third, both objective and perceptual food environment variables derived from the eight different assessment methods were used to characterize residents' food environment exposures, and were compared to see which methods lend themselves to the creation of variables that most strongly predict residents' diet quality, body mass index, and waist circumference. Finally, the research explicitly tests whether residents' perceptions mediate the associations between objective food environment measures and diet-related health outcomes as proposed in Glanz and colleagues' conceptual model (18). Although several studies implicitly assume that residents' perceptions mediate associations between objective measures and diet-related outcomes, no studies to date have explicitly tested this hypothesis. The three studies presented in Chapters 3, 4, and 5 all contribute to the refinement of Glanz and colleagues' model, as will be discussed in the concluding chapter. This research took place in close collaboration with the Region of Waterloo's Public Health Department, to ensure that findings are translated into meaningful and relevant policy messages in a region where healthy food systems are a priority (19, 20).

1.2 Theoretical Approach and Research Aims

The field of food environment research is still in its infancy (8, 9, 21). As will be described more fully in Chapter 2, there is little consistency in terms of conceptual models upon which researchers rely to design food environment studies, develop assessment methods, or identify outcomes of interest. While policy-makers are becoming increasingly interested in food environment interventions, certain foundational measurement issues have yet to be fully addressed, precluding researchers from providing solid evidence to policy-makers to inform potentially effective food environment interventions. This dissertation addresses several of these foundational measurement issues with an eye toward informing future interventions.

This dissertation uses an ecological approach to conceptualize food environments. Chapter 2 will describe a literature review of conceptual models of the food environment, and will provide justification for the use of Glanz and colleagues' conceptual model (1) to inform the study design, variable selection, and statistical tests of the research questions described in this dissertation. Figure 1-1 is a reproduction of Glanz and colleagues' model. Glanz and colleagues used an ecological approach to categorize policy variables, environmental variables, and individual variables that act as determinants of eating patterns. This dissertation focuses on the *community* nutrition environment (variables related to food access, such as the type and location of food stores), the *consumer* nutrition environment (for example, the availability of healthy options and within-outlet marketing), and the *perceived* nutrition environment as determinants of diet-related health outcomes. Of note, the research presented in this dissertation deviates from Glanz and colleagues' model by examining diet quality and weight outcomes as outcomes of interest rather than "eating patterns" per se. A variety of outcomes were examined; diet quality was used to operationalize eating patterns, and weight related outcomes (body mass index and waist circumference) were also considered potential outcomes of interest. Weight-related outcomes are determined in part by eating patterns (22-24). It was therefore expected that weight outcomes may additionally be predicted by food environment variables. Certain socio-demographic characteristics that have been associated with both food environment exposures and diet-related outcomes were also included as covariates as discussed below. Chapter 4 will directly test the hypothesized relationship represented by the arrow between the community and consumer nutrition environment and the outcome of interest (eating patterns for Glanz and colleagues; diet quality and measures of obesity for the current research). Chapter 5 directly tests the hypothesized mediated effect by which objective community and consumer food environments affect outcomes of interest through residents' perceptions. Mediators transmit the effect of an independent, antecedent variable to the outcome of interest (25, 26). In Figure 1-1, these relationships are represented by the arrow from the community and consumer nutrition environment to the perceived nutrition environment (exposure to mediator), and the arrow from the perceived nutrition environment to the outcome of interest (mediator to outcome).

To overcome some of the issues identified in the extant literature, this dissertation presents the rationale, methods, results, and implications of three studies, and concludes with a discussion of contributions made, lessons learned, and plans for future work. This dissertation has two main, overarching themes to which each subsequent chapter contributes. The first theme is the construct validation of environmental measures. Construct validity comprises both operational definitions (how are constructs measured?) and syntactical definitions (how do constructs fit together in a theoretical system?) (27). Both components of construct validity will be addressed in the following chapters.

The second overarching theme is to assess cross-sectional associations between community and consumer food environment characteristics and neighbourhood residents' diet quality and weight status. The research presented in Chapters 4 and 5 specifically aims to examine how food environments "get under the skin" of residents. In other words, the research aims to assess hypotheses about mechanisms by which objective food environment features may be cross-sectionally associated with diet-related outcomes. Indeed, the impetus for the research described in this dissertation is to assess these associations for the purpose of contributing to advancing scholarship in the field and to promoting evidence-based policies, as will be described in detail in Chapter 6.

The next section provides an overview of the methods employed throughout this dissertation; the final section outlines the structure of this dissertation.

2. Overview of Methods

The studies described in this dissertation draw on data from the NEWPATH (<u>N</u>eighbourhood <u>E</u>nvironments in <u>W</u>aterloo Region: <u>Pa</u>tterns of <u>T</u>ransportation and <u>H</u>ealth) project and from primary food environment data collected for the purposes of the studies described herein. NEWPATH recruited participants from Kitchener (population 219,153), Cambridge (population 126,748), and Waterloo (population 98,780)(28), the three cities within the Region (Figure 1-2 provides a map of the Region of Waterloo). The three cities are spatially contiguous, and the Region of Waterloo's Official Plan guides the urban planning in each city (Pat Fisher, Public Health Planner, Region of Waterloo, personal communication). Therefore, not only are the three cities spatially contiguous, it is likely that given the governance structure, they are more homogeneous in urban form than would be three cities with different governing bodies. This has implications for the research presented here in that variability in food environments features, which is dependent to a large extent on urban form, is likely lower than it would be had cities in different regions, provinces, or countries been examined. In terms of research findings, this fact may mean that associations between food environment features and diet-related outcomes are underestimated, since, if a true relationship exists, reduced variability in an independent variable means that the full range of exposures will not have been captured. Similar findings have been reported with walkability and physical activity research; single-country studies of walkability likely underestimate associations between walkability and physical activity because walkability varies exponentially more between rather than within countries (29).

One of NEWPATH's aims was to characterize associations between objective and subjective aspects of built environments including walkability, physical activity, dietary behaviours, and health outcomes in an urban, population-based sample. NEWPATH data collection occurred in six phases between May 2009 and May 2010 (conditional response rates, the proportion of household that completed the survey once recruited, varied between 56% and 64% over the six phases); food environment data were collected between May and August, 2010. The NEWPATH study received ethics clearance from the University of Waterloo Office of Research Ethics and the Behavioural Research Ethics Board at the University of British Columbia. Ethics clearance was not necessary for food environment data collection, as no data were collected from human participants. Table 1-1 describes the variables analyzed in the following chapters. The following discussion provides an overview of the study, participants and measures. Relevant statistical analyses are presented in Chapters 3, 4, and 5.

2.1 Participants

Because NEWPATH aimed to examine features of the built environment in relation to health outcomes, the sample was stratified by neighbourhood walkability, household income and household size, with allocation to achieve high statistical power to detect hypothesized effects of walkability (30). Proportional sampling was used to recruit a stratified random sample (N=4902 individuals in 2228 households) representative of income and household size in the study area according to 2006 Canadian census data. Although proportional sampling was employed to ensure that the NEWPATH sample was representative of the broader study region, there were difficulties in recruiting households into the low-income, large-household, high walkability cell. Therefore, data were additionally weighted to reflect 2006 Canadian census data.

Households were recruited in day-pairs across all days of the week; everyone in the household over the age of 10 years participated in the study. All analyses presented in this dissertation were restricted to participants 19 years of age and older, since children and youth may interact differently with the built environment than adults (12), and the number of children and youth in the dataset was insufficient to support age-specific analyses. Moreover, children and youth did not provide data on education level, which was considered a covariate in all regression analyses (discussed below). As described in Table 1-1, data used in the following studies were multilevel, with individual data at level 1 and household data at level 2.

Participating households were recruited to complete either a “simple” or “complex” survey package. The “simple” version included a telephone recruitment survey (which included demographic information on households and individuals) and a paper questionnaire that included food environment perceptions of the self-identified main food shopper. All participants self-reported their weight, height, and waist circumference. Participants from households who completed a “complex” survey package additionally completed food records over the two days of the survey.

For the following studies, the sample comprised 4102 individuals within 2223 households (2932 individuals in 1533 households completed the “simple” survey package; 1170 individuals within 690 households completed the “complex” survey package) who had complete data on all variables of interest.

2.2 Measures

2.2.1 Outcome variables

Diet Quality

Two-day food record data from all participants completing the “complex” survey were used to calculate average Healthy Eating Index adapted for Canada (HEI-C) scores over the two-day survey (31). The HEI-C is a comprehensive diet quality indicator based on dietary adequacy (including the number of servings of vegetables and fruits, whole grains, number of grams of saturated fats) and moderation (including the proportion of energy intake from saturated fats and sodium intake). The HEI-C reflects Canadian food intake recommendations based on participants’ age and sex, and ranges from 0 to 100; higher scores represent better diet quality (31). Mean HEI-C scores was considered a continuous variable to capture even small variations in diet quality, which may not have been captured using a more crude categorical outcome of diet quality. The HEI-C is a state-of-the-science measure of diet quality given its comprehensive nature and its operationalization of national guidelines on healthy eating. While the HEI-C captures diet quality, it does not reflect overall caloric consumption. Therefore, it better reflects the quality of the diet (in terms of micronutrients and certain macronutrients, notably saturated fat) rather than the overall amount consumed.

Anthropometric measures: body mass index and waist circumference.

Body mass index (BMI) was calculated based on self-reported weight and height (kg/m^2). The mean of two self-reported waist circumference (WC) measures was used to determine WC, consistent with protocol from previous research that showed self-reported WC to be a satisfactorily accurate proxy for measured WC (32). Although survey respondents generally overestimate height and underestimate weight (33, 34), estimates of health risks associated with variations in self-reported BMI are not significantly different than those associated with variations in measured BMI (35). WC was additionally included as an anthropometric outcome of interest given that it has been shown to be clinically superior to BMI in terms of predicting mortality risk (36).

2.2.2 Food Environment Exposures

Food Environment Perceptions

The self-identified main food shopper in every household was asked to rate their agreement or disagreement on a 4-point Likert scale (ranging from 1=strongly disagree to 4=strongly agree) with statements that were intended to address residents' perceptions of food *access*, food *availability*, food *quality*, and food *affordability* (asterisks indicate that items below were reverse-scored). Four statements related to food *access*: "There are no food outlets in my neighbourhood*"; "It is easy to purchase fresh fruits and vegetables in my neighbourhood"; "It is easy to purchase low-fat products (such as low-fat milk or lean meats) in my neighbourhood"; "There are a lot of fast food restaurants in my neighbourhood*". Three statements related to food *availability*: "There is a large selection of fresh fruits and vegetables available in my neighbourhood"; "There is a large selection of low-fat products available in my neighbourhood"; "It is easy to eat healthily at the restaurants in my neighbourhood." Three statements related to food *affordability*: "I shop elsewhere because the prices in my neighbourhood are too high*"; "The produce in my neighbourhood is more expensive than that in other neighbourhoods*"; "The low-fat products in my neighbourhood are more expensive than those in other areas.*" Two statements related to food *quality*: "The fresh produce in my neighbourhood is of high quality"; "The low-fat products in my neighbourhood are of high quality." Therefore, *access* perceptions were scored out of 16, *availability* perceptions were scored out of 12, *affordability* perceptions were scored out of 12, and *quality* perceptions were scored out of 8.

Although the questions were intended to assess residents' perceptions of the four distinct constructs mentioned above, high correlations between *access*, *availability* and *quality* scores (Cronbach's alpha based on standardized items for the three scores was 0.904) justified the creation of an "access-related" perceptual variable; *access*, *availability*, and *quality* scores were thus summed and standardized. Perceptions of food *affordability* were not correlated with the other three measures, and therefore the affordability score was standardized on its own. The two resulting perceptual variables were treated as continuous variables. In both cases, higher scores represent increased agreement with statements related to improved neighbourhood food *access*, *availability*, *quality*, or *affordability*. These two perceptual variables were used in Chapters 4 and 5; Chapter 3 made use of the distinct perceptions scores along each construct, since determining convergent and discriminant validity among measures purportedly assessing different constructs was the main objective.

Objective food environment assessment procedures

All food environment data collection tools and protocols employed in this research are appended to this dissertation (see Appendices A-F). All objectively-measured food environment exposures are listed in Table 1-1. Six observers with at least two years of university education collected objective food environment data. After successfully completing a Nutrition Environment Measures Survey "Train the Trainer" workshop in 2008, I trained raters to use the Nutrition Environment Measures Survey-Stores (NEMS-S)(37), the Nutrition Environment Measures Survey – Restaurants (NEMS-R) (38), and linear shelf-space measures of specific "healthy" and "unhealthy" items (14, 39) listed in Table 1-1 according to standard protocol. Training included classroom sessions and fieldwork in food outlets, with feedback on results, and took approximately one week until raters consistently achieved all correct answers on measures. During debriefing sessions, discrepancies were discussed and consensus on appropriate data was reached. Decision rules were added to protocol handbooks, which trainers took to each outlet assessment to support precision in rating. Different raters periodically assessed the same outlet throughout data collection to compare results; immediate feedback was given to limit drift from occurring in observations. I participated in all data collection. Inter-rater reliability was assessed using intraclass correlation coefficients for the shelf-space measure, and ranged from a mean ICC=0.858 for canned fruit to mean ICC=0.996 for fresh vegetables (mean ICC for all specific items assessed = 0.940).

Names and addresses of all food outlets in the three cities (Kitchener, Cambridge, and Waterloo) were obtained from the public health inspection database maintained by the Region of Waterloo's Public Health Department. One of each chain restaurant (e.g., McDonald's, Burger King), convenience store (e.g., 7-11), pharmacy (e.g., Shopper's Drug Mart), and warehouse club or superstore (e.g., Walmart) were randomly selected from the database to be assessed, since chains strive to maintain consistency in menus, available products, and promotions. Every grocery store and specialty store and each independently owned restaurant, convenience store, and pharmacy were assessed. The amounts and types of foods in grocery stores seemed to vary by the size of grocery store (L. Minaker, unpublished observation), thus, every grocery store was assessed. Stores were assessed using the NEMS-S(37), and linear shelf-space measures of specific “healthy” and “unhealthy” items (14, 39), listed in Table 1-1. In restaurants, the NEMS-R (38) was completed.

In total, 611 restaurants were assessed (full-service restaurants, limited-service eating places, and drinking places). NEMS-R scores from the randomly-selected chain restaurants were imputed into the same 301 additional chain restaurants listed in the Public Health Inspection database, resulting in data from 912 unique restaurant locations being compiled. Forty-seven supermarkets and grocery stores were assessed, 47 specialty stores were assessed, 169 convenience stores (including those attached to gas bars) were assessed, 9 pharmacies were assessed, and 3 warehouse clubs open to the general public without a membership were assessed. Approximately 11% of grocery stores and 10% of convenience stores identified in the Public Health Inspection Database were either not applicable to the NEMS-S or shelf-space measures or were not at the address given. Four convenience stores and one grocery store were found through direct observation (40), and were not listed in the public health database. In total, assessments on 94% of outlets that were at the location listed, open during business hours, and applicable to the food environment assessment methods were carried out, with the highest refusal rate among convenience stores. Reasons for missing data include the food outlet being closed for renovations or that the owner or manager refused the raters access to their establishment. A probability-based technique was used to randomly assign NEMS-S scores and shelf-space data from the observed stores to missing data from similar types of stores (n=131, 31% of stores; 10% of the total number of outlets); this procedure has been used in previous food environment research (14). Final buffer zone databases were based on data from 421 food stores and 912 restaurants within the study area. Buffer zone creation is described below.

Geographic Scale Operationalization

ArcGIS 9.1 was used to establish Euclidean distance buffer zones around respondents’ home addresses at 250m, 500m, 1000m, and 1500m. Table 1-1 describes how each variable was aggregated within each buffer zone.

Covariates

Socioeconomic position (SEP) is associated with both residents' perceptions and with food environment characteristics (16, 17, 41-43). In the research described in this dissertation, household income was considered low (<$35,000 per year), medium ($35,000 to $85,000 per year) and high (>$85,000 per year), based on sample stratification. Participants reported their highest level of education reached, which was categorized as low (highschool completion or lower), medium (some college or university), or high (at least a university undergraduate degree completed). For the present study, level-1 covariates include education level, sex, and age. Level-2 covariates include household income and car ownership, as described in Table 1-1.

3. Structure of the Dissertation

The rest of this dissertation follows a "paper" format, rather than a traditional format, and includes a literature review followed by three manuscripts and a concluding chapter. Chapter 2 presents findings from a comprehensive literature review, which provides the research context for the studies presented in this dissertation.

Chapter 3 addresses the operational component of construct validity of food environment measures using a multitrait-multimethod (MTMM) matrix approach. Chapter 3 presents the first study to my knowledge to adapt this traditional psychometric procedure for use with environmental constructs and measures, and does so at a variety of geographic scales to determine whether geographic scale influences construct validity of environmental measures.

Chapter 4 extends the exploration of construct validity of environmental measures by considering syntactical definitions. It does so by exploring a) how perceived food environment constructs are predicted by objective food environment measures, and b) whether objective and perceived food environment characteristics predict diet quality, body mass index, and waist-circumference in a population-based sample. The multilevel regressions employed in Chapter 4 help to elucidate how some of the food environment characteristics hypothesized to predict diet-related outcomes fit within a conceptual food environment model.

Chapter 5 further extends the evaluation of the syntactical component of construct validity by testing mediation of hypothesized pathways by which food environments predict diet-related outcomes. Specifically, Chapter 5 presents the first study to our knowledge to explicitly test Glanz and colleagues' conceptual hypothesis that residents' perceptions of their food environments mediate associations between objective food environment characteristics and diet-related outcomes.

Chapters 3, 4 and 5 are intended to be stand-alone papers worthy of submission to academic journals. Chapter 6, the conclusion, is intended to be dissertation-specific, and reflects on the contributions to theory, knowledge, and practice made by the studies described in this dissertation.

Table 1-1. Overview of variables used in the analyses in the following chapters

Variable Name	Scale	Description
Level 1: Individual		
Outcome		
Diet Quality	Continuous	Operationalized as Healthy Eating Index adapted for Canada (HEI-C), a comprehensive diet quality score ranging from 0 to 100, with increasing scores reflecting "healthier diets", defined as those adhering to Canada's Food Guide to Health Eating.
Body Mass Index (BMI)	Continuous	Self-reported weight (kg) divided by self-reported height (m^2).
Waist Circumference	Continuous	Mean self-reported waist circumference of two measurement participants were instructed to take.
Covariates		
Sex	Nominal	Male, female
Age	Interval	Participant's age in years
Education level	Ordinal	Low (high school completion or lower), medium (at least some post-secondary), and high (at least an undergraduate degree)
Level 2: Household		
Perceptual Exposures		
Access-related perceptions	Continuous	Perceptions of the main food shopper in each household related to neighbourhood food access, quality and availability were standardized and transformed using Box-Cox transformations to ensure normality.
Affordability perceptions	Continuous	Perceptions of the main food shopper in each household related to neighbourhood food affordability was standardized and transformed using Box-Cox transformations to ensure normality.
Objective Exposures		
Distance from home to the nearest grocery store	Continuous	Network distance from respondent's home to the nearest grocery store (km).
Distance from home to the nearest convenience store	Continuous	Network distance from respondent's home to the nearest convenience store (km).
Distance from home to the nearest fast food outlet	Continuous	Network distance from respondent's home to the nearest fast food outlet (km).
Store intensity	Continuous	The number of food stores (including grocery store, convenience stores, pharmacies, big-box stores and specialty stores) within a specified buffer zone.
Restaurant intensity	Continuous	The number of restaurants (including fast food outlets, sit-down restaurants, buffet restaurants, and bars or pubs that are open at least part of the day to the general public) within a specified buffer zone.

Table 1-1. Overview of variables used in the analyses in the following chapters		
Diversity	Interval	The number of diverse types of food outlets within a specified buffer zone.
Retail Food Environment Index (RFEI)	Continuous	The ratio of the number of fast food outlets and convenience stores to the number of grocery stores and specialty stores.
Nutrition Environment Measures Survey – Stores (NEMS-S)	Continuous	The NEMS-S tool is an inventory measure that assesses specific food item availability, relative affordability of regular vs. more nutritious options of specific foods, and the quality of fresh fruits and vegetables. The mean NEMS-S sub-scores related to availability, affordability, and quality components of all food stores within the specified buffer zone were calculated.
Nutrition Environment Measures Survey – Restaurants (NEMS-R)	Continuous	The NEMS-R tool is an inventory measure that assesses food access, food availability, food affordability and barriers and facilitators to healthy eating in restaurants. The mean NEMS-R sub scores related to access, availability, affordability, and barriers and facilitators to healthy eating components of all restaurants within the specified buffer zone were calculated.
Linear shelf-space of fruits and vegetables	Continuous	The linear shelf-space of fresh, frozen and canned varieties of fruits and vegetables was measured in all food stores. Cumulative linear shelf-space of fruits and vegetables from all food stores within a specified buffer zone was calculated (m).
Linear shelf-space of energy dense snack foods	Continuous	The linear shelf-space of energy dense snack foods (including salty snack foods, cookies and crackers, donuts and pastries, candy, and carbonated beverages) was measured in all stores. Cumulative linear shelf-space of energy dense snack foods from all food stores within a specified buffer zone was calculated (m).
Covariates		
Household income	Ordinal	Low (<$35,000 per year), medium ($35,000 to $85,000 per year), and high (>$85,000 per year)
Car ownership	Nominal	Whether or not the household owns a car

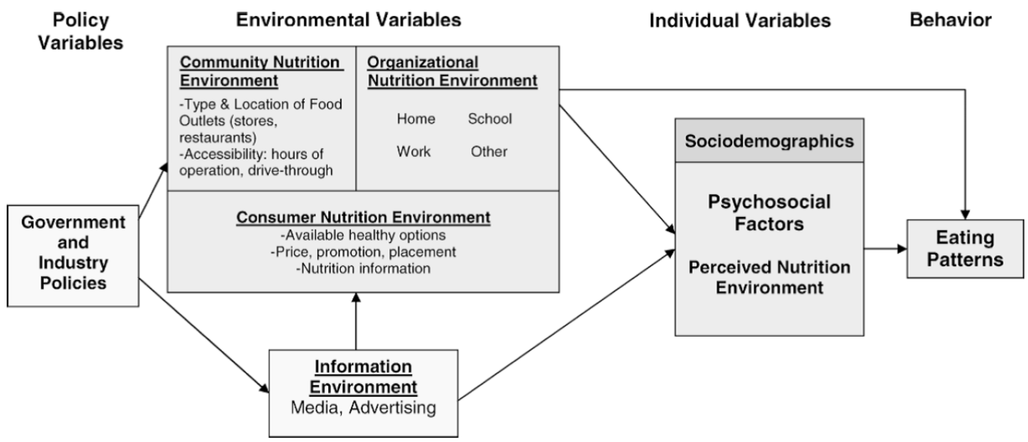

Figure 1-1: Glanz and colleagues' conceptual model of Community Nutrition Environments (1).

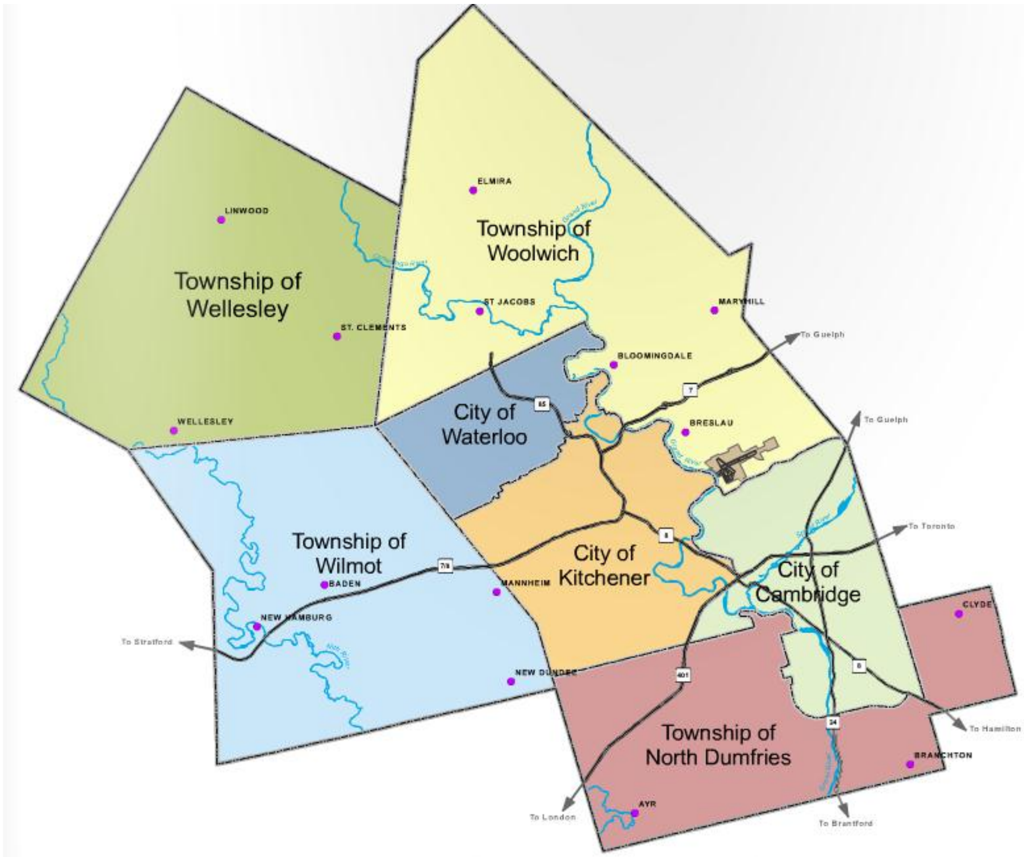

Figure 1-2: Map of the Region of Waterloo

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Chapter 2. Food environments: theory, evidence, and future directions

Minaker, L.M., Raine, K.D., Wild, T.C., Nykiforuk, C.I.J. (Under revision). Food environments: theory, evidence, and future directions. *Obesity Reviews*.

1. Introduction

Determinants of food choice act and interact at different levels to create conditions that promote overweight and obesity (44-50). A growing body of research focuses on identifying associations between aspects of the built environment and diet-related outcomes (11, 12, 49, 51-53), often with the goal of informing upstream policy initiatives designed to improve population diet quality (44, 54). However, inconsistent methodologies, inadequate theoretical consideration, and overreliance on cross-sectional studies have created uncertainty with respect to the relationship between food environment (FE) characteristics and diet-related health outcomes, including obesity (52). This review of conceptual models of the FE adds to this literature by reviewing the historical context of food choice research, discussing theoretical and conceptual models of FEs, discussing the state of the science in light of two especially relevant conceptual models, describing commonly-studied FE characteristics, and evaluating concepts and definitions of neighbourhoods most often used in FE literature. The paper outlines recommendations to guide future FE research.

2. Methods

This review focuses on conceptual and theoretical underpinnings of community and consumer food environment research as relevant to diet-related outcomes. Community nutrition environments are reflected in measures of food access, and are distinct from consumer nutrition environments, which represent characteristics of the FE important to consumers who have already reached their food store or restaurant destinations (e.g., food availability, affordability, quality, and barriers and facilitators to healthy eating) (1). As such, reviews (both systematic and meta-analyses) and conceptual papers related to FE characteristics were sought from three databases (Web of Science, Scopus, and PubMed (Medline)) using the search terms: (1) “built environment*”, “food environment*”, “nutrition environment*” “obesogenic”, “food desert*”, “food access”, “food scape”, “food retail*”, and (2) "diet*", "adiposity", "obesity", “obese”, “fruit” “vegetable”, “weight”, "body mass index", “BMI”, “concept*”, where asterisks represent wild cards. Databases were searched for reviews or conceptual papers published until March 2012. Reference searches of relevant papers were also conducted.

The search was restricted to reviews or conceptual papers examining at least one aspect of community or consumer nutrition environments and their relationships with diet-related health outcomes (e.g., dietary patterns or behaviours, food purchasing, or weight-related outcomes). The socio-economic patterning of FEs (e.g., research on 'food deserts' or 'food swamps') was considered out-of-scope for the current review, as were reviews focused solely on food insecurity. Criteria for inclusion of reviews or conceptual papers were that they (1) reported a systematic review, meta-analyses, or addressed conceptual or theoretical matters related to at least one aspect of community or consumer food environments as well as at least one diet-related health outcome, (2) reported on studies conducted among humans in developed countries and (3) were published in English. Because the interest of the current review is conceptual and theoretical models rather than the veracity of claims made regarding associations between FE characteristics and diet-related health outcomes, the quality of the reviews was not assessed.

3. Results

The initial search for reviews and conceptual papers returned 663 papers. Based on the title scan, papers that focused solely on genetics or policy or program interventions, and papers that did not focus on human populations were excluded, which resulted in 163 reviews or conceptual models with potentially relevant titles. Thirty-nine duplicates were removed, leaving 124 for abstract reviews. The abstract scan further reduced the number of papers for full-text review to 69. Papers that did not directly address aspects of the community or consumer nutrition environment, papers that addressed built environments in relation to physical activity (to the exclusion of diet-related health outcomes), and papers that focused on describing interventions in the absence of research and evaluation were excluded, as were conceptual papers that did not offer recommendations for future research. Seven additional, relevant papers were identified through reference searches of the selected articles. Forty-nine studies met the inclusion criteria and inform the current review (27 literature reviews (six of which also included conceptual models), and 22 conceptual papers). Conceptual papers were defined as articles that addressed conceptual issues in the field but did not specify methodology related to the literature review.

3.1 Food Choices: From Individual to Ecological Perspectives

Historically, theories of food choice emphasized factors influencing decisions made by individuals. This approach rested on the premise that, given adequate knowledge, individual consumers would forgo dietary behaviours shown to be unhealthy in order to prevent future illness (55). This belief pervades public opinion, with up to 90% of Americans attributing obesity to individual behaviour alone (56), perhaps in part due to media coverage of obesity that emphasizes personal responsibility and individual decision making (57). This is important for the development of obesity-related healthy public policies because beliefs about the causes of obesity help determine public support of such policies (58, 59).

Contrary to public opinion, however, psychosocial factors only explain a fraction of dietary behaviours (60). Moreover, emphasising individual responsibility negates the role of social context in shaping behaviour and implies an artificial separation between people and their environments (61). Exclusively focusing on individual-level determinants of diet quality “ignores what is known about human behaviour and minimizes the importance of evidence about the environmental assault on health” (62) (p. 256). Finally, the abundance of individual-level interventions and the high prevalence of appropriate tools with which to gauge their success have not resulted in populations adopting healthier diets (63).

As a complement to individual-level theories of food choice, environmental-level theories emphasize physical and social variables (see, for example, (64-66)). While not exclusively concerned with food and diet, a common framework used to characterise aspects of “obesogenic” environments is the ANGELO (analysis grid for environments linked to obesity) framework (67). In this framework, determinants of obesity-related health behaviours can be categorized as physical, economic, political or sociocultural features of settings (micro-level) or sectors (macro-level). Advocates of an environmental perspective have stated, “obese individuals cannot be expected to have total self-control over their weight in an environment that promotes weight gain by reinforcing overeating and inactivity any more than they can control their genes.” (65) (p. 202). Environmental factors such as nearly unlimited access to highly palatable and calorically-dense foods, which are generally consumed in large portion sizes (64) are primary determinants of the dramatic increase in obesity prevalence over the last few decades. Other important factors thought to contribute to obesity, from this perspective, are area-level disadvantage (68) and place of residence (65), with disadvantaged people being less able to withstand the "toxic environment"(69) than more advantaged people.

Environmental perspectives avoid the "blame the victim" sentiment elicited by many individual-level theories. Moreover, they are able to explain how excess caloric consumption has increased so rapidly in the past few decades better than individual-level theories. Environmental-level interventions may benefit the entire population, rather than only selected individuals, and may also be more easily sustained than individual-level interventions. However, a sole focus on the environment as the cause of caloric overconsumption ignores the fact that not all people within a given environment have poor diets. In other words, solely focusing on the environment ignores human agency: the ability of people to become empowered to resist obesogenic environments and change their behaviours (70).

An ecological (or multilevel) perspective of food choices retains the strengths of both extreme positions while avoiding many of their respective weaknesses. An ecological approach is "a way of approaching issues that accounts for interrelationships between persons and settings, constructionist premises, collaborative style, and social process" (50), (p. 308). An ecological model is defined as "a formalized conceptualization of the individual and environmental determinants of health behaviours and public health outcomes." (50) (p. 308). One key feature of the ecological approach is its recognition that behaviours are influenced by determinants within a number of different contexts, namely: intra- and inter-personal factors, community (which includes FE characteristics) and organizational factors, and public policies (50, 71-73).

Richard and colleagues (50) recently argued that an ecological perspective is appropriate for understanding dietary behaviours, and noted that the recognition of social and environmental determinants of food choice has gained momentum over the past two decades. Although developments in the field of nutrition lag behind those in physical activity, diet research does show signs of becoming more ecological in orientation (44-47, 49, 50, 74, 75). In research, the last two decades have seen a reconceptualization of food choices as a matter of "personal responsibility" to food choices as being embedded within various contexts. Importantly, determinants at different levels are dynamically linked. For example, zoning bylaws (public policy level) may influence the geographic placement of food stores (community level), which can further influence how families procure foods (interpersonal level). While features of the FE can constrain healthy food choices, they are not static; individuals' decisions can either reproduce or transform social structures, as suggested by Giddens' structuration theory (76). In terms of FEs, for example, land-use planning decisions by municipal actors (representing human agency) can affect the location of grocery stores (an aspect of social structure), while individuals' patronage of grocery stores and purchases within grocery stores (agency) can affect the food supply within grocery stores (structure).

Researchers have embraced ecological models as a way of understanding the reality that behaviours cannot be divorced from contexts, which themselves are created by patterns of interactions between different levels of determinants. Policies and interventions related to obesity also benefit from ecological perspectives, as the most effective interventions are expected to be those operating on multiple levels to create an environment in which the default option is a healthy option (77). Benefits of including policy components in comprehensive obesity interventions are that everyone within the jurisdiction is affected by the policy, and that effects should last as long as the policy is in effect (and as long as the person lives there) (77).

3.2 Food Environment Conceptual Models

The literature review revealed that 18 conceptual models addressing aspects of the FE and diet-related health outcomes have been published (1, 6, 11, 44, 78-91). The earliest conceptual model was published in 2001; 15 (83%) of the models have been published in the last five years. All but two of the models (89%) were consistent with an ecological approach. Table 2-1 describes the conceptual models reviewed, including the ecological levels included in each model, the constructs addressed, the outcome of interest, and a general description. The following section describes and compares several of the published models of the FE. This discussion is not exhaustive; models were chosen to show variation in concepts, disciplines of origin, and foci.

Glanz and colleagues (1) presented a parsimonious, ecological conceptual model of FEs (see figure 2-1). The model was intended as a starting point for categorizing and thinking about environmental variables related to eating behaviours. This model incorporated constructs theoretically and empirically related to eating patterns from several academic fields, including public health, health psychology, consumer psychology, and urban planning. Community nutrition environments were reflected in measures of food access, and were distinct from consumer nutrition environments, which represented characteristics of the FE important to consumers who have already reached their food store or restaurant destinations (e.g., food availability, affordability, quality, and barriers and facilitators to healthy eating). Sociodemographic factors were seen as mediating and/or moderating the impact of FE variables on eating patterns.

Daniel and colleagues' model (86) made an important contribution by specifying hypothesized causal pathways by which environmental characteristics (including opportunities to procure nutritious foods) affect cardiometabolic disease and its consequences. Also unique to this model was its reliance on lifecourse theory. The importance of time was conceptualized both in terms of ongoing evolution of person-place interactions as well as cumulative exposures, variable induction periods, and lagged outcomes. Although the authors focused on cardiometabolic disease, it seems feasible that other diet-related health outcomes might involve similar causal pathways. Daniel and colleagues' model is a comprehensive and complex model, specifying many processes and pathways between environment and outcomes. While the model is useful in terms of conceptualizing specific biological pathways, its complexity may make it unwieldy for a single study to attempt to operationalize all of the model's features. The model also does not lend itself to cross-sectional studies, given its focus on lifecourse theory.

Lytle's (92) conceptual model extended previously published contributions by considering how individual, environmental, and social factors explain variance in eating behaviours (see figure 2-2). This model proposed that as individual and social factors (intra- and interpersonal factors as well as organizational factors) become increasingly restricted (e.g., through lower income or lower social support) the environment (community and public policy factors) explains a higher proportion of variance in eating behaviours. Based on this conceptual model, Lytle suggested that understanding how the FE affects diet quality may be especially important in populations for whom individual and social factors are very restricted. In Lytle's conception, eating behaviours of socio-economically disadvantaged people would be more strongly associated with the quality of their FE compared to advantaged people. Lytle's conception may have empirical merit. For example, in Los Angeles, people who did not own cars (an example of a social or individual restriction) and who lived in areas of high fast food concentration were 12 lbs heavier compared to those living in areas of zero fast food concentration. The difference in high to zero fast food concentration among car owners, on the other hand, was found to be 1lb (93), supporting the hypothesis that those who are more restricted may be more reliant on their immediate environments than those who are less restricted.

Forsyth and colleagues'(94) model emerged from a land-use and transportation background, and depicted how transportation and land use intersect with food purchasing and consumption. The model was ecologically constructed, recognizing individual, social, and economic determinants of food behaviours. "Personal constraints" were viewed as moderators of food preference, and a number of FE factors related to food availability and access were hypothesized to moderate the relationship between food preference and consumption. Forsyth and colleagues' conceptual model is unique in its mention of food sources beyond stores and restaurants, by recognizing local agriculture and opportunities for gardening (95, 96).

Rose and colleagues (79) presented a theoretical framework of food purchases based on an economic model of food consumption. The framework considered aspects of the consumer nutrition environment, specifically in-store prices and in-store characteristics as well as the community nutrition environment (e.g., food store placement and neighbourhood food access), in line with the authors' recommendation to pursue a multi-dimensional understanding of food purchasing. These authors did not consider aspects of the organizational nutrition environment nor did they consider food purchases from restaurants, which may be a limitation of the framework. Moreover, they recognized that although the arrows in the figure have been drawn in one direction, demand influences supply as well.

Although outcomes of interest vary between models (e.g., dietary patterns vs. cardiovascular disease vs. food purchasing), all models presented above address socioeconomic status an important factor to consider in the relationship between FE characteristics and outcomes. Glanz and colleagues' (2005) model is especially useful for organizing how researchers and practitioners can think about FE characteristics by distinguishing between community and consumer nutrition environments and then by categorizing characteristics such as food availability, food affordability and food quality. Lytle's (2009) model is helpful in providing a conceptual framework regarding the differential impact of FEs on individuals' dietary behaviours based on the level of restriction of other individual and social factors. Together, these two models provide a comprehensive view of FEs and their interactions with other variables to affect population diet quality that can be used across disciplines to act as a conceptual foundation for food environment research.

3.3 Food Environment Characteristics

This review uses Glanz and colleagues' model for organizing food environment characteristics, recognizing that the food environment characteristics described here can be situated as physical features (food access, food availability, food quality) or economic features (food affordability) of micro-environmental settings (usually neighbourhoods) as per the ANGELO framework. Systematic evaluation of Lytle's model has only been conducted in one review to date, as discussed below. Therefore, although Lytle's model was identified as important in the development of future research, it was not used to organize the following discussions in the same way as Glanz and colleagues' model.

Table 2-2 outlines the findings of the 27 reviews published to date, and identifies whether the reviews' results support Glanz and colleagues' and Lytle's conceptual models. The first review was published in 2000, and 22 of the reviews (81%) have been published in the last five years. Eight reviews focused solely on youth (defined as children and adolescents)(6, 21, 97-102), seven reviews focused solely on adults (5, 85, 87, 103-106), and 12 reviews included studies among both youth and adult populations (11, 77, 78, 80, 107-114). Only one of the reviews (107) found no support for Glanz and colleagues' model; this review only examined one article that showed no relationship between proximity to fast food outlets and weight status in low-income children. Twelve (44%) of the reviews found generally significant associations in the hypothesized directions between aspects of the FE and diet-related health outcomes (support for Glanz and colleagues' model) and 14 (52%)

showed mixed results (mixed support for Glanz and colleagues' model). Only one review explicitly reported on characteristics that modified associations between environmental variables and outcomes (5): in support of Lytle's model, this review found that associations between FE characteristics and outcomes appeared stronger among women and low-SES individuals. Of the 26 reviews that did not explicitly examine hypotheses related to Lytle's model, 16 (62%) recommended that future studies examine how individual or social factors moderate associations between FE characteristics and outcomes. In other words, although the majority of the reviews did not provide empirical support for Lytle's model, Lytle's model was conceptually supported in terms of reviews' authors identifying the importance of testing her hypothesis.

FE characteristics have been objectively and subjectively assessed. Four objectively-measured characteristics of the local FE have been identified as influencing diet and/or health outcomes: food access, food availability, food affordability, and food quality (115, 116). Implicitly or explicitly, research on FEs assumes that improved FEs (operationalized as increased access, availability, affordability, or quality of healthy food) will be tied to improved population-level dietary behaviour and weight status irrespective of human agency (117). The following discussion draws on the reviewed literature to address objectively-measured characteristics of the FE shown to be correlated with residents' diets. The importance of subjectively-measured characteristics will be subsequently discussed.

3.3.1 Objectively-Measured Characteristics

Community Nutrition Environment: Food Access

Food access has been the most frequently studied of the four constructs described here, and can be considered as a measure of the "community nutrition environment" as per Glanz and colleagues' model (117). Potential access, which represents food availability and which has spatial (geographic) and nonspatial (e.g., social) dimensions, differs conceptually from realized access, which reflects actual use (118). Food access can be operationalized as geographic proximity (e.g., distance between a person's home and the nearest grocery store), density (e.g., concentration of fast food outlets or proportion of unhealthy to healthy food stores types within a defined geographic area) and variety (e.g., degree of different types of food outlets within a specified area) (119).

Food access measures categorize food stores and restaurants as “healthy” (e.g., supermarkets or fruit and vegetable markets) or “unhealthy” (e.g., fast-food outlets and convenience stores). Using these classifications, food access measures are considered a proxy for healthy food availability. Assuming that healthy food availability varies by store type is not without merit, since food availability, food quality, and affordability have been found to differ by store type (37, 120, 121). Relying solely on food access to operationalize the quality of the FE, however, is limited because neighbourhood differences in food availability (i.e., the underlying characteristic theoretically associated with dietary behaviours) exist even after accounting for store type (122-125). In addition, using only food access measures to describe FEs ignores the fact that physical disabilities, lack of access to a vehicle for grocery shopping, lack of culturally appropriate foods, and inadequate family income can all impair food access (126-128). Despite the theoretical problems, food access is used to characterize the FE because the data are relatively simple to obtain and assessment methods are relatively easy to use. Questions about the reliability and validity of food access measures have not been satisfactorily answered. Four traditional data sources for food access data have been identified: fieldwork (e.g., “ground-truthing” to document whether an identified food store actually exists, and if so, what type of food store it is), land use and parcel data (often available in municipal GIS databases, these data contain information about land parcels and buildings), health and agriculture department licensing data (collected at the municipal level, the regional or county level, or the state or province level, these data reflect public concerns such as food safety), and commercial business data (for example, telephone directories, business directories, and company websites. In general, studies examining food access necessitate the use of GIS to derive food access scores for different areas.

Of the 20 systematic literature reviews that included more than one study examining associations between food access and diet-related outcomes, 12 showed mixed results (6, 9, 11, 77, 80, 99, 102-104, 109, 111, 113), and 8 showed generally positive results (5, 21, 85, 87, 100, 105, 110, 112). These findings provide mixed support for Glanz and colleagues' hypothesis that community nutrition environments are associated with diet-related outcomes.

Five longitudinal studies have been published within the last year and were not included in any of the reviews to date. These studies are among the first efforts to examine food access over time and its association with dietary behaviours or weight. The first prospective cohort study on point reported that supermarket access was generally not related to diet quality or fruit and vegetable intake, but that fast food access (defined as fast food outlets located within 3km of respondents' homes) did predict consumption of fast food among low income, male respondents (129). Authors note that relying solely on food access may have caused null findings, and suggest that evidence of health benefits of nearby supermarkets may reflect self-selection bias – a confounding individual-level factor related to both diet behaviours and neighbourhood selection (129). Another study showed no relationship between neighbourhood fast food access and fast food consumption in a large, national sample of young adults in the U.S. (130). A third study found that only the neighbourhood density of small grocery stores measure was significantly related to weight status among urban residents over time (131). The fourth study assessed the association between weight and proximity to food establishments over a 30-year period. Results indicated that each 1km increase in distance to the closest fast food outlet was associated with a 0.11 unit decrease in BMI, but only for women. Other food environment characteristics were either inconsistently or not significantly associated with BMI (132). The final longitudinal study, conducted among children, found that differential exposure to food outlets did not independently explain weight gain over time (133). All five longitudinal studies examining food access and diet-related outcomes over time have found a limited impact among both children and adults, although two (129, 132) show support for Lytle's hypothesis that environmental features explain more in terms of diet-related behaviours or outcomes in some populations relative to others.

Consumer Nutrition Environment: Food Availability

Food availability pertains to the "consumer nutrition environment" (117) and can be operationalized through check lists (e.g., yes/no questions on the availability of specific foods) or shelf-space measures (e.g., linear length of shelf-space allotted to specific foods or food groups) (134). Measuring food availability overcomes some of the limitations associated with relying solely on food access to define a healthy FE: there is no need to assume store type is an adequate proxy for healthy food availability when availability is directly measured. Despite this, social constructs such as neighbourhood disorder, safety concerns, and residents' concerns about food quality may nonetheless impede residents' use of local food stores where fresh produce and other healthy foods might be available (135, 136).

Overall, food availability has increased over the past few decades, with approximately 520 more calories available in 2003 than in 1970 in the U.S. (137) and up to 530 more calories available in 2002 than in 1985 in Canada (138), mainly in the form of salad oils, wheat flour, soft drinks and shortening (23). Only three reviews included studies examining food availability in relation to dietary outcomes. Both reviews on studies conducted among children found restaurant fruit and vegetable availability predictive of intake. Specifically, one review found that three out of four associations between restaurant fruit and vegetable availability and fruit and vegetable intake were significant and positive, although one association between grocery store fruit and vegetable availability was not correlated with fruit and vegetable consumption (21). The other found that the only neighbourhood food environment variable that received preliminary support in terms of determining dietary behaviours was the availability of fruits and vegetables in restaurants (102). The third review, examining evidence from studies conducted among adults, suggested that good local availability of fruits and vegetables seems to be significantly associated with intake, although the authors caution that evidence is limited (104).

Two recent studies examined neighbourhood food availability and were not included in any reviews. One study found that neighbourhood availability of dark green and orange vegetables was significantly associated with residents' consumption (139). Contrary to its hypothesis, another study found higher healthy food availability associated with higher BMI among urban residents of predominantly white neighbourhoods and with lower BMI among urban residents of predominantly black and low-SES neighbourhoods (140). Pathways by which healthy food availability impacts diet and weight status are still unclear.

Consumer nutrition environment: Food Affordability

The inverse relationship between energy density and energy cost has been well-documented, and is reflected in the lower cost of diets high in refined grains and added fats and sugars being compared to diets based on whole grains, fresh vegetables and fruits and lean meats and dairy (141-143). The cost of healthy food has risen much faster than unhealthy foods in the U.S. (18% price increase for healthy foods and -1.8% increase for unhealthy foods between 2004 and 2006 in Seattle) (144) and Australia (14-18% price increase in healthy foods, but no difference in unhealthy foods) (145). In a number of studies conducted in various micro-environmental settings such as cafeterias in workplaces and schools, decreasing the cost of targeted "healthy foods" consistently resulted in increased consumption, regardless of visual promotion (45, 146-149). Given the importance of food affordability for the diet quality of populations, as well as its potential amenability to policy change (e.g., through subsidization or taxes), researchers have begun to examine the impact of food affordability in neighbourhood settings as well. Of five reviews including more than one study on food affordability, all found significant, positive associations between healthy food affordability and diet-related outcomes. Two reviews among children found food cost to be an important determinant of dietary behaviours, particularly for lower-income children (98, 101). All other reviews examined studies conducted among both youth and adults. One found greater cost barriers to fast food consumption to be associated with healthier diets and reduced levels of obesity (110), another found that affordability of fruits and vegetables was associated with lower gains in BMI (80). The final review indicated that price might be a more salient determinant of dietary intake than food access, particularly for fast food intake (109).Measures of food affordability, like other measures of FE constructs, are inconsistent, which may partly explain inconsistent findings. Overall, few studies have examined associations between neighbourhood food affordability and diet-related outcomes.

In a recent longitudinal study among young adults, a 10% increase in the price of fast food was associated with a 13.2% reduction in the probability of obesity for men, although this effect was no longer significant after controlling for other socio-demographic factors, indicating that these factors may overcome the effect of food prices for young adults (150). Food and restaurant prices have been found to exert small effects on weight outcomes, although these findings vary by socioeconomic status, with the association between prices and weight stronger among more disadvantaged populations, which supports Lytle's hypothesis that individuals experiencing more restrictions may be more dependent on immediate food environment features than less restricted individuals (151, 152). One recent study found no association between neighbourhood healthy food price score and weight status (153), although relative higher food prices of fruits and vegetables has been associated with lower frequency of fruit and vegetable consumption (154), lower fibre intake, and higher BMI among children (151, 155, 156). On the other hand, relative higher prices of fast food have been associated with better diet quality among young children (151).

Consumer nutrition environment: Food Quality

Few studies have assessed neighbourhood food quality (116). Food quality, like availability and affordability, is an attribute of the neighbourhood food supply that is most often subsumed by food access measures (i.e., store type is used as a proxy for food quality). This strategy is not without merit, as food quality has been found to vary by store type, with convenience stores generally selling fresh produce of lower quality than grocery stores (37, 157). Food quality is related to food availability in that the quality of available foods acts as a determinant of food purchasing behaviours. Poor food quality (e.g., withered or bruised fresh produce, rotting meat, and expired canned foods) acts as a deterrent of food purchasing (158). None of the 27 literature reviews assessed here addressed food quality.

In summary, food access is often used as a proxy for features of the consumer nutrition environment, particularly food availability, because food access measures are easier and less resource-intensive to create and use. Findings from the literature review suggest that while food access is the most commonly studied characteristic to date, food affordability may be a more important neighbourhood determinant of diet-related outcomes. Many of the literature reviews have found mixed findings; reasons for this will be discussed in the recommendations section. The following discussion describes subjectively-measured FE characteristics.

3.3.2 Subjectively-Measured Characteristics

The majority of the literature reviews described here included objective FE measures to the exclusion of residents' perceptions. Despite this, assessing residents' perceptions of their FEs is an important contribution to establishing an ecological perspective, and was recommended by six of the reviews assessed (5, 6, 80, 99, 107, 113). "An important consideration in assessing the FE in the context of an ecologic model is how the individual chooses to behave in the environment" (159) (p. S140). Considering individual perceptions is appropriate given the suitability of an ecological perspective for examining dietary outcomes.

Residents' perceptions differ significantly from observed aspects of the FE (160, 161), consistent with research examining perceived vs. objective aspects of physical activity environments (162). Perceptions of FE constructs may be more strongly correlated with food-related behaviours such as food purchasing (43) and diet quality (42, 163) than objective FE measures. Including individual residents' perceptions in FE studies may advance the understanding of how individuals intersect with their environments (159), and may inform policy recommendations. Finding that objective but not perceptive access to food is associated with diet quality has very different policy implications than finding the opposite. In the first case, findings would suggest that improved access (i.e., more grocery stores, fewer fast food outlets) may improve health. In the second case, findings would suggest that strategies to improve residents' perceptions of their local FEs should be pursued. Questions about how individuals interact with their environments to procure food and to eat have not been adequately addressed in the current literature (164-166). As eloquently stated by Cummins (166), "Without a deeper and more complex understanding of how 'environment' gets into the 'body', interventions based exclusively upon existing theoretical models will never be able to fulfill their public health potential." (p. 197)

Examining residents' perceptions may also inform the criticism outlined above regarding the validity of only using food access measures to characterise FEs. In terms of whether food access measures adequately capture other FE characteristics, emerging research indicates that food availability may, in fact, be a construct separate and distinct from food access. For example, residents' perceptions of neighbourhood healthy food availability showed only a low correlation with the density of supermarkets within a one mile radius of their homes (160), which led study authors to conclude that perceived healthy food availability may indeed be tapping into a different construct than food access. Importantly, residents' positive perceptions of availability of fruits and vegetables were positively associated with intake, regardless of food store type and location, which are two key aspects of food access measures (163). Similar to objective measures, FE perceptions have been inconsistently associated with outcomes. One study conducted in the U.S. found no association between perceived neighbourhood affordability and fruit and vegetable intake (163), while an Australian study found that residents' perceptions of neighbourhood food affordability almost wholly mediated the association between socioeconomic position and diet quality (42). Finally, perceptions of the quality of fresh produce have been associated with fruit and vegetable consumption (124) and identified as an important factor in food choices (167).

In summary, residents' perceptions can inform objective FE research. Using subjective measures to characterise FEs can complement objectively-measured characteristics and also contribute to an ecological understanding of FEs. The following section addresses how neighbourhoods, particular geographic contexts that have been identified as relevant settings for food environment research and action, have been conceptualized and defined.

3.4 Neighbourhood: Conception and Definition

Zenk and colleagues (2) defined the neighbourhood FE as "a group of factors including the types of retail food outlets and the availability, quality, and price of different kinds of foods, such as prepared foods, fresh produce, and other groceries, in a given geographical area" (p. 61). In this definition, the authors summarize in one sentence the constructs of the FE most frequently assessed in the literature. Alternative definitions of neighbourhoods are relevant for different research questions, and the relevant geographic area may vary according to the processes through which the area effect is hypothesized to operate (168). Operationalizing neighbourhoods for research is a challenging endeavour, because people live and function in multiple settings; people live and work in multiple geographic areas and influential environments are often nested, and; single neighbourhoods contain multiple types of environments, including physical, social, cultural, and policy environments (169).

"Neighbourhoods" in FE research have been operationalized as pre-defined administrative areas, ego-centered areas (e.g., Euclidean or network-distance buffer zones around homes), and activity spaces. The majority of studies to date have relied on administrative boundaries (5, 113, 119), partly because many potentially relevant and publicly available data exists at the level of census tracts or agglomeration areas, and partly because individuals can be easily aggregated into administrative boundaries. In addition, administrative boundaries are useful for policy applications, since governing bodies have jurisdiction over administratively-bounded areas.. Administrative boundaries, however, do not necessarily represent neighbourhoods as experienced by residents (170), nor are they based on geographic scales that would theoretically influence the outcome of interest.

Buffer zones are ego-centered geographic areas created for respondents' home address or other places of interest (e.g., schools or worksites). If neighbourhoods are conceived as buffer zones, individual data cannot be aggregated because buffer zones are specific to each point (e.g., home or school). Acknowledging this difficulty, however, it may be more theoretically justified to use buffer zones than administrative boundaries because it is likely that residents would perceive neighbourhoods as including their home and the surrounding area, which a buffer zone captures. There is no consensus around what buffer zone scale is most associated with residents' weight or diet quality, although buffer zones should theoretically capture areas where food is procured. A recent review reported that buffer sizes around residences ranged from 100m to almost 5km (5).

One limitation associated with both administrative boundaries and buffers is the assumption that people stay in their neighbourhoods to purchase foods and/or to eat out. In other words, neighbourhood FE research assumes that individuals buy food in their own census tracts, buffer zones, or zip codes – an assumption for which there is no evidence (5, 43, 84, 171). One U.S. study found that people travel an average of three to five miles for food-related purchasing (172). It has further been suggested that individuals can sometimes travel far geographical distances for food to places that are "relationally" proximate because of social ties or previous familiarity

(173, 174). This limitation is also relevant to Lytle's hypothesis, that individual and social factors can moderate associations between FE features and outcomes. Specifically, while people are able to move out of their administrative boundaries or buffer zones to procure food, the area relevant to diet-related outcomes may be moderated by car ownership, access to public transportation, and mobility issues, among other factors.

The size of geographic area relevant to different health outcomes is still poorly understood, although recent research on "activity spaces" relevant to diet and physical activity has begun to address this question (175-177). This most recent stream of research fits theoretically within a socio-ecological framework in that it examines how people interact with their environments to procure food, and on a larger scale than qualitative inquiry would allow. Activity spaces have been operationalized differently, and have been found to vary by individual socio-demographic characteristics (in support of Lytle's hypothesis) and by activity space definition. Importantly, activity space research could provide a more solid evidence base for policies related to supporting healthy food systems than the current state of the evidence, which mainly examines residential neighbourhoods (5).

4. Recommendations

Huang and Glass (178) recommended a multilevel obesity research strategy, characterized by cross-disciplinary questions and research strategies, building capacity in multilevel research, and maintaining a global perspective on obesity. They note that the dominant, individual-level focus in obesity research has been inadequate to achieve population-level change and argue that, "Until healthy eating and physical activity become naturally embedded in everyday life, there is little chance that the burden of the obesity epidemic will diminish." (p. 1813). In order to fulfill the goals of building cross-disciplinary research teams and multilevel study designs, several gaps in the current FE literature must be addressed. The following discussion aims to highlight challenges in the field and to provide recommendations for future research. In the current review of literature reviews and conceptual papers, the most commonly-recommended directions for future research were to develop and refine valid and reliable FE assessment methods, and to use these methods consistently in studies (78% of reviews and 73% of conceptual papers), to examine whether associations between FE characteristics and diet-related outcomes are mediated or moderated by intra- and inter-personal variables (67% of reviews and 36% of conceptual papers), to engage in longitudinal studies and natural experiments (63% of reviews and 50% of conceptual papers), and to use theory and conceptual models to inform study design, FE assessment method selection, and outcomes of interest (48% of reviews and 73% of conceptual papers). Other common themes included recommending replication of studies and improved study methods to increase comparability among studies (44% of reviews and 14% of conceptual papers), operationalizing neighbourhood based on theoretical considerations (44% of reviews and 27% of conceptual papers), using multilevel study designs and analytic models (26% of reviews and 18% of conceptual papers), and to use multidisciplinary teams to address complex issues of the FE (22% of reviews and 23% of conceptual papers).

4.1 Theory and Conceptual Models

A recent review noted, “It is remarkable that within the abundance of studies of environmental influences on overweight, clear, conceptually sound hypotheses of the underlying process by which environmental factors impact on behaviour are lacking.” (53), (p. e140). The lack of peer-reviewed reward structure for employing conceptual models and the multidisciplinary nature of food environment research have been identified as challenges to increasing the rate at which researchers rely on conceptual models to inform their studies (179). While different models may resonate with different disciplines (for example, Forsyth and colleagues’ model (94) may resonate with urban planners and Rose and colleagues’ (79) model might be more salient for economists), this paper argues that Glanz and colleagues’ model (1) and Lytle’s model (83) are useful across disciplines, and provide a useful way of both categorizing food environment characteristics as well as hypothesizing that increasing individual and social restrictions result in an increased proportion of variance in eating behaviours explained by food environments. The conceptual models should be improved and refined based on recent evidence (94, 110), and should underlie research and interventions (11, 104).

In addition to explicitly theorizing about how FEs affect diet-related outcomes, the way neighbourhood is operationalized should also be theoreticallyfounded (7, 11). Justifications for why and how neighbourhood is defined should be explicit and tied to outcomes. Future work could look at effects of different geographic scales and address why some associations between aspects of the FE and diet-related outcomes vary by scale.

4.2 Study Design and Measurement Strategies

A number of study design issues have been addressed, including the inconsistent methodologies used to assess FEs (9, 104), psychometric and ecometric evaluation of assessment methods, the need for mixed-methods study designs and the high prevalence of cross-sectional research on point.

4.2.1 Inconsistent Measures:

The issue of inconsistent measurement and the concomitant inability to adequately compare studies is the most commonly-cited challenge, with 78% of reviews and 73% of conceptual papers addressing this particular issue. Several reviews that were determined to be out-of-scope for the current review focus exclusively on assessment methods (119, 134, 180-182), and point to the need for researchers to develop and refine valid and reliable tools as well as to test their application in a variety of subgroups. Currently, over 500 articles and instruments that assess aspects of FEs have been compiled by the National Cancer Institute (see https://riskfactor.cancer.gov/mfe/). One recent systematic review noted the wide range of methods by which researchers classify food outlets (117); another noted that most studies used their own definition of "fast food" in fast food access studies (9). Given that the National Cancer Institute already maintains a database of FE measures, it may be a logical body to also propose definitions of food outlet types.

In addition to the variety of actual FE assessment methods, geographic metrics used vary widely (7, 12). Within the general categories of administrative units, buffer zones, and activity spaces (discussed above), there are no "gold standards" when it comes to which geographic scale best captures meaningful FE exposures. Future research should provide explicit rational for operationalizing neighbourhood to improve study comparability and to clarify the meaning of different boundaries and measures (11). FE-related activity space research, which examines individuals' movements and travel within their environments, can be used to examine accessibility to services based on travel patterns rather than residential locale.

Recently, activity space research methods have been applied to food environments (175-177); these methods have been identified as being on the forefront of food environment research advancement (183)

4.2.2 Psychometric and Ecometric Measurement Approaches:

Lytle asked, "To what psychometric standards should tools that assess the FE be held?" (92)(p. S135). She distinguished psychometrics (the field of study concerned with measurement theory and methods, including reliability and validity) from ecometrics (community members' perceptions of their neighbourhoods), and suggested how traditional psychometric terms translate to FE characteristics. For example, construct validity is "the extent to which the measure 'behaves' in a way consistent with theoretical hypotheses" (p. S136). Several studies have attempted to assess construct validity by assessing agreement between residents' perceptions and at least one objective measure (41, 160, 184, 185). These studies generally indicate that food environment measures (particularly subjective vs. objective) are not strongly associated (41, 160, 184). Only one study used more than one objectively-defined measure in its analyses (184) and none have simultaneously considered how different objective measures of the food environment might be related to each other. The question of whether different objective measures are truly measuring the constructs they purport to measure remains. Because measures differ in the resources needed to implement, there is a need among both researchers and practitioners to know how closely a healthy food environment characterised by one method corresponds to its characterization by another method. By examining several methods simultaneously in the same population, it will become clearer whether less resource intensive methods will provide similar results to more resource intensive methods. Future research should explore whether traditional psychometric methods such as a multitrait-multimethod matrix (186) and/or factor analysis (187) could be applied to FE measures. Moreover, cost-benefit analyses would also make unique contributions to determine the relative quality of output from various methods relative to the resources required to implement.

4.2.3 Mixed-Methods Study Designs:

Most studies have used either quantitative or qualitative methods to assess FEs. Including FE perceptions in quantitative studies is suitable for an ecological approach and was recommended by 22% of the reviews and 23% of the conceptual papers. While appropriate methods differ given the research question, conducting mixed-methods study in the same area can help to elucidate how people feel and think about their environments with respect to food access, availability, affordability, and quality (92, 188). Several questions could be assessed with mixed-method designs, including, “How well do objective assessment methods capture residents’ lived experiences?” or “Do objective or perceptive characteristics better predict outcomes of interest?” In general, residents’ perceptions are not strongly correlated with objectively-measured environmental characteristics, and individual- and neighbourhood-level factors can affect FE perceptions (17, 160, 189). The importance of establishing how closely objectively measured vs. subjectively derived FE characteristics predict outcomes is in the policy implications, described above.

4.2.4 Overreliance on cross-sectional study designs:

Sixty percent of the reviews and half of the conceptual papers examined here recommended that future studies employ longitudinal designs and take advantage of natural experiments (e.g., the opening or closing of a large supermarket), since cross-sectional studies limit causal inferences. The longitudinal studies to date examining food access have found limited (129, 131, 132) or no effect (130, 133) on diet-related outcomes. Future longitudinal studies should incorporate aspects of the consumer nutrition environment in addition to food access measures.

4.2.5 Data Limitations

Several important data limitations have been identified in the FE literature. Three main limitations with respect to data have been identified. First, detail and completeness of data are not uniform across regions or research questions. FE data available from different data sources can be disparate, with corresponding implications for study findings (94). Selection of data sources should be explicitly outlined in methods sections, along with details regarding data quality. Second, as with any methodological literature, complex data structures require complex statistical models and reporting. Researchers must consider benefits and drawbacks to using aggregate data (e.g., giving the mean score of responses from individuals living within a census block group) vs. buffer zone data (e.g., each household has its own unique buffer zone, even though buffer zones can overlap). Finally, there are several considerations related to data given the relative newness of the field. Specifically, the large amount of data collected in some studies may lead researchers to conduct atheoretical statistical tests, which may lead to statistically significant findings due to chance. In addition, gold standard FE assessment methods have not yet been described; little is known about how well methods assessing different constructs predict outcomes. Moreover, methods that purportedly measure certain constructs (e.g., food availability and food affordability) are more time and resource intensive to implement than those measuring food access. It is still unclear whether investing the time and resources into using FE checklists or shelf-space measurements rather than GIS-derived food access measures are worth the extra investment (in terms of better predicting outcomes of interest). Studies aimed at examining construct validity that employ more than one type of FE measure could contribute to answering the questions of the importance of certain trait-method variables in predicting diet-related outcomes.

4.2.6 Contexts

Contexts are common considerations in health geography and social epidemiology. FEs may not "get into the body" the same way in all communities. Community characteristics include predominant culture, area-level income, social capital, and built and natural environments in which the neighbourhoods are situated. For example, a predominantly upper-class neighbourhood with high rates of vehicle ownership might be far less dependent on their immediate environments for food than an area in which very few residents own vehicles and access to public transportation is poor. Reviews have identified the need to examine where people actually procure food and eat (94); to explore whether individual-level factors such as whether someone works at home, the elderly, or those with reduced mobility are disproportionately affected by area exposures (11); to examine the influence of the FE on minorities and children (53, 110, 190), and; to seek a broader understanding of historical, political and cultural underpinnings to socioeconomic characteristics and racial segregation in an area (9). Using Lytle's model as a conceptual framework will help organize study designs aimed at assessing how contexts influence the relationship between FE characteristics and diet-related outcomes. In addition, researchers should explore cross-level interactions to examine whether certain individual factors moderate relationship between environments and outcomes. Finally, researchers should pursue activity space research (e.g., (176, 177)) to determine theoretically meaningful places and to explore how activity spaces vary by individual and social restrictions.

5. Conclusion

This paper examines literature reviews and conceptual papers to situate FE research within an ecological approach, and recommends two particularly salient conceptual models for consideration in future research. FE characteristics have been described, common operationalizations of neighbourhoods have been examined, and future directions for the field have been recommended. This chapter argues that while different measures and definitions of neighbourhoods may be appropriate for different areas of inquiry, method selection and neighbourhood operationalization should be explicitly and theoretically justified. Promising avenues of research include work on activity spaces, particularly related to food procurement, and greater consideration of psychometric evaluation of FE constructs. Finally, researchers should consider the policy implications of their findings (20). Policies related to the FE are becoming increasingly common (19, 191-193). While many factors are at play in determining policies related to food environments (19), there may be a window of opportunity in terms of public support for FE policies. The recommendations have been presented here in the hopes that stronger evidence will help facilitate policy decisions aimed at improving public health.

Although two conceptual models were presented as especially salient for guiding FE research (Glanz and colleagues' model and Lytle's model), the remainder of this dissertation employs Glanz and colleagues' model for study design, variable selection, and statistical analyses, to keep the scope of the dissertation manageable and to test construct validity of the constructs proposed by Glanz and colleagues as well as hypothesized pathways by which food environments "get under the skin" of residents. As mentioned, Glanz and colleagues' conceptual model has been presented as a useful way of organizing food environment constructs and Lytle's model hypothesizes how social and individual restrictions modify associations between food environments and diet-related health outcomes. While the following three studies presented in this dissertation employ Glanz and colleagues' model for the overarching objective of construct validation of environmental measures, future research should employ Lytle's model to examine how social and individual restrictions in fact modify the relationship between food environments and outcomes of interest. Such a study could, for example, examine food environment variables as predictors of diet-related health outcomes through the creation of income-specific statistical models to examine how neighbourhood food affordability predicts diet quality for low income relative to high income. This type of study would also be useful for policymakers who may want to support "priority neighbourhoods". If Lytle's hypothesis is supported empirically, policymakers could be encouraged to act to improve food environments in areas where a significant proportion of the population is "restricted", either through reduced income, reduced mobility, or other social or individual restrictions that may be more reliant on their immediate environments for food.

Table 2-1: Description of conceptual models relevant to food environment research presented by year

Author, year	Ecological levels included	Constructs Addressed	Outcome	Description
Booth et al, 2001	**Intrapersonal**: self-identities, genetics, physiology, social roles, socio-demographics **Interpersonal**: relationships, cultural identities **Organizational:** Behaviour settings include workplace, school, day care **Community**: Behaviour settings include food stores, restaurants, and neighbourhoods **Public Policy**: proximal and distal leverage points (e.g., food industry, government, information industry)	Food access, food availability, food affordability, barriers and facilitators to healthy eating	Dietary behaviours	An ecological model for physical activity and eating behaviour is presented. Hypothesized influences on nutrition related to food stores included packaging of healthful foods, coupons for processed foods, prevalence of small stores in disadvantaged areas, perceived food cost, junk food placement, in-store promotion of healthy foods, shelf-space of healthy foods, and portion size/unit packaging. Influences related to neighbourhoods included the presence of vending machines, fast food outlets and farmers' markets, outdoor advertising, and supermarket and minimart access. Influences related to restaurants included portion size, limited choices of healthy foods, prompting for additional items, pricing for combination meals, availability of nutrition information, food processing or preparation, and consumption incentives. Proximal factors are considered enablers of choice, while distal factors are considered behavioural settings, proximal and distal leverage points.
Diez Roux, 2003	**Intrapersonal**: stress and psychosocial factors **Interpersonal**: social environment (e.g., social support and cohesion, social norms) **Organizational:** n/a **Community**: physical environment (e.g., availability and cost of healthy foods) **Public Policy**: n/a	Food access, food availability, food affordability	Cardio-vascular risk or disease	The aim of the model is to represent hypothesized causal pathways by which environmental features influence the development of cardiovascular disease. The conceptual model includes the "availability and relative cost of healthy foods" and "food and tobacco advertising" as two of eight features of the physical environment related to diet that impacts proximate biological factors (such as blood pressure and BMI), which can lead to cardiovascular disease. Features of the FE may be socio-economically patterned, although little research has focused on relationships between FEs and outcomes.

Author, year	Ecological levels included	Constructs Addressed	Outcome	Description
Glanz et al, 2005	**Intrapersonal**: psychosocial factors; perceived nutrition environment; socio-demographics **Interpersonal**: psychosocial factors **Organizational**: home; school, work **Community**: aspects of community and consumer nutrition environments **Public Policy**: government and industry policies; information environment	Food access, food availability, food affordability, barriers and facilitators to healthy eating	Dietary behaviours	This parsimonious, ecological model indicates that FE features may act as direct moderators of eating patterns or may mediate the relationship by acting on individual variables, which then impact eating patterns. Socio-demographics may mediate and/or moderate the impact of environmental variables on eating patterns.
Papas et al, 2007	**Intrapersonal**: genetics, socio-demographics **Interpersonal**: family and peer influences **Organizational:** n/a **Community**: Economic influences (food access, cost) **Public Policy**: n/a	Food access, food affordability	Weight	The ecological model presents food consumption as mediating the relationship between FEs and body weight. Food consumption is also affected by individual factors (genetics, socioeconomic characteristics, and other individual characteristics) and social factors (family and peer influences, and socioeconomic characteristics).
White, 2007	**Intrapersonal**: educational attainment; aspirations and expectations; inherited wealth; dietary knowledge **Interpersonal**: socioeconomic position; culturally determined dietary and food purchasing norms **Organizational**: healthiness of prepared food from fast-food outlets **Community**: healthiness grocery purchases; use of supermarkets or local convenience stores **Public Policy**: n/a	Food access, food availability	Dietary behaviours	In the hypothesized causal model presented by the author, food retailing factors mediate the relationship between socioeconomic factors and dietary intake. The author suggests that evidence for both the existence of food deserts and the impact of food retailing on dietary behaviours is mixed, and that the most robust evidence to date suggests that food retail access does not profoundly influence dietary consumption (in the UK).

Author, year	Ecological levels included	Constructs Addressed	Outcome	Description
Story et al, 2008	**Intrapersonal**: cognitions, attitudes, biological factors **Interpersonal**: family, friends, peers **Organizational**: work sites, schools, child care **Community**: neighbourhoods and communities, supermarkets, convenience and corner stores, restaurants **Public Policy**: societal and cultural norms, food marketing and media, economic systems, government and political structures and policies	Food access, food availability, food affordability, barriers and facilitators to healthy eating	Dietary behaviours	An ecologic conceptual framework is presented. The authors situate "neighbourhoods and communities", "restaurants and fast food outlets", "supermarkets", and "convenience and corner stores" within "Physical environments (settings)", the third most proximal level to actual behaviours (individual factors and the social environment are considered more proximal; macro-level environments are considered more distal). Levels are seen as interacting and all directly or indirectly contribute to shaping dietary behaviours. Access to supermarkets and grocery stores is suggested to be an important determinant of dietary behaviour and is also suggested to be socio-economically patterned with poorer and rural areas having decreased access to supermarkets. Both community and consumer nutrition environments are identified as promising venues for positive change. The authors also identify eating foods prepared away from home as a potentially important intervention setting.
Daniel et al, 2008	**Intrapersonal**: psychosocial factors, individual SES and resources **Interpersonal**: social capital **Organizational**: educational facilities **Community**: opportunities to procure healthy foods **Public Policy**: health/social services	Food access	Cardio-vascular risk or disease	This ecological model focuses on biological plausibility of place impacting cardio-metabolic disease. Opportunities to access healthy foods are considered contextual factors that interact with structural factors to affect both the indirect-cognitive path (psychosocial factors) and the direct-contextual path (non-conscious perceptions, individual SES and resources), which then affects allostatic load. Weight status and allostatic load interact to cause cardio-metabolic disease. Many epistemological perspectives in trans-disciplinary studies of health and place are needed. Difficulties in ascribing causality to associations between place and health include modest strength of associations; limited grounds for demonstrating temporal order and; biological plausibility.

Author, year	Ecological levels included	Constructs Addressed	Outcome	Description
Black & Macinko, 2008	**Intrapersonal**: genetics; attitudes and norms **Interpersonal**: social support and capital **Organizational**: not explicit **Community**: access to high quality food; physical features **Public Policy**: social, historical and political factors	Food access, food quality, food availability	Weight status	Neighbourhoods act as moderators on health behaviours, a relationship which may also be mediated by individual-level variables. Neighbourhoods may also act as mediators in the relationship between social, historical and political factors and individual factors.
Ford & Dze-walt-owski, 2008	**Intrapersonal**: SES **Interpersonal**: not explicit **Organizational**: not explicit **Community**: quality of the retail FE **Public Policy**: not explicit	Food access, food availability, food affordability	Dietary behaviours	SES moderates the impact of FEs on eating behaviours. Specifically, higher SES is protective at all levels of FE quality. High quality FEs are identified as ones in which good-quality healthy foods are accessible and available.
Brug et al, 2008	**Intrapersonal**: Demographic and psychosocial factors **Interpersonal**: Micro socio-cultural factors **Organizational**: not explicit **Community**: Physical environments **Public Policy**: Macro-level political, economic and socio-cultural environments	Food access, food availability, food affordability	Dietary behaviours	The ANGELO framework and the EnRG model organize the extant research and recommend future research strategies. The EnRG model is a dual-process model recognizing that behaviours can be direct, automatic responses to environmental cues or can be the result of conscious beliefs and decisions. EnRG hypothesizes that FE characteristics categorized by the ANGELO framework can have a direct influence on dietary behaviours by triggering more or less automatic responses to environmental cues. The authors note the lack of well-designed studies on point lead to a lack of strong evidence for the crucial importance of FEs in causing overeating.

Author, year	Ecological levels included	Constructs Addressed	Outcome	Description
Chow et al, 2009	**Intrapersonal**: Psychosocial behaviour, biologic risk factors **Interpersonal**: Social networks, social capital **Organizational**: not explicit **Community**: Access and availability of healthy food choices **Public Policy**: food policy, advertising, promotion of healthy vs unhealthy foods	Food access, food availability, food affordability, barriers and facilitators to healthy eating.	Cardio-vascular risk or disease	Neighbourhood FE features related to diet include aspects of both community nutrition environments (relative access to healthy vs. unhealthy food stores; variety and quality of stores; variety and quality of restaurants; vending machine availability) and consumer nutrition environments (food costs, in-store retail environments, relative availability of healthy and unhealthy items in stores and restaurants).
Lytle, 2009	**Intrapersonal**: individual factors **Interpersonal**: social factors **Organizational**: social factors **Community**: environmental factors **Public Policy**: not explicit	Food access, food availability, food affordability	Dietary behaviours	The author presents a conceptual model that examines the proportion of variance in eating behaviours explained by individual, social, and environmental factors. This conceptual model hypothesizes that as individual and social restrictions increase, environmental factors explain an increasing proportion of eating behaviours. The author provides examples related to psychometric testing of FE assessment methods, and discusses relevant measurement issues in the field.
Mayer, 2009	**Intrapersonal**: Income, education, socio-demographics **Interpersonal**: culture **Organizational**: Schools **Community**: food access **Public Policy**: not explicit	Food quality, food access, food affordability	Weight status	In the ecological model presented, the community FE is seen as interacting with community-level physical, political, and economic features, with various other theoretical models, and with community characteristics (including income, education, race/ethnicity) to impact food quality, convenience, and cost, which themselves interact with the theoretical frameworks to impact on community dietary behaviour and childhood obesity.

Author, year	Ecological levels included	Constructs Addressed	Outcome	Description
Diez Roux, 2010	**Intrapersonal**: stress, behavioural mediators, biological attributes **Interpersonal**: neighbourhood social environments **Organizational**: not explicit **Community**: neighbourhood physical environments (e.g., food resources) **Public Policy**: inequalities in resource distribution	Food access, food availability, food affordability	Health	In the conceptual model presented in this article, residential segregation by race and SEP can reinforce inequalities in resource distribution, such as neighbourhood physical environments (including food resources). Neighbourhood physical and social environments interact to produce outcomes related to behavioural mediators and stress, which interact to impact health. Historically, neighbourhood research has been atheoretical and has relied on convenient data. More recently, the development and refinement of neighbourhood-level environmental measures has resulted in researchers being able to adopt more theoretical approaches.
Forsyth et al, 2010	**Intrapersonal:** taste preferences; health concerns **Interpersonal:** social/household context **Organizational:** social context **Community**: store and restaurant access; seasonal availability of food; opportunities for gardening **Public Policy:** local agriculture	Food access, food availability, food affordability	Dietary behaviours	In the conceptual framework proposed by the authors, personal constraints are seen as moderating an individual's preference for specific foods, while a land-use and transportation factors related to food availability and access (e.g., access to stores and restaurants, food cost, availability of food) moderate the relationship between food preference and purchasing and consumption behaviours.
Rose et al, 2010	**Intrapersonal**: tastes and preferences; income; age, ethnicity, education; car ownership **Interpersonal**: social acceptability **Organizational**: in-store characteristics; social acceptability **Community**: travel cost; food cost; neighbourhood food access **Public Policy**: not explicit	Food access, food availability, food affordability, barriers and facilitators to healthy eating	Dietary behaviour	The authors present an economic model of food choice, adapted to include neighbourhood effects. In the proposed model, the relationship between neighbourhood food access and food purchasing is mediated by a number of intra- and inter-personal factors including travel cost, food cost, promotional effects, social acceptability, and tastes and preference. The authors argue for a multidimensional approach to studying links between food access and dietary behaviours, and note that in general, findings from the studies that have used multi-dimensional measures of access show significant

				relationships between the neighbourhood FE and dietary behaviours.
Author, year	Ecological levels included	Constructs Addressed	Outcome	Description
Giskes et al, 2011	**Intrapersonal**: not explicit **Interpersonal**: not explicit **Organizational**: not explicit **Community**: FE **Public Policy**: not explicit	Food access, food availability, food affordability, food quality	Dietary behaviours and weight status	The simple conceptual model presented by the authors indicates that dietary intakes mediate the relationship between the FE and weight status. In other words, dietary intakes are identified as the mechanism by which FEs impact weight status.
Casey et al, 2011	**Intrapersonal**: biologics, demographics, psychosocial **Interpersonal**: social support, cultural and normative constraints **Organizational**: not explicit **Community**: Spatial accessibility of food stores and restaurants **Public Policy**: not explicit	Food access, food availability, food affordability, barriers and facilitators to healthy eating	Weight status	The second conceptual model presented by the authors indicates that features of the built environment (including food access) interacts with the social environment to impact food and physical activity behaviours, as well as overall health. The relationship between built environment features and behaviours is modified, mediated, and/or confounded by individual characteristics and characteristics of the social environment (such as population density, collective functioning, and social networks).

Table 2-2: Reviews and support for Glanz and colleagues' model and Lytle's model.

Author, Year	Outcome	Subjects	Nutrition environment addressed	Main Findings	Glanz et al's model	Lytle's model
Richter et al, 2000	Dietary behaviour	Youth	Consumer	Only one of 16 studies examining environments related to nutrition or physical activity examined an aspect of the FE in relation to a dietary outcome. This study found food availability associated with residents' diets.	+	n/a
Booth et al 2005	Obesity	Youth and adults	Community	Only one of nine articles reviewed addressed FE features (fast food access). No relationship was found between weight status in low-income children and proximity to fast food outlets. Limitations in environmental research include use of self-reported BMI and indirect measures of place (e.g., GIS-or census-defined) rather than environmental audits.	-	+
Matson-Koffman et al, 2005	Dietary behaviour	Youth and adults	Consumer	Of nine community-level interventions related to food availability and affordability, most showed some association with improved nutrition. Four out of five quasi-experimental designs showed positive associations while one showed negative associations; three out of four non-experimental designs showed positive associations while one showed mixed results (i.e., associations were positive in certain populations).	+	n/a
Taylor et al, 2005	Dietary behaviour	Youth	Community and Consumer	Food cost is the most important determinant of food choice when income is restricted. The increased availability and marketing of fast foods is also concerning in terms of dietary behaviours.	+	+
Kamphuis et al, 2006	Dietary behaviour	Adults	Community and Consumer	Thirteen associations between FE factors and fruit and vegetable intake were examined. Only three were significant and in the hypothesized direction. Good local availability of fruits and vegetables seems to be positively related to intake, although evidence is limited.	Mixed	+
Casa-grande et al, 2007	Dietary behaviour	African American adults	Community	Only two studies addressed environmental features related to dietary intake among African Americans, and both found positive associations between FE characteristics and diet quality.	+	+

Author, Year	Outcome	Subjects	Nutrition environment addressed	Main Findings	Glanz et al's model	Lytle's model
Faith et al, 2007	Dietary behaviour and obesity	Adults	Community and Consumer	Three macrolevel approaches related FEs were reviewed: taxing or subsidizing foods, manipulating food access, and restricting access to certain foods. Findings from the limited data on point indicated that subsidizing healthy foods increases purchases of those foods. No studies examined effects of taxation on dietary outcomes. In terms of manipulating or restricting food access, evidence was less consistent.	+	n/a
Giskes et al, 2007	Dietary behaviours	Adults	Community and Consumer	Of the nine associations (from two studies) examined between FE factors and dietary intakes, only two showed significant relationships with dietary intakes. Few studies examined aspects of the community or consumer nutrition environment. Therefore, it is too premature to make conclusions about the impact of the environment on diet.	Mixed	n/a
van der Horst, et al, 2007	Dietary behaviours	Youth	Community and Consumer	Both studies among children examining FE characteristics and dietary behaviours found significant associations in the hypothesized directions. Among adolescents, three out of four associations between fruit and vegetable consumption and fruit and vegetable availability at restaurants were significant and positive; one association examined between food availability and dietary behaviours was not significant. Few studies examined FE determinants of dietary behaviours in neighbourhoods.	+	n/a
Papas et al, 2007	Obesity	Youth and adults	Community and Consumer	Of six studies addressing some aspect of the FE and BMI, five examined food access, and one examined food affordability. Food affordability was positively related to lower gains in BMI over a three-year period. Results of studies examining food access and weight were less consistent.	+	+
Story et al, 2008	Dietary behaviours	Youth and adults	Community and Consumer	Access to supermarkets and grocery stores is suggested to be an important determinant of dietary behaviour and is also suggested to be socio-economically patterned with poorer and rural areas having decreased access to supermarkets. Both community and consumer nutrition environments are identified as promising venues for positive change. The authors also identified eating foods prepared away from home as a potentially important intervention setting.	+	+

Author, Year	Outcome	Subjects	Nutrition environment addressed	Main Findings	Glanz et al's model	Lytle's model
Black & Macinko, 2008	Obesity	Youth and adults	Community and Consumer	Of seven articles reviewed related to food access and obesity, three found associations between food access and weight status in the expected directions; four found no significant associations. One study examining food affordability found a positive association between weight status and higher prices of fruits and vegetables.	Mixed	+
Ford & Dzewalt-owski, 2008	Obesity	Adults	Community	All three studies reviewed found significant associations supporting the hypothesis that individuals exposed to poor quality retail FEs are more likely to have poorer dietary and weight outcomes than those exposed to higher quality FEs.	+	+
Holsten, 2009	Obesity	Youth and adults	Community	Five of seven studies reviewed showed associations between an aspect of the FE and BMI. Significant findings were related to the presence of different food store types, food store proximity, and food store distribution.	Mixed	+
Larson & Story, 2009	Dietary behaviours	Youth and adults	Community and Consumer	The authors of this review employed a snowball sampling methodology to review articles related to environmental determinants of food choices. Evidence regarding retail food store and restaurant access and diet-related outcomes was mixed, although some evidence suggests that price might be a more salient determinant of dietary intake than access, particularly for fast food intake.	Mixed	+
Larson et al, 2009	Dietary behaviours and obesity	Youth and adults	Community and Consumer	Evidence from the US generally suggests that those who have better access to supermarkets and reduced access to convenience stores have healthier diets and lower levels of obesity. With respect to restaurant access, there were less consistent findings. Some evidence suggests that neighbourhood residents who have better access to full serve restaurants and greater cost barriers to fast food consumption have healthier diets and lower obesity.	+	+
Lovasi et al, 2009	Obesity	Youth and adults	Community	Four of the seven studies examining supermarket access and weight outcomes found significant associations between lack of supermarket and higher levels of obesity. Associations between the presence of small grocery stores or convenience stores were mixed (one out of two found associations in the hypothesized direction). Strong support exists for supermarket availability as an important FE characteristic.	Mixed	+

Author, Year	Outcome	Subjects	Nutrition environment addressed	Main Findings	Glanz et al's model	Lytle's model
Sallis & Glanz, 2009	Dietary behaviours and obesity	Youth and adults	Community and Consumer	Food access appears to contribute to the dietary behaviours of local residents, although evidence is mixed regarding racial and ethnic disparities in access to full-service supermarkets. There is stronger evidence to suggest that fast food restaurants are more concentrated in poorer neighbourhoods, but the evidence for the impact on residents' diets and weight status is mixed. Variations in consumer nutrition environment features might explain some of the racial/ethnic or socioeconomic disparities in nutrition-related outcomes.	Mixed	+
Carter & Dubois, 2010	Obesity	Youth	Community	Five studies examined the relationship between food access and children's weight status with mixed results.	Mixed	n/a
Feng et al, 2010	Obesity	Youth and adults	Community	Little between-study similarity of methods prevented estimation of pooled effects and limits what can be learned from this body of evidence. Of the 22 studies examining aspects of the FE and weight status, 14 showed significant associations in the expected direction, six showed no association, and two showed associations in an unexpected direction.	Mixed	+
Galvez et al, 2010	Dietary behaviours and obesity	Youth	Community	Of four studies examining food access and obesity, three found associations in the hypothesized direction (using measures of proximity, density, and presence/absence of stores as environmental exposure variables). Of the five studies focused on the relationship between food access and dietary behaviours, four found associations in the hypothesized direction.	Mixed	n/a
de Vet et al, 2011	Dietary behaviours	Youth	Consumer	In this review of reviews, seven reviews (which included 232 unique studies) examined environmental determinants of dietary behaviours. In the only review reportedly examining an aspect of the FE (food price), authors report a negative association between food price and overweight among children and youth.	+	n/a

Author, Year	Outcome	Subjects	Nutrition environment addressed	Main Findings	Glanz et al's model	Lytle's model
Fleisch-hacker et al, 2011	Obesity	Youth and adults	Community	Of 15 studies examining weight status and fast food access, seven (47%) found significant associations with obesity, while eight (53%) found no significant associations. Only one of five studies in children found fast food access to be associated with weight. Six studies examined associations between dietary behaviours and fast food access and reported mixed results.	Mixed	+
Safron et al, 2011	Dietary behaviours and obesity	Youth	Community and Consumer	In eight systematic reviews included, the only FE variable receiving preliminary support in terms of impacting diet was the availability of fruits and vegetables in restaurants. The availability in grocery stores showed no or mixed support for being an important determinant of youth's weight or dietary behaviours. Conclusions should be drawn with caution, since the review indicates that evidence for associations are weak (due to the lack of replication and the high prevalence of cross-sectional studies).	Mixed	n/a
Giskes et al, 2011	Dietary behaviours	Adults	Community and Consumer	Of 14 studies examining some aspect of the FE and outcomes, weight status (but not dietary behaviours) was consistently associated with food access: greater supermarket accessibility and lower fast food outlet accessibility were associated with lower overweight or obesity. Environmental factors may influence BMI through a complex interplay of factors, including physical activity. Great variation existed between studies in measurement and in defining environmental factors and dietary behaviours, which may have contributed to the heterogeneous findings.	Mixed	n/a
Casey et al, 2011	Obesity	Youth	Community	Thirteen papers examined FEs and childhood obesity and found the most consistent relationships between weight status and convenience store access. Links between built environment characteristics and dietary behaviours are inconsistent, and analysed in few studies.	Mixed	+

Author, Year	Outcome	Subjects	Nutrition environment addressed	Main Findings	Glanz et al's model	Lytle's model
Leal & Chaix, 2011	Cardio-vascular risk and disease	Adults	Community and Consumer	Significant associations were reported between aspects of the FE and weight status in 22 of 29 studies (76%). Grocery store access was associated with lower weight status, while convenience store access was associated with higher weight. Less consistent associations were reported by studies examining restaurant access and obesity. Price was consistently associated with weight. Associations appeared stronger among women and low SES individuals.	+	+

\+ The majority of associations examined showed significant associations in the expected direction between the FE characteristic of interest and the outcome of interest

\- No studies showed significant associations in the expected direction

Mixed FE features were inconsistently related to outcomes of interest

n/a Support for this model was neither assessed in the review nor discussed in the article

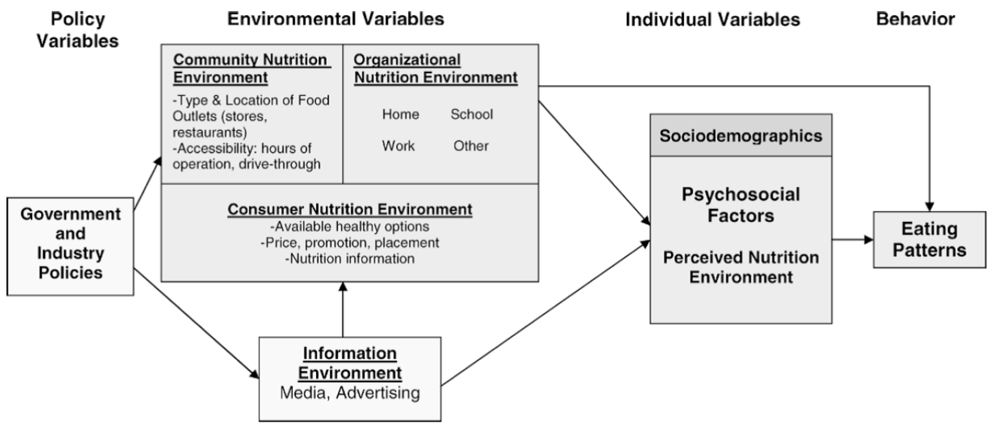

Figure 2-1: Glanz and colleagues' model of community nutrition environments

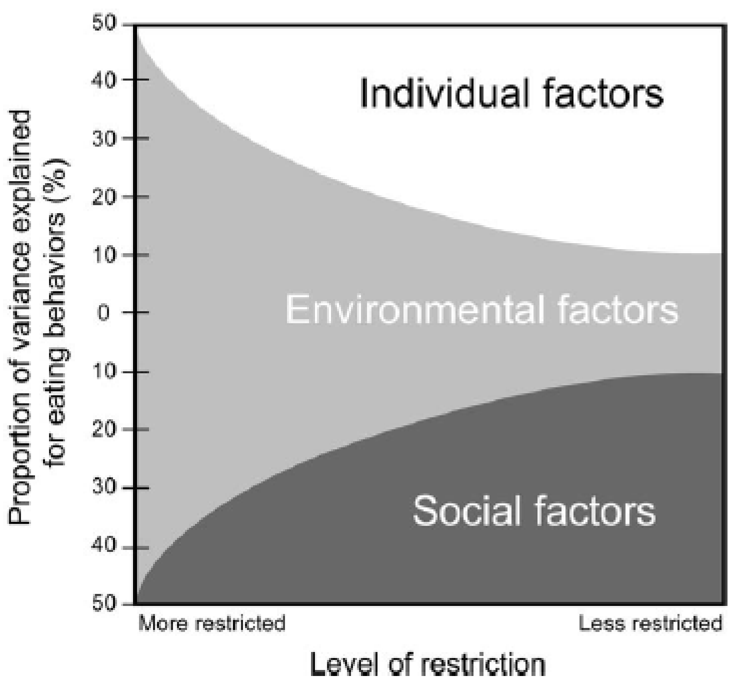

Figure 2-2: Lytle's model, The relationships among individual, environmental, and social factors

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Chapter 3. Construct validation of four food environment assessment methods: adapting a multitrait-multimethod matrix approach for environmental measures

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1. Introduction

Public health researchers and practitioners are increasingly interested in how the built environment affects health. In that broad context, the recognition of environmental determinants of food-related behaviour has gained momentum over the past twenty years, with a number of ecological models of food choice and eating behaviour being developed over the past decade or so (50). Conceptual models of the food environment, reviewed elsewhere (194), reflect different disciplinary foci, including public health, marketing, and land use planning and transportation. Conceptual models also differ in their categorization of specific determinants and outcomes of interest: body mass index, diet quality, and food purchasing have all been treated as outcomes in published models. Glanz and colleagues proposed an especially salient model, which has been cited in many food environment studies (1). Several benefits of employing environmental (as a complement to individual-level) assessments have been identified, including potentially less bias from self-reports, greater efficiency and cost-effectiveness than individual-level measures, and increased sensitivity to early program effects relative to individual-level health outcomes (54).

The neighbourhood food environment has been defined as, "… a group of factors including the types of retail food outlets and the availability, quality, and price of different kinds of foods, such as prepared foods, fresh produce, and other groceries, in a given geographical area." (2)(p. 61). In the definition presented above, neighbourhood food environments consist of a number of related constructs. In general, extant research attempts to demonstrate associations between one or more of these constructs (e.g., food access, availability, quality, and affordability) and a diet-related health outcome, or with area-level disadvantage (e.g., research examining food deserts, generally defined as disadvantaged areas lacking access to affordable, nutritious food) (8, 9, 194). Food *access*, a geographical understanding of locations people can procure food, has often been used as a proxy for the underlying construct of food *availability*, the kinds of foods available where people shop. With food access measures, researchers often categorize food outlets as "healthy" (e.g., grocery stores, farmers' markets, fruit and vegetable stands) or "unhealthy" (e.g., fast food restaurants, convenience stores) based on the assumption that healthy foods are more or less available at different types of outlets (194).

Over the past few decades, over 500 food environment assessment methods have been developed and have been compiled in a database maintained by the National Cancer Institute, part of the U.S. National Institutes of Health (13). The sheer number of existing assessment methods and the few extant studies that compare different food environment measure (18, 41, 43, 160, 185) mean that the field of food environment assessment is characterised by inconsistent operational definitions (194). Contributing to these inconsistent findings is a lack of consistent operational definitions the geographic scale at which environmental exposures are hypothesized to operate (5, 194). These inconsistencies have created varied findings with regard to purported associations between food environment variables and health outcomes and have hampered attempts to use policies (e.g., zoning restrictions of fast food or convenience stores around schools; incentives for grocery stores to open in underserved areas) to improve health outcomes.

1.1 The Measurement Imperative

While theoretical models of the food environment are being developed and tested using a number of methods, much work needs to be done to better understand the measurement properties of food environment assessment tools. For example, a literature review published in 2009 reported that only 13.1% of food environment measures had been tested for any psychometric properties, including inter-rater or test-retest reliability and/or construct validity (195). A more recent review and critique of food environment measures noted an urgent need for better psychometric testing, since only one-quarter of tools reviewed reported both validity and reliability testing and a further 12% reported reliability testing alone (115). The most recent review examining food environment measures did not report the proportion of tools that have undergone psychometric or ecometric testing, but noted that instruments should undergo rigorous validity and reliability testing in the formative stages of development to assure the usability and adaptability of food environment measures (117). Several systematic reviews of food environment constructs and diet-related outcomes have recommended that assessment tools be psychometrically and/or ecometrically evaluated (7, 9, 94, 110).

Psychometric evaluation is concerned with establishing validity and reliability in its overarching interest in the theory and technique of measurement, while ecometric evaluation refers to an aggregate measure of community members' perceptions of their environments (92). To date, psychometric research has generally been conducted at the level of the individual, and has explored individual motivations, beliefs, perceptions and attributes (92). Construct validity, an important consideration in psychometrics, has been defined as the extent to which a given measure "behaves" in a way consistent with theoretical hypotheses (92). Construct validity is comprised of two main components: operational definitions (how are constructs measured?), and syntactical definitions (how are constructs related to one another within a theoretical system?) (27). Ecological assessment methods have generally lagged behind psychometric approaches to measurement in general (196), although several studies have examined construct validity by comparing certain food environment measures with others in the same population (18, 41, 43, 160, 184, 185). Of particular interest in these studies is the extent to which agreement exists between objective and perceived characteristics of food environments. For example, one study used intra-class correlation coefficients to assess agreement between self-reported and directly measured healthy food availability, and produced a receiver operating curve to show how sensitivity and specificity of a perception-based measure in relation to an objective environment measure changed with different cut-off points (41). Another study used logistic and multinomial regression to estimate associations between perceptions and objectively-assessed healthy food availability (184). A third study used chi-square goodness of fit tests to assess the agreement between food access perceptions and objectively defined food environment variables (185). One of the earliest papers to compare different methods of characterising local food environments examined supermarket density, individual perceptions of healthy food availability and aggregate survey responses of independent informants (160). Authors analysed each type of variable in separate binomial regressions to examine whether the results were qualitatively similar between food environment measures. Taken together, the results from these studies generally indicate that objective and perceptual measures of food environment constructs exhibit only modest, and inconsistent associations (41, 160, 184) Consequently, the extent to which health-related outcome variables are more influenced by objective or perceptual measures of food environments has yet to be definitively established.

Only one study used more than one objectively-defined measure in its analyses (184), and none have simultaneously considered how different objective measures of the food environment might be related to each other. Thus, the question of whether different objective measures of food environment variables are truly measuring the constructs they purport to measure remains. Because measures differ in terms of resources needed to implement, there is a need among both researchers and practitioners to know how closely a healthy food environment characterised by one method corresponds to its characterization by another method. By examining several methods simultaneously, it will become clearer how closely different methods are related to each other.

A multitrait-multimethod matrix (MTMM matrix) is a psychometric procedure used to assess the *operational definition* component of construct validity. MTMM procedures are “concerned with the adequacy of tests as measures of a construct, rather than the adequacy of a construct as determined by the confirmation of theoretically predicted associations with measures of other constructs.”(186) In other words, MTMM matrices examine the operational, rather than the syntactic, component of construct validity. In this procedure, originally developed by Campbell and Fiske(186) a set of c constructs is measured by m methods. The resulting data are cm measures and the correlation matrix is known as a MTMM matrix. Using this approach, construct validity is demonstrated through high convergent validity between different measures purportedly assessing the same constructs, and low discriminant validity between the same assessment procedures measuring different constructs or different measures assessing different constructs. MTMM matrices have been used in a wide variety of disciplines to describe construct validity of individual-level constructs, such as personality traits or individuals’ perceptions about diverse issues.

The objectives of the present study were to: (1) construct a MTMM matrix to systematically examine the construct validity of four different types of food environment measures purportedly assessing three different constructs: food availability, food affordability, and food quality, and; (2) examine how geographic scale influences convergent and divergent validity coefficients.

2. Methods

2.1 Sampling

This study was undertaken in collaboration with NEWPATH (Neighbourhood Environments in Waterloo Region: Patterns of Transportation and Health) in the three urban centres of the Region of Waterloo (population 553,000(197)), Ontario, Canada, a study designed to examine how different urban built environments impact a variety of health-related outcomes, including physical activity, diet, and obesity (methods described elsewhere)(198). The NEWPATH sample was stratified by neighbourhood walkability, household income and household size, with allocation to achieve high statistical power to detect hypothesized effects of walkability. This stratified random sample was recruited to achieve representativeness in income and household size according to 2006 Canadian census data. Participating households completed a paper questionnaire that included food environment perceptions. Home addresses of NEWPATH participants who had complete survey data in the urban centres of the Region (n=2397 household with complete survey data for the following analyses) were geo-coded, entered into a database and represent the centroids from which buffer zones were established. The three urban centres of the Region of Waterloo are spatially contiguous and are surrounded by four rural townships. Because of the lack of consensus around which geographic scale is most appropriate for examining food environments, ArcGIS 9.1 software was used to establish 250m, 500m, 1000m, and 1500m Euclidean distance buffer zones around respondents' households. Four different buffer zone sizes were examined to test construct validity at different scales; previous food environment research using buffer zones have tested different geographic scales and reported significant findings at some scales but not others (14, 15).

2.2 Food Environment Assessment

Four different food environment assessment methods were used to measure characteristics of food outlets in the three cities in the Region, including three objective measures (NEMS-S (37); shelf-space (122), and; the Retail Food Environment Index (RFEI) (15)) and one subjective measure (NEWPATH participants' perceptions of their local food environment, defined as stores within a 10 to 15 minute walk, approximately 1km to 1.5 km from their homes). Table 3-1 describes food environment assessment methods employed in the current study. Two of the objective store methods (shelf-space and NEMS-S) assessed one of each chain convenience store, pharmacy and superstore, and each grocery store and independently-owned convenience store, pharmacy, and specialty store in the three cities. Because chains strive to be identical in terms of advertising, promotions, price, and food available within the outlet, this process of assessing only one of each chain restaurant, pharmacy, superstore and convenience stores was deemed acceptable. Because grocery stores in the Region differ in size (and may offer different products), all grocery stores were assessed. Names and locations of food outlets were identified using the Region of Waterloo's Public Health Inspection database, which includes geo-coded data for each food outlet in the region whose premises are inspected by public health inspectors, and by systematic observation (40). All outlets in the resulting database were coded to reflect standard North American Industry Classification System codes for use in the RFEI calculation. Data were collected between May and August, 2010.

2.2.1 Training of Raters

A total of six observers conducted food outlet assessments. Raters had all obtained at least two years of university education. Raters were trained to use the NEMS-S by the first author, who completed a NEMS Train-the-Trainer workshop in March 2008 (199). A NEMS-S survey that has been adapted for Canada was used, as the study took place in Canada (200). The first author also trained all raters to conduct shelf-space measures in stores, based on standard protocol (14, 122). Training included classroom sessions to provide background information, review of the tools, practice sessions, and field work in food outlets, with feedback on results, and took approximately one week until raters consistently achieved all correct answers on measures. During debriefing sessions, discrepancies between raters were discussed and consensus on appropriate data was reached. Decision rules were added to protocol handbooks, which trainers took to each outlet assessment to support precision in rating. In addition, different raters periodically assessed the same outlet throughout data collection for purposes of comparison and immediate feedback to limit drift from occurring in observations. Inter-rater reliability was assessed using intraclass correlation coefficients for the shelf-space measure, and ranged from an average ICC=0.858 for canned fruit to an average ICC=0.996 for fresh vegetables (mean ICC for all types of food assessed=0.940). The first author participated in all data collection, and weekly meetings further clarified questions or issues that arose during data collection.

2.3 Statistical Analyses

Two sets of MTMM matrices were constructed for each of the four buffer zone sizes (250m, 500m, 1000m, 1500m). The first set of MTMM matrices included all data (buffer zones where food outlets existed as well as those where no food outlets existed), to assess both convergent and discriminant validity of with respect to ranking food environments and also in assessing the presence and absence of food outlets within each buffer zone. The second set of MTMM matrices only included buffer zones where food outlets existed, to answer the question, “Of the buffer zones that contain food outlets, how well do measures agree in ranking ‘healthy’ food environments?” Databases for each buffer zone were created that included all method-construct variables (e.g., NEMS-S food availability; shelf-space food availability; RFEI food availability). Since not all methods were designed to assess all constructs, the resulting MTMM matrices differed from traditional individual-level MTMM matrices in that they were slightly unbalanced. Reliability coefficients differed for each tool employed. For the NEMS-S and food environment perceptions, internal consistency using Cronbach’s alpha was calculated. For shelf-space, inter-rater reliability was calculated. Although the RFEI was originally developed to assess food access, the current study included RFEI scores as a “food availability” variable because, as mentioned, food availability is thought to be the underlying mechanism by which food access affects diet-related outcomes. The RFEI measure did not lend itself to the calculation of reliability coefficients because it is a one-item measure (which makes assessing Cronbach’s alpha impossible), it is not a measure that changes over a short time (necessitating test-retest reliability) nor is it rated by more than one rater (necessitating inter-rater reliability). For all convergent and discriminant validity coefficients, Spearman rather than Pearson correlations were calculated because the metrics for each assessment tool were different. Correlations were calculated using SPSS Statistics 19.

Food availability as defined by the NEMS-S was recently classified as a "proxy gold-standard"(41), and has been shown to be related to diet quality (201) and weight status (153). To further assess the validity of the other food environment measures against the NEMS-S, sensitivity and specificity of all measures were calculated by dichotomizing the NEMS-S food availability score at the median and all others were discretized at the distributional deciles, consistent with previous research (41). A receiver operating characteristics (ROC) curve was plotted to show how the selection of different cut-off points for the measures affected calculated sensitivity and specificity. The ROC curve was created by estimating sensitivity and specific for the food environment measures using 10 threshold values based on distributional deciles. For the ROC curve, data were limited to those households that included at least one food outlet within 1000m. Data at 1000m were included to increase consistency between how respondents were asked to think about their neighbourhood when answering the questions (within 1-1.5km from their homes) and the objectively measured characteristics.

3. Results

Food environment assessments were carried out on 47 grocery stores, 51 specialty stores, 9 pharmacies (representing 22 unique locations), three warehouse clubs (representing 13 unique locations), and 169 convenience stores (representing 289 unique locations) in the three cities. Final buffer-zone databases were based on data from 421 food stores within the study area. Using the Public Health Inspection Database to identify food outlets, 11% of grocery stores and 10% of convenience stores were either not applicable to the NEMS-S or shelf-space measures (i.e., they sold no food or beverages or they only sold a limited number of canned goods that were not rated by either tool) or not at the address given. Four convenience stores and one grocery store were found through systematic direct observation method (40) and did not exist in the public health database. In total, assessments on 68% of stores that were at the location listed and open during business hours were carried out, with the highest refusal rate among convenience stores (almost 40% of convenience stores refused to allow raters complete assessments). A probability-based technique was used to randomly assign NEMS-S scores and shelf-space data from the observed stores to missing data from similar types of stores (n=131, 32% of stores), consistent with previous food environment research (202). Reasons for missing data include the food outlet being closed temporarily for renovations or that the owner or manager refused the raters access to their establishment.

MTMM matrices showed that each tool had generally good reliability, with the exception of the NEMS-S Affordability component (α=-0.173). Inter-item reliability for the NEMS-S food availability and food quality components were good and excellent (α=0.861 and α=0.925) respectively. Interrater reliability for the shelf-space method ranged from good (ICC of 0.858 for canned fruit) to excellent (ICC of 0.996 for fresh vegetables), with an average ICC of 0.940 (excellent) for the eleven items assessed. Inter-item reliability for subjective measures were acceptable to good (α=0.746 for food availability; 0.772 for food quality; 0.833 for food affordability).

In the first set of MTMM matrices using all data, relatively high convergent validity coefficients between objectively-measured characteristics (ranging from r=0.789 for shelf-space and RFEI to r=0.911 for NEMS-S and shelf-space within 250m,m for example) indicated that measures performed well. Table 3-2 shows trends in convergent validity coefficients by buffer zone size. In general, convergent validity among objective measures decreased with increasing geographic size (e.g., r=0.911 for shelf-space and NEMS-S at 250m to r=0.174 at 1500m; r=0.851 for NEMS-S and RFEI at 250m to ρ=0.069 at 1500m), whereas convergent validity among perceived measures increased or remained stable with increasing geographic size (e.g., r=-0.010 for NEMS-S and perceived food availability at 250m to r=0.213 at 1000m). In the second set of matrices (presented in tables 3 to 6), convergent validity coefficients were lower, indicating that measures do not as successfully rank food environments in the same order (e.g., r=0.911 for NEMS-S and shelf-space at 250m for the first set vs. r=0.459 for the second set).

For both sets of MTMM matrices, high discriminant validity coefficients existed between the constructs of food availability and food quality for both objective (NEMS-S) (r=0.785 at 250m for the first set (data not shown); r=0.577 at 250m for the second set) and perceived measures (r=0.830). Conversely, low discriminant validity coefficients existed between food affordability and the other constructs (e.g., at

250m, r=-0.323 for food affordability and NEMS-S availability; r=-0.015 for food affordability and shelf-space). In addition, convergent validity coefficients were generally very low between objective and perceived measures in both sets of matrices (e.g., at 250m in the second set, r=-0.010 for perceived and NEMS-S food availability; r=0.014 for perceived availability and shelf-space).

The ROC curve in Figure 1 shows sensitivity and specificity using various cut-offs for shelf-space, RFEI and perceived availability using NEMS-S availability of all stores within 1000m as the standard. The area under the curve represents the probability that a higher score in shelf-space, RFEI or perceived availability for a randomly chosen high NEMS-S availability score will exceed the result for a randomly chosen negative case. The area under the curve was highest for shelf-space (0.666, p<0.001), 0.580 (p<0.001) for perceived availability, and lowest for the RFEI (0.523, p=0.093), indicating that shelf-space is the most accurate predictor of "good food availability" as characterized by the NEMS-S, despite it being "fair" by conventional interpretations.

4. Implications

This study focused on the *operational definition* component of construct validation using a traditional psychometric procedure to assess the convergent and discriminant validity of four food environment measures assessing three different food environment constructs: food availability, food quality, and food affordability.

Internally, each measure appeared to be reliable, consistent with previous reports of reliability for NEMS-S(37) (other than the items measuring affordability), shelf-space (122), and residents' perceptions (160, 196). Despite the generally good reliability, the second set of matrices (which only included data from environments where food outlets existed) showed low convergent validity coefficients at all geographic scales for the multi-method assessment of the food availability construct. These results suggest a method effect, i.e., what is actually being measured by these instruments differs substantially by method. In terms of the multi-method assessment of food availability using RFEI and NEMS-S, low convergent validity coefficients may not be surprising, considering that the RFEI takes fast food outlets into account in addition to food stores, while the NEMS-S is only relevant for food stores. Similarly, the relatively low convergent validity between shelf-space and NEMS-S may be due to the fact that the shelf-space measure did not take into account all of the "nutritious foods" assessed by the NEMS-S (e.g., while the shelf-space measure assessed fruits and vegetables, the NEMS-S collects data on low fat and whole grain products in addition to fruits and vegetables). Because each instrument reflects different underlying assumptions about "healthy" vs. "unhealthy" foods, these tools assess different food items. Interestingly, every method used in the current study has shown some correlation with weight status (14, 15, 140, 153) or diet quality (41, 160, 201), albeit in different populations, and despite the relatively low convergent validity between the different methods assessing the same construct. This is interesting because the low convergent validity among the tools employed might indicate different pathways through which the actual constructs measured are associated with weight status or diet quality. The different measures may be tapping into constructs that exhibit different (and even contradictory) effects on outcomes, or may tap into different mechanisms by which outcomes occur.

In general, findings from the current study contradict the argument that benefits of environmental assessments may include less bias from self-reports and increased sensitivity to early program effects (54). Findings indicate that environmental assessment method selection may indeed influence how food environments are ranked or categorized.

Unexpectedly high discriminant validity coefficients between food availability and food quality both for objective measures (NEMS-S) and perceived measures indicate that food availability and food quality may not be separate and distinct constructs, at least in this study setting. Therefore, food environment methods assessing both food availability and food quality may be redundant. Practically speaking, including quality measures may not contribute meaningfully to food environment assessments because of its high correlation with food availability measures. The high correlation is not necessarily surprising, given that it is the quality of *available* foods that is assessed. Several studies have found food quality to vary by area-level socioeconomic status, with more disadvantaged areas selling foods of lower quality (37, 116, 203). For lower correlations to exist, foods must be present but not of high quality. In urban areas in the Region of Waterloo, food deserts have been identified (204), but these areas are lacking in food retail outlets altogether, which would also increase the correlation between food availability and quality (204). In other contexts, where low-income and/or minority residents are concentrated and poor food quality has been identified as a barrier to healthy eating (158), assessing food quality may be an important feature of overall food environment assessment. Methodologically speaking, including variables that are not as highly correlated (e.g., food availability and food quality in areas where available foods are of lower quality) would also more meaningfully contribute to predictive models.

On the other hand, the low discriminant validity coefficients between food affordability and other measures would argue for the inclusion of food affordability measures in food environment research, since the low discriminant validity coefficients indicate that current affordability measures assess a different construct than availability or quality. That said, although inter-item reliability was adequate for perceived affordability, inter-item reliability for NEMS-S affordability was surprisingly low and negative. The NEMS-S tool scores outlets based on relative, rather than absolute, affordability. Specifically, points are given if the “healthier option” is cheaper than the regular option (e.g., low-fat milk compared to higher-fat milk; whole-wheat bread compared to white bread; low-sugar cereals compared to higher-sugar cereals). A low inter-item reliability reflected the fact that there was no consistency within outlets in terms of whether the healthier items cost less or more than the regular items. Indeed, the NEMS-S creators note that in their sample, price scores were low in general, and differed significantly by store type and area-level income, but not in the hypothesized direction (convenience stores and low-income areas had lower prices for some healthy foods than grocery stores and higher-income areas) (37). Findings suggest that improving food affordability measures may be an important direction for future research. One potential avenue of exploration is healthy food baskets, which have been identified as a meaningful way to capture food affordability (205, 206). The National Nutritious Food Basket (NNFB) in Canada, for example, describes the cost of approximately 60 foods that represent a nutritious diet for individuals based on age and gender; a Revised Northern Food Basket has also been created for Aboriginal communities and includes culturally acceptable foods (207). Municipal and provincial governments use the NNFB to monitor the cost of a nutritious diet in their jurisdiction (206). Further, describing the cost of the NNFB as a proportion of welfare payments engages the NNFB as a useful advocacy tool for groups concerned with food insecurity in their communities (208).

The second objective of the current study was to examine how geographic scale influences validity coefficients. In general, convergent validity between objective measures decreases with increasing geographic scale. If two variables are roughly bivariate normal and positively associated because they measure the same construct, the most typical pattern would be a decrease in correlations as buffer zone size increases, because with larger buffer zones, observations increasingly violate independent assumptions. In other words, the smaller the buffer zone, the closer the observations are to being independent, since there is less overlap between buffer zones.

In both sets of matrices, correlations between perceived measures and objective measures seemed to increase with increasing geographic scale. This finding may reflect the wording of the question participants were asked. Specifically, participants were instructed to "Please think of your neighbourhood as only the area within about a 10-15 minute walk (1 to 1.5 kilometres) from your home" in assessing their food environments. The current study supports previous food environment studies suggesting that residents' perceptions are not strongly related to objective assessments of environments (17, 189); however, within this finding there is some evidence that residents may be able to conceptualize a 1 km buffer zone around their homes, since correlations between objective and subjective measures were generally highest at the 1km buffer zone level (reflecting the question's wording).

Regarding the ROC analyses, the statistically significant area under the curve for both shelf-space and perceptions indicate that these two measures predict "good food availability" derived from the NEMS-S significantly better than chance. The area under the curve is a useful one-statistic summary of the accuracy of the test as a predictor of the gold-standard test, which is especially helpful given the three different methods that were compared to the NEMS-S. Previous research using a ROC curve for perceived availability vs. directly measured availability (also using NEMS-S) reported the area under the curve for perceived availability was 0.658 (41), slightly higher than the current study, which found the area under the curve to for perceived availability to be 0.580.

The current study contributes to the field of environmental assessment methodology through the novel application of a traditional psychometric tool. Assessing measurement properties of environmental characteristics is much less developed than the field of psychometrics (92, 196). Previous work to translate psychometric theory to environmental constructs has been criticized for being limited to consideration of levels of potential error for longitudinal observations or for relying on ecometrics, which may not be a valid indicator of objective environmental characteristics (92). Lytle described the challenges in translating psychometric principles to environmental measures. In her example of how construct validity might be assessed in food environment research, Lytle seems to favour syntactic definitions over operational definitions in defining construct validity as "the extent to which the measure 'behaves' in a way consistent with theoretical hypotheses" (92) (p. S136). In focussing on *operationally* defining food environment assessment methods, the current paper aims to set the stage for future work on *syntactically* defining constructs by first describing convergent and divergent validity of different method-construct combinations. A *syntactic* definition would consider how constructs are related to one another within a theoretical system (27), and would require outcomes and other theoretically-involved variables of interest to be analysed. Future research should consider how different conceptual models are upheld using theoretically justified variables of interest by assessing whether and how outcomes are predicted by different food environment variables after controlling for pertinent covariates.

Several limitations of the current study exist. First, using buffer zones around households as the geographic unit meant that independence assumptions were most likely violated. The novel application of an MTMM matrix to environmental constructs, however, is a strength of the study. Second, the study could have been strengthened by including an absolute measure of food affordability, such as a nutritious food basket. The low convergent validity for affordability between the NEMS-S and residents perceptions may have been due to the low reliability of the NEMS-S affordability measure. The NEMS-S has been applied in many settings (e.g., seven studies published in 2011 used the NEMS-S or an adapted NEMS-S to characterize food environments) (153, 184, 209-213), and therefore it is important that the current study informs future use of the tool. Third, the study was conducted in three cities where, although food deserts have been identified, overall food access is very high (204). If the current study was conducted in a context where the quality of food environments was more variable, results may have been different. Fourth, the use of Euclidean distance rather than network distance buffer zones may be a limitation, however when respondents report on food environment features within 1 to 1.5km of their homes, it is unlikely that they reflect on precise network distances.

Future research should carefully consider which food environment assessment methods and geographic scales are most appropriate. Although there is some evidence that commonly-used assessment methods adequately distinguish between the presence and absence of food outlets, they do not agree as much in how food environments should be ranked. Finally, returning to the relevance of the current study for policy makers interested in policies aimed at improving food environments, findings do not support the notion that all food environment assessment methods measure the same constructs. In the context of restricted resources and competing priorities in local public health departments, if measures were highly correlated, a recommendation could be made to use the least expensive method, since all measures assess the same construct. Based on these findings, however, we cannot recommend that less resource-intensive methods (e.g., the RFEI) should be used over more resource-intensive methods (e.g., the NEMS-S), since the measures seem to be assessing different constructs. Future work examining *syntactic* definitions (and specifically examining how well different measures predict diet-related health outcomes) will help to elucidate the question of whether simpler, less expensive measures predict outcomes as well as (or better than) more comprehensive measures.

Table 3-1: Description of food environment measures

Instrument	Outlet type assessed	Constructs Addressed	Methodology	Psychometric tests conducted previously
Shelf-space measures(122)	Stores	Availability	Cumulative linear shelf space of fruits and vegetables (fresh, frozen and canned varieties).	Inter-rater reliability; face and construct validity
NEMS-S Checklist(37)	Stores	Availability Affordability Quality	Objective audits of food stores	Inter-rater and test-retest reliability; face and construct validity
Retail Food Environment Index (RFEI)(15)	Stores and restaurants	Availability	Geographic analysis of ratio of number of fast-food outlets and convenience stores to grocery and specialty stores	None
Neighbourhood food environment perceptions(160, 196)	Stores and restaurants	Availability Affordability Quality	Agreement with the following statements on a 4-point Likert scale assessed residents' perceptions of their food environment. Three statements assessed food availability: "There is a large selection of fresh fruits and vegetables available in my neighbourhood"; "There is a large selection of low-fat products available in my neighbourhood"; "It is easy to eat healthily at the restaurants in my neighbourhood." Three statements assessed food affordability: "I shop elsewhere because the prices in my neighbourhood are too high"; "The produce in my neighbourhood is more expensive than that in other neighbourhoods"; "The low-fat products in my neighbourhood are more expensive than those in other areas." Two statements assessed food quality: "The fresh produce in my neighbourhood is of high quality"; "The low-fat products in my neighbourhood are of high quality."	Inter-item and test-retest reliability

Table 3-2: Convergent validity trends using all data

Method-trait variables	Correlation at 250m buffer	Correlation at 500m buffer	Correlation at 1000m buffer	Correlation at 1500m buffer
Food Availability				
NEMS-S & Shelf-space	0.911	0.849	0.455	0.174
NEMS-S & RFEI	0.851	0.724	0.213	0.069
NEMS-S & Perceptions	-0.010	0.036	0.213	0.069
Shelf-space & RFEI	0.789	0.798	0.343	-0.019
Shelf-space & Perceptions	0.014	0.081	0.262	0.238
RFEI & Perceptions	0.005	0.020	0.035	0.007
Food Quality				
NEMS-S & Perceptions	-0.045	-0.032	0.035	0.030
Food Affordability				
NEMS-S & Perceptions	0.022	0.013	0.029	0.036

Table 3-3: MTMM Matrix at 250m

	NEMS			Shelf Space	RFEI	Perceptions		
	A	B	C	A	A	A	B	C
1. NEMS-S								
A. Food availability	*0.861*							
B. Food quality	0.577	*0.925*						
C. Food affordability	-0.323	-0.054	*-0.173*					
2. Shelf-Space								
A. Food availability	**0.459**	0.406	-0.015	*0.858 to 0.996*				
3. RFEI								
A. Food availability	**0.089**	0.120	-0.132	**0.240**				
4. NFE Perceptions								
A. Food availability	**-0.010**	-0.041	0.029	**0.014**	**0.005**	*0.746*		
B. Food quality	-0.027	**-0.045**	0.033	-0.006	-0.022	0.830	*0.772*	
C. Food affordability	0.042	0.032	**0.022**	0.034	0.042	-0.171	-0.110	*0.833*

Reliability coefficients
Convergent validity coefficients
Discriminant validity coefficients

Table 3-4: MTMM matrix at 500m

	NEMS			Shelf Space	RFEI	Perceptions		
	A	B	C	A	A	A	B	C
1. NEMS								
A. Food availability	*0.861*							
B. Food quality	0.499	*0.925*						
C. Food affordability	-0.229	-0.105	*-0.173*					
2. Shelf-Space								
A. Food availability	**0.467**	0.290	-0.073	*0.858 to 0.996*				
3. RFEI								
A. Food availability	**0.061**	0.121	-0.078	**0.401**				
4. NFE Perceptions								
A. Food availability	**0.036**	-0.007	0.041	**0.081**	**0.020**	*0.746*		
B. Food quality	0.006	**-0.032**	0.037	0.041	-0.007	0.830	*0.883*	
C. Food affordability	0.046	0.053	**0.013**	0.032	0.094	-0.171	-0.110	*0.772*

Reliability coefficients
Convergent validity coefficients
Discriminant validity coefficients

Table 3-5: MTMM matrix at 1000m

	NEMS			Shelf Space	RFEI	Perceptions		
	A	B	C	A	A	A	B	C
1. NEMS								
A. Food availability	*0.861*							
B. Food quality	0.427	*0.925*						
C. Food affordability	-0.265	-0.234	*-0.173*					
2. Shelf-Space								
A. Food availability	**0.310**	-0.008	0.015	*0.858 to 0.996*				
3. RFEI								
A. Food availability	**0.028**	-0.084	-0.247	**0.192**				
4. NFE Perceptions								
A. Food availability	**0.169**	0.035	-0.031	**0.262**	**0.035**	*0.746*		
B. Food quality	0.166	**0.035**	-0.067	0.210	0.034	0.830	*0.833*	
C. Food affordability	-0.014	-0.110	**0.029**	-0.001	0.055	-0.171	-0.110	*0.772*

Reliability coefficients
Convergent validity coefficients
Discriminant validity coefficients

Table 3-6: MTMM matrix at 1500m

	NEMS			Shelf Space	RFEI	Perceptions		
	A	B	C	A	A	A	B	C
1. NEMS								
A. Food availability	*0.861*							
B. Food quality	0.548	*0.925*						
C. Food affordability	-0.234	-0.208	*-0.173*					
2. Shelf-Space								
A. Food availability	**0.143**	-0.018	0.070	*0.858 to 0.996*				
3. RFEI								
A. Food availability	**0.031**	-0.115	-0.291	**-0.051**				
4. NFE Perceptions								
A. Food availability	**0.127**	-0.009	-0.013	**0.238**	**-0.007**	*0.746*		
B. Food quality	0.167	**0.030**	-0.059	0.214	-0.004	0.830	*0.833*	
C. Food affordability	0.011	0.000	**0.036**	0.015	0.047	-0.171	-0.110	*0.772*

Reliability coefficients
Convergent validity coefficients
Discriminant validity coefficients

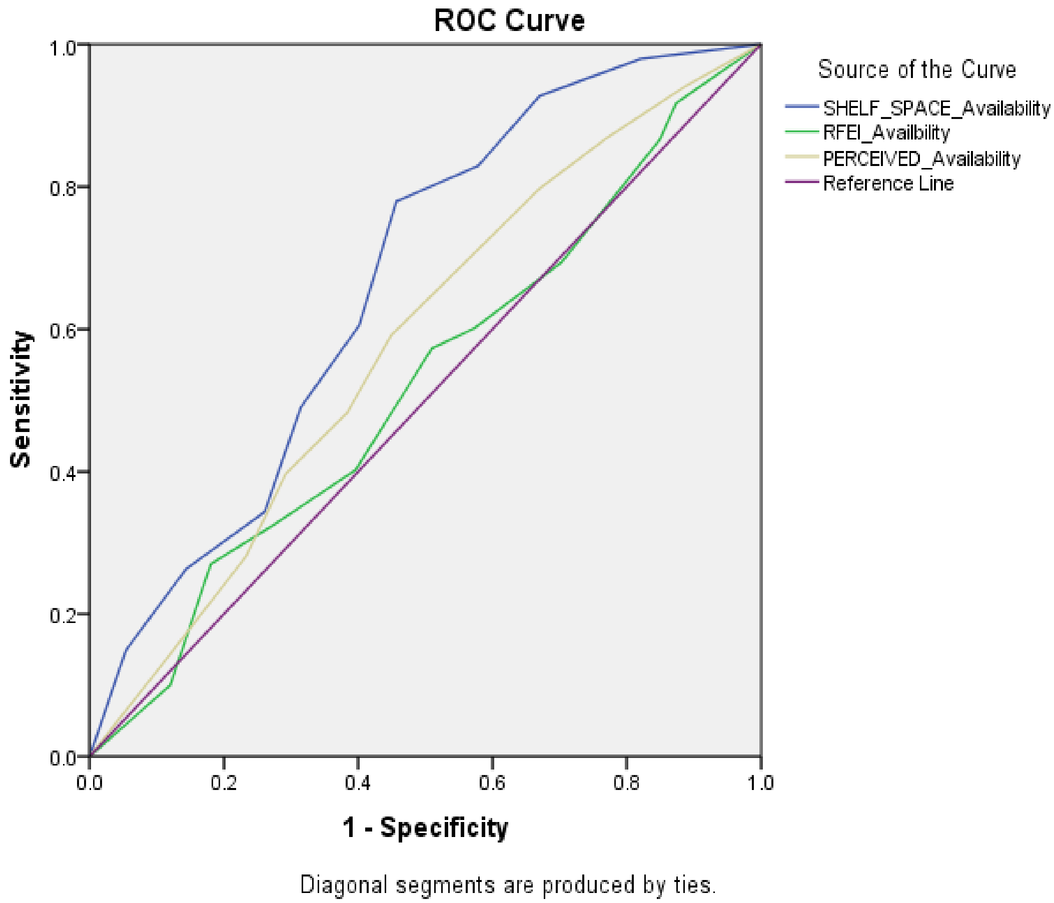

Figure 3-1. Receiver operating curve for food environment measures versus directly measured availability, Kitchener, Cambridge and Waterloo, Ontario, 2010. Directly measured availability (NEMS-S Availability) was dichotomized at the median; curves reflect data discretized at the distributional deciles. Data assessed at the 1000m buffer are displayed here.

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Chapter 4. Neighbourhood food environments: objective features predict perceptions and diet-related health outcomes

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1. Introduction

Healthy diets are essential for maintaining health and preventing chronic diseases (214, 215). The importance of environmental determinants of dietary outcomes is increasingly recognized (216), and an environmental perspective on dietary behaviours has been advocated (69, 217). The topic of food environments, in particular, is gaining traction with researchers and policymakers. Policymakers – often with little empirical evidence – have begun to take action on food environments through zoning regulations and land-use planning in communities (19, 20, 218). Expanding the empirical basis for such policies could facilitate the implementation and evaluation of policies for dissemination to other jurisdictions. However, food environment assessment research is rife with inconsistencies in terms of assessment methodology and operationalizing relevant geographic area, contributing to inconsistent associations found between food environments and outcomes (92, 219). This is problematic because the impact of policies attempting to modify food environments cannot be rigorously evaluated without using valid and reliable food environment assessment measures.

Lack of standard assessment tools has resulted in an inability to compare findings across places and populations, which is a significant limitation in the literature to date (219). Public health practitioners and organizations are increasingly interested in obtaining reliable and valid measures of important food environment constructs in the context of budgetary constraints (115). One important issue that has not been adequately addressed to date is the relative predictive power of residents' perceptions of the food environment vs. objective measures of the food environment, although several studies have attempted to compare residents' perceptions with at least one objective measure (18, 41, 43, 184, 220). This issue is particularly important for policymakers interested in facilitating "healthy food environments" – contexts in which healthy diets are supported. The relative predictive strength of perceived vs. objective food environment measures with respect to diet-related outcomes has different implications for policy. If perceptions about food environments are more predictive, more effective policies might focus on increasing residents' awareness of nutritious, affordable foods in their neighbourhoods. Conversely, if objective food environment variables are more predictive, effective policies might aim to increase objective access to nutritious, affordable foods (e.g., through strategies aimed at improving nutritious food affordability in corner stores).

In addition to policy implications, comparing perceptions and objective measures also has theoretical consequences. While objective measures may describe the availability of specific foods within a defined area or residents' proximity to different types of food outlets, perception-based measures "may have the unique advantage of being able to tap into residents' intentions to utilize nearby food outlets" (219)(p. 1185). Moreover, a better understanding of the relationship between perceptions and objective measures and the relative predictive power of perceptions vs. objective measures will support empirical refinement of theoretical models (and interventions or policies developed from these models) (166).

Constructs of the food environment have been categorized as fitting within the community nutrition environment, which relates to food *access* (i.e., proximity to, density of, or diversity of designated food outlet types within a defined geographic area), and the consumer nutrition environment, which incorporates food *availability*, food *affordability*, food *quality* (1, 117). Food *availability*, the presence or amount of healthy foods available for purchase within a specified geographic area, is often hypothesized to be the underlying mechanism by which food *access* affects health outcomes, since food outlet types have been found to differ in terms of food *availability* (37). Neighbourhood food *affordability* can be defined as the relative or absolute cost of nutritious foods in a specified geographic area, and food *quality* is considered the quality of available foods, including considerations of withered or bruised fresh produce or expired foods, which act as a deterrent of food purchasing (158). Each of these constructs may be influenced by different levels of government and other sectors. For example, municipal governments can take action on food *access* through land use planning (19), federal or state governments can affect food *affordability* and *availability* by subsidizing nutritious foods in remote communities (221) or through implementing guidelines to provide nutritious foods in a range of settings.

Studying associations between perceptions and objective measures, which will advance a theoretical understanding of food environments, has resulted in mixed findings. Residents' perceptions of food environment constructs are usually hypothesized to be positively associated with objective measures of the same constructs. Associations between objective and perceived characteristics are generally inconsistent, or low and positive some studies (16, 18, 41, 220, 222, 223), and nonexistent in others (184). Few studies have examined how different objective measures might predict perceptions in the same study population. In one study, satisfaction with local fruit and vegetable availability was lower in neighbourhoods further from a supermarket, but was not associated with objective observations of neighbourhood fruit and vegetable variety, prices, or quality (17). In another study, supermarket density positively predicted respondents' ratings of selection and availability of nutritious foods; other food *access* measures (store variety, small store density) inconsistently predicted residents' perceptions (18). For a more complete theoretical understanding of food environments, more research building on previous correlational research is needed to clarify which of the many existing objective measures best predict residents' perceptions.

Studies on the relative predictive power of objective measures vs. perceptions for diet-related outcomes, which has policy implications as described above, also show inconsistent findings. For example, perceived (but not objective) food *availability* and *affordability* were predictive of food purchasing in Australia (43). Both perceived and objective food environment measures predicted diet quality (18) and fruit and vegetable intake (224) in the United States. Another study from the United States found objective measures (but not perceptions) predicted diet and weight among low-income women (184). Intuitively, perceptions might be expected to better predict outcomes, given that people's patronage of food outlets might be more reflected by their perceptions than by objective measures (43).

Three main limitations of the extant research relate to the use of non-generalizable samples, geographic scale concerns, and measurement issues. First, much research has relied on samples for which results are not generalizable: low income individuals (17, 184, 223); only women (16, 42, 184); only adolescents (225, 226), or; convenience samples (224)). Second, not all studies have used geographically congruent scales for perceived and objective variables (e.g., objective food environment measures have been implemented at one scale and resident surveys at another scale (16)). Third, no studies to our knowledge have used more than one objective measure to operationalize each food environment construct, although a few studies have made use of more than one kind of objective measure (41, 160, 184). In terms of outcome measures, only one study to our knowledge used a comprehensive indicator of dietary quality as an outcome (160); other research has been limited to examinations of specific dietary behaviours (e.g., fruit and vegetable intake (184, 224, 225)) or specific food purchasing behaviours (43, 226).

To overcome these gaps, the current study examines the extent to which different objective food environment measures predict perceptions, and also explores whether a variety of objective and perceived food environment assessment methods predict diet-related outcomes in a population-based sample. The objectives of the current study were to:

1. describe the diet quality, body mass index (BMI), waist circumference (WC), and food environments in a population-based sample;
2. determine the extent to which a variety of objective food environment measures predict residents' food environment perceptions, and;
3. determine the relative ability of objective and perceived food environment measures to predict diet quality, BMI or WC.

We hypothesized that (a) objective food environment characteristics will predict perceptions, and (b) food environment characteristics, particularly perceptions of food environments, will predict diet quality, BMI, and WC, even after adjusting for the confounding effects of individual and household-level factors associated with these outcomes.

2. Methods

This study was conducted in conjunction with the NEWPATH (Neighbourhood Environments in Waterloo Region: Patterns of Transportation and Health) project (see (30)). NEWPATH's objective was to characterize associations between objective and subjective aspects of built environments including walkability, physical activity, dietary behaviours, and health outcomes in an urban, population-based sample. NEWPATH data collection occurred between May 2009 and May 2010. Data from a complementary project aimed at characterizing food environments in the same three cities from which NEWPATH participants were recruited (Kitchener, Cambridge, and Waterloo, Ontario), were collected between May and August, 2010 (220). The

NEWPATH study received ethics clearance from the University of Waterloo Office of Research Ethics and the Behavioural Research Ethics Board at the University of British Columbia. Ethics clearance was not necessary for the second study, as no data were collected from human participants.

2.1 Participants

One of NEWPATH's aims was to examine features of the built environment in relation to health outcomes; therefore, the sample was stratified by neighbourhood walkability, household income and household size, with allocation to achieve high statistical power to detect hypothesized effects of walkability (30). This stratified random sample (N=4902 individuals in 2228 households) was recruited to achieve representativeness in income and household size according to 2006 Canadian census data. Conditional response rates (proportion of household that completed the survey once recruited) varied between 56% and 64% over the six phases of data collection (30). Households were recruited in day-pairs across all days of the week. Everyone in the household over the age of 10 years participated in the study, although inferential analyses presented here were restricted to participants 19 years of age and older, since children and youth may interact differently with the built environment than adults (12), and the number of children and youth in the dataset was insufficient to support age-specific analyses. Moreover, children and youth did not provide data on education level, which was considered a covariate in all regression analyses (discussed below).

The NEWPATH study contains nested data: individuals within households. Individual-level data were considered level-1; household data were considered level-2. Participating households were recruited to complete either a "simple" or "complex" survey package. The "simple" version included a telephone recruitment survey (which included household- and individual-level demographic information) and a paper questionnaire that included food environment perceptions (considered a household-level variable, since the self-identified main food shopper in the household completed that survey instrument). All participants self-reported their weight, height, and waist circumference, according to standard protocol (32). Participants from households who completed a "complex" survey package additionally completed food records over the two days of the survey.

For descriptive analyses, the sample included 4734 individuals within 2223 households (3382 individuals in 1533 households completed the “simple” survey package; 1352 individuals within 690 households completed the “complex” survey package) who had complete data on all variables of interest. For the inferential analyses, the sample (excluding those aged 18 and under) comprised 4102 individuals within 2223 households (2932 individuals in 1533 households completed the “simple” survey package; 1170 individuals within 690 households completed the “complex” survey package) who had complete data on all variables of interest.

2.2 Measures

2.2.1 Outcome variables

Perceptions

To examine whether objective measures predicted perceptions (objective two), perceptions were considered outcome variables. Table 4-1 lists the questions used to create four perceptual scores related to *access*, *availability*, *affordability*, and *quality*. Each question was assigned a score out of four (ranging from 1=strongly disagree to 4=strongly agree); therefore, *access* was scored out of 16; *availability* was scored out of 12; *affordability* was scored out of 12; *quality* was scored out of 8. High correlations between *access*, *availability* and *quality* scores (Cronbach’s alpha based on standardized items for the three scores was 0.904) justified the creation of an “access-related” perceptual variable, with *access*, *availability*, and *quality* scores being summed and standardized. Perceptions of food *affordability* were not correlated with the other three measures, and therefore the affordability score was standardized on its own. The two perceptual variables were treated as continuous variables. In both cases, higher scores represent increased agreement with statements related to improved neighbourhood food *access*, *availability*, *quality*, or *affordability*.

Obesity: body mass index and waist circumference

To examine the relative predictive power of objective vs. perceived food environment measures on individual-level outcomes (objective three), outcome measures from all study participants included BMI, which was calculated based on self-reported weight and height (kg/m^2), and the mean self-reported WC from two measurements. Self-reported WC has been found to be a satisfactorily accurate proxy for measured WC (32).

Diet Quality

Two-day food record data from all participants completing the “complex” survey were used to calculate Healthy Eating Index adapted for Canada (HEI-C) scores (31). The HEI-C is a comprehensive diet quality indicator based on dietary adequacy (including the number of servings of vegetables and fruits, whole grains, number of grams of saturated fats) and moderation (including the proportion of energy intake from saturated fats and sodium intake). The HEI-C reflects Canadian food intake recommendations based on participants’ age and sex, and ranges from 0 to 100; higher scores represent better diet quality (31). Mean HEI-C scores over the two days was considered a continuous variable to capture even small variations in diet quality, which might not have been captured using a more crude categorical outcome of diet quality.

2.2.2 Exposure variables

Objective food environment assessment procedures

Names and addresses of all food outlets in the three cities were obtained from the public health inspection database maintained by the Public Health Department. North American Industry Classification System (NAICS) codes were used to categorize outlet types listed in the database (227). When NAICS codes were not obvious from outlets’ names, web searches or site visits confirmed the appropriate NAICS code. One of each chain restaurant (e.g., McDonald’s, Burger King), convenience store (e.g., 7-11), pharmacy (e.g., Shopper’s Drug Mart), and warehouse club or superstore (e.g., Walmart) were randomly selected from the database to be assessed. Because chains strive to maintain consistency in menus, available products, and promotions, the decision to assess one of each chain was deemed justifiable. Every grocery store and specialty store and each independently owned restaurant, convenience store, and pharmacy were assessed. The amounts and types of foods in grocery stores seemed to vary by the size of grocery store (L. Minaker, unpublished observation), thus, every grocery store was assessed. Stores were assessed using the Nutrition Environment Measures Survey-Stores (NEMS-S)(37), and linear shelf-space measures of specific “healthy” and “unhealthy” items (see Table 4-1) (14, 39). In restaurants, the Nutrition Environment Measures Survey – Restaurants (NEMS-R) (38) was completed. Of note, in addition to assessing *availability* and *affordability*, the NEMS-R also purportedly assesses barriers and facilitators to healthy eating. This measure, although included in analyses, was not the main focus of the current study and is therefore not further discussed below.

Six observers with at least two years of university education each collected food environment data. The first author trained raters to use the NEMS-S (199) and shelf-space measures (14, 122). Training included classroom sessions and field work in food outlets, with feedback on results, and took approximately one week until raters consistently achieved all correct answers on measures. During debriefing sessions, discrepancies were discussed and consensus on appropriate data was reached. Decision rules were added to protocol handbooks, which trainers took to each outlet assessment to support precision in rating. Additionally, different raters periodically assessed the same outlet throughout data collection for purposes of comparison and immediate feedback to limit drift from occurring in observations. The first author participated in all data collection. Inter-rater reliability was assessed using intraclass correlation coefficients for the shelf-space measure, and ranged from a mean ICC=0.858 for canned fruit to mean ICC=0.996 for fresh vegetables (mean ICC for all specific items assessed =0.940).

In total, 611 restaurants were assessed (full-service restaurants, limited-service eating places, and drinking places: NAICS codes 7221, 7222, and 72241 respectively). NEMS-R scores from the randomly-selected chain restaurants were imputed into the same 301 additional chain restaurants listed in the Public Health Inspection database, resulting in data from 912 unique restaurant locations being compiled. Forty-seven supermarkets and grocery stores were assessed (NAICS code 44511); 47 specialty stores were assessed (NAICS codes 445210 – 445299); 169 convenience stores (including those attached to gas bars) were assessed (NAICS code 44512); 9 pharmacies were assessed (NAICS code 446110), and; 3 warehouse clubs open to the general public without a membership were assessed (NAICS code 45291). Table 4-2 shows details related to the food environment assessments. Approximately 11% of grocery stores and 10% of convenience stores identified in the Public Health Inspection Database were either not applicable to the NEMS-S or shelf-space measures or were not at the address given. Four convenience stores and one grocery store were found through direct observation (40), and were not listed in the public health database. In total, assessments on 94% of outlets that were at the location listed, open during business hours, and applicable to the food environment assessment methods were carried out, with the highest refusal rate among convenience stores . Reasons for missing data include the food outlet being closed for renovations or that the owner or manager refused the raters access to their establishment. A probability-based was used to randomly assign NEMS-S scores and shelf-space data from the observed stores to missing data from similar types of stores (n=131, 31% of stores; 10% of the total number of outlets); this procedure has been used in previous food environment research (14). Final buffer zone databases were based on data from 421 food stores and 912 restaurants within the study area. Buffer zone creation is described below.

Geographic Scale Operationalization

ArcGIS 9.1 software was used to establish Euclidean distance buffer zones around respondents' home addresses at 250m and 1000m. Initial findings revealed food environment measures exhibited the best construct validity at 250m buffers; however, variables within 1000m buffer zones were also calculated, since these most closely corresponded to the wording of the food environment perceptions questions (i.e., "Please think of your neighbourhood as only the area within about a 10-15 minute walk (1 to 1.5 km) from your home").

Food environment measures

Table 4-1 lists all food environment assessment methods.

Perceptual food environment variables

As described above, two perceptual food environment variables were created; one reflects residents' perceptions of *access*, *availability*, *quality,* the other reflects residents' perceptions of affordability. In the first set of analyses (Objective 2), these variables were treated as outcome variables; in the second set of analyses (Objective 3), they were treated as independent variables.

Objective food environment variables

Food Access

Seven objective *access* measures were included. Two intensity measures (the number of stores within each buffer zone and the number of restaurants within each buffer zone) (153, 228, 229), three proximity measures (distance to the nearest grocery store, nearest convenience store and nearest fast food outlet) (153, 230), a diversity measure (number of diverse food outlet types) (153, 229), and the Retail Food Environment Index (RFEI) (15) assessed *access*.

Food Availability

Three objective *availability* measures were included. A shelf-space measure assessed linear shelf-space of fruits and vegetables (fresh, frozen, and canned varieties) and energy dense snack foods (salty snack foods, cookies and crackers, donuts and pastries, candy, and carbonated beverages) in stores, and has been associated with weight status (14). The NEMS-S (37) has been associated with residents' weight status (153), availability perceptions (41) and dietary patterns (201), and has been considered a "gold standard" food environment measure (41). For the current study, a Canadian adaptation was used to reflect Canadian consumption patterns and food intake recommendations (200). The NEMS-R (38) has also been associated with residents' weight status (153). Mean NEMS-S and NEMS-R availability scores from all outlets within each buffer zone were calculated. Cumulative linear shelf-space of fruits and vegetables and of energy dense snack foods was calculated in metres for each buffer zone.

Food affordability

Three measures assessed *affordability*: two were derived from the NEMS-S measure and one was derived from the NEMS-R measure. The traditional NEMS-S *affordability* score assesses relative *affordability* of healthier versions of standard foods by assigning points to the lower-fat, whole-grain, or lower-sugar option of two comparable foods (37). Poor inter-item reliability results for the NEMS-S affordability scores (α=-0.173) in this sample (220) led to the development of an absolute price score. Price data collected using the NEMS-S (e.g., the actual prices of specific foods in standardized amounts) were used to create a Healthy Food Basket price for each store. Both imperial and metric measures were used in the creation of the Healthy Food Basket because in Ontario, some foods are most commonly measured in lbs (e.g., fresh fruits), while other foods are measured in grams (e.g., loaves of bread) or litres (e.g., milk). Because the NEMS-S collects price data on a limited number of food options and not all options are nutritious, foods that overlapped between the NEMS-S and the National Nutritious Food Basket (231) were summed to create a Healthy Food Basket price. Appendix A lists the foods and amounts included in the Healthy Food Basket. Inter-item reliability statistics between basket components (relevant items were summed to create the following categories: vegetables and fruit; low-fat products, and; grain products) indicated that they had significantly higher internal consistency (α=0.589) than did the original NEMS-S *affordability* score. Grocery stores in the three cities selling all items (n=38) were included in the mean Healthy Food Basket price in each buffer zone. The traditional mean NEMS-S *affordability* scores and the mean NEMS-R *affordability* score were calculated across stores and restaurants, respectively, for each buffer zone.

Food Quality

The NEMS-S assessed the *quality* of fresh fruits and vegetables according to a standard protocol (37); mean NEMS-S *quality* score for all stores within each buffer zone was calculated.

2.2.3 Covariates

Socioeconomic position (SEP) is associated with both residents' perceptions and with food environment characteristics (16, 17, 41-43). For the present study, level-2 covariates included household income and car ownership; level-1 covariates included education and age. Household income was categorized into low (<$35,000 per year), medium ($35,000 to $85,000 per year), and high (>$85,000 per year) based on the sample stratification. Car ownership (yes/no) was included as a covariate since it is associated with food environments and with residents' BMI (93). Adult education level was classified as low (high school completion or lower), medium (at least some post-secondary), and high (at least an undergraduate degree). Age was also included as a covariate.

2.3 Statistical Analyses

Before proceeding with the analyses, clustering of BMI and diet quality scores within administratively-bound neighbourhoods (the forward sortation area (FSA)), was examined. The degree of dependence was measured by calculating the intraclass correlation coefficient (ICC) between FSA and BMI (small ICC of 0.044, p=0.070), and

FSA and HEI score (very small ICC of 0.002, p=0.471), suggesting that BMI and diet quality were independent of FSA. Perceptions were similarly not clustered within FSAs (ICC= -0.036 for *availability* perceptions, p=0.912; ICC= -0.040 for *affordability*, p=0.933; ICC= -0.059 for *access*, p=0.988, and; ICC= -0.038 for *quality*, p=0.926). Therefore, it was unnecessary to account for clustering within administrative geographic areas. SPSS 20.0 was used to determine the ICCs.

To fulfill research objective one, diet quality, BMI and WC were examined using descriptive statistics.

To fulfill research objective two, two sets of linear regressions (one for each perceptual variable) were used to examine whether objective variables significantly predicted the perceptual variable of interest. Household-level covariates included household income, and car ownership, and were entered into all models. Objectively-measured variables were entered into separate models, with the exception of those derived from the NEMS-S (the traditional *affordability* score, the *availability* score, and the *quality* score were entered together), the NEMS-R (the *availability*, *affordability*, and barriers and facilitators scores were entered together), and the intensity scores (the number of stores and restaurants within buffer zones were entered together). SPSS 20.0 was used for the linear regression analyses.

To fulfill research objective three, sex-specific multilevel linear regression analyses were used to examine whether individual-level outcomes (BMI, WC and diet quality) were predicted by objective and perceived food environment variables after controlling for individual education and age, and household income and car-ownership. Sex specific analyses were conducted since males and females may respond differently to built environments (232, 233). HLM 7 was used for the multilevel regression analyses. Food environment variables were entered separately, with the exception of the NEMS-S (the traditional *affordability* score, the *availability* score, and the *quality* score were entered together), the NEMS-R (the *availability* score, the *affordability* score, and the barriers and facilitators score were entered together), perceptions (perception scores were entered together), and intensity (store and restaurant intensity scores were entered together). Because initial results indicated that BMI, WC, and both perceptual variables were skewed, Box-Cox transformations were used to improve the normality of these variables (234). For all analyses, p=0.05 was considered statistically significant, and data were weighted to reflect Canadian Census 2006 totals for the area.

3. Results

3.1 Descriptive characteristics

3.1.1 Sample Characteristics

Household Level

Just under one-quarter of the sample was low-income (24.5%), 43.9% was mid-income, and 31.6% was high income. Rates of vehicle ownership were very high (94.7%) (corresponding to census data indicating that 88% of employees 15 years and over drive or are driven to work), and the sample was fairly equally split by sex (52.7% female). Before standardization, the mean *access/availability/quality* perceptual score was 24.9 out of 36 possible and the mean *affordability* perceptual score was 6.5 out of 12 possible. On average, the closest grocery store was approximately 1km away from respondents' homes (1001m), the closest convenience store was about half a kilometre away (526m), and the closest fast food outlet was 582m away. Participants had 419.5m of linear shelf space dedicated to energy dense snack foods and 126.4m of shelf space dedicated to fruits and vegetables within 1km of their home on average. Participants had an average of 9 food stores and 20 restaurants within 1km of home, and the mean RFEI score was 5.6, indicating that there were 5.6 times as many fast food outlets and convenience stores as there were grocery stores and specialty stores within 1km of respondents' homes.

Individual Level

About 7% of the sample was aged 10-14 years; 16% was aged 15-24 years; 34% was aged 25-45 years; 33% was aged 45-65 years and; 10% was over 65 years. For females, mean BMI was 26.8, mean WC was 86.2cm, and mean HEI-C score was 54.6 (which corresponds to a "diet in need of improvement" (31). Among females aged 12-20, 79.3% were normal weight, 17.0% were overweight, and 3.7% were classified as obese, according to International Obesity Task Force (IOTF) cut-offs. Among female adults, 36.9% were normal weight, 30.5% were overweight (BMI between 25 and 29.9), 19.3% were class I obese (BMI between 30-34.9), 5.5% were class II obese (BMI between 35 and 39.9) and 7.7% were class III obese (BMI>40); 62.7% had a WC over 79.9cm, representing increased or high risk (235).

For males, mean BMI was 27.6, mean WC was 94.1cm, and mean HEI-C score was 50.8 (which represents diet quality on the border between "poor" and "needs improvement") (31). Among males aged 12-20, 65.3% were normal weight, 22.2% were overweight, and 12.5% were obese, according to IOM cut-offs. Among male adults, 21.7% were normal weight, 43.9% were overweight (BMI between 25 and 29.9), 25.5% were class I obese (BMI between 30-34.9), 6.9% were class II obese (BMI between 35 and 39.9) and 2.7% were class III obese (BMI>40); 54.1% had a WC over 93.9cm, representing increased- or high-risk (235).

3.2 Perceptions predicted by objective food environment characteristics

3.2.1 Proximity variables

Distance to the nearest grocery store (B=-0.39, p<0.001) and distance to the nearest fast food outlet (B=-0.144, p=0.002) significantly predicted *access-related* perceptions. The strongest predictors of *affordability* perceptions included distance to the nearest fast food outlet (B=-0.15, p=0.002), distance to the nearest convenience store (B=-0.11, p=0.031) (see Table 4-3).

3.2.2 250m Buffers

No objective factors at 250m significantly predicted either perceptual variable (data not shown).

3.2.3 1000m Buffers

Table 4-3 highlights objective predictors of the two perceptual variables at 1000m. The strongest predictors (largest B values) of *access-related* perceptions were linear shelf space of fruits and vegetables (B=2.31, p<0.001) and linear shelf-space of energy-dense snack foods (B=0.52, p<0.001). Other objective measures at 1000m that significantly predicted *access-related* perceptions included diversity, store intensity, NEMS-S availability and quality, NEMS-R barriers and facilitators to healthy eating, and the mean healthy food basket price.

Linear shelf-space of fruits and vegetables within 1000m (B=-0.45, p=0.012) significantly predicted affordability perceptions. The only objective measure purportedly assessing food *affordability* that significantly predicted affordability perceptions was the healthy food basket price (B=-0.002, p=0.029). Other significant predictors of affordability perceptions included store and restaurant intensity, the RFEI, and the NEMS-R access score.

3.3 Diet-related health outcomes explained by food environment characteristics

Only *access*-related perceptions predicted diet quality among males (B=1.09, p=0.019); neither perceptual variable predicted any other outcomes among females or males, as shown in Table 4-4. Table 4-5 shows regression coefficients of food environment variables at 1000m for females and males, as well as proximity measures and perceptual variables.

3.3.1 Proximity variables

For females, distance (km) from home to the nearest convenience store was significantly, negatively associated with BMI and WC (B=-2.23, p<0.001 and B=-6.41, p<0.001, respectively) and distance to the nearest fast food outlet was significantly, negatively associated with WC (B=-4.95, p<0.001). For males, distance (km) from home to the nearest grocery store significantly predicted BMI (B=0.52, p=0.020), and marginally significantly predicted diet quality (B=-1.41, p=0.065).

3.3.2 250m Buffers

For females, both NEMS-S *availability* and *quality* predicted BMI (B=0.144, p=0.005 and B=-0.449, p=0.01, respectively), as did store intensity (B=0.691, p=0.002) and restaurant intensity (B=-0.152, p=0.044). WC was predicted by store intensity (B=1.53, p=0.003), NEMS-S *affordability* (B=-1.54, p=0.034), shelf space of energy-dense foods (B=0.020, p=0.006), RFEI (B=0.623, p=0.018), and diversity (B=0.658, p=0.019).

For males, BMI was predicted by NEMS-S *quality* (B=-0.490, p=0.002) and NEMS-R *affordability* (B=0.453, p=0.020), while WC was predicted solely by NEMS-S *quality* (B=-0.97, p=0.006).

3.3.3 1000m Buffers

For females, store and restaurant intensity predicted BMI (B=0.09, p=0.027 and B=-0.04, p=0.014, respectively). NEMS-S *affordability* scores were significantly, negatively associated with BMI (B=-0.60, p=0.02), and NEMS-R *availability* and *barriers and facilitators to healthy eating* scores significantly predicted BMI (B=-0.32, p=0.006 and B=0.17, p=.023, respectively).

For males, restaurant intensity was significantly, negatively associated with BMI (B=-0.03, p=0.024) and RFEI was significantly, positively associated with WC (B=0.18, p=0.025). NEMS-S *affordability* was significantly, negatively associated with both BMI and WC (B=-0.55, p=0.021 and B=-1.42, p=0.016, respectively), and NEMS-R *barriers and facilitators to healthy eating* scores were significantly, positively associated with WC (B=0.33, p=0.043). Only NEMS-S *availability* significantly predicted diet quality among males (B=0.34, p=0.005), although linear shelf-space of fruits and vegetables and mean healthy food basket price marginally significantly predicted diet quality (B=8.33, p=0.061 and B=0.04, p=0.056, respectively).

4. Discussion

This study has advanced both theoretical and policy considerations by determining the extent to which objective food environment measures predict residents' food environment perceptions, and by examining the relative predictive ability of objective vs. perceived food environment measures with respect to diet-related outcomes.

4.1 Theoretical contributions

In terms of theoretical contributions, many of the objective measures predicted residents' perceptions of *access*, *availability* and *quality* and of *affordability*. Linear shelf-space of fruits and vegetables was a stronger predictor of access-related perceptions relative to the NEMS-S, indicating that the amount or prominence of nutritious foods might better predict perceptions than their presence or absence (as measured by the NEMS-S). Moreover, while researchers have hypothesized about the existence of different food environment constructs (1, 219), this study found a) perceptions along the constructs of *access*, *availability* and *quality* to be highly correlated, indicating that these may not be separate and distinct constructs from a perceptual perspective, and b) *affordability* perceptions were predicted by only one of three objective measures purportedly assessing *affordability* (the mean healthy food basket price), but were predicted by five of seven food *access* measures, and an *availability* measure. This could reflect discrepancies between respondents' perceptions of their neighbourhoods and how researchers have operationalized food environment constructs. Future theoretical development should acknowledge that constructs may be more interconnected or nuanced than previously thought.

Food environment characteristics are hypothesized to act on weight status through dietary mechanisms, so it was somewhat surprising that BMI (and not diet quality) was predicted by several food environment variables, since better diet quality is associated with lowered risk of overweight and obesity in Canada (24). This finding is, however, consistent with previous research (8), and perhaps indicates that the amount of food (reflected by BMI), rather than the quality of the diet (captured by HEI-C) is the main mechanism through which food environments act on outcomes. Alternatively, despite being comprehensive, the average HEI score over two days may be too short-term of an instrument to capture dietary patterns, which may indeed be related to food environments. This finding further indicates a need for future research to carefully consider how “eating patterns” are operationalized. Diet quality (in terms of adequate micronutrient consumption and moderation of specific micro- and macronutrients including sodium and saturated fat) was not predicted by food environment variables, but perhaps overall caloric consumption would have been better predicted as a proximal outcome of food environments. Future research should examine whether eating patterns (variously operationalized) mediate associations between food environments and weight status.

One final theoretical consideration relates to the variability of food environment characteristics. The current study took place in three adjacent cities in southern Ontario. Findings from an ongoing 12-country built environment research project (236) indicates that built environment metrics vary exponentially more *between* countries than *within* countries. Therefore, associations between built environment features and outcomes may be significantly underestimated in single-country studies (29). In the current study, the fact that the three cities are spatially contiguous and also relatively homogeneous in terms of urban form may mean that variability in food environment measures is even smaller than would variability be had three spatially separate cities been examined. Indeed, national or state-level policies influencing food production, distribution, and marketing might inhibit the variability of local food environments, precluding a full understanding of food environments’ associations with outcomes in a single-region study. Food environment research could benefit from international comparisons to further investigate the role of food environments in shaping outcomes.

4.2 Methodological contributions

Methodologically, findings from this study indicate that *access* and relative *affordability* in stores were most predictive of BMI and WC, which underlines the importance extending traditional examinations of food *access* to include considerations of relative *affordability*. Interestingly, absolute *affordability* (operationalized with the mean healthy food basket price) did not significantly predict any outcomes. This finding further reflects the complexity of operationalizing food environment constructs and merits further investigation to examine how food costs, variously defined, are associated with outcomes.

Second, geographically, objective measures more successfully predicted perceptions at 1000m buffers relative to 250m buffers, possibly corresponding with the geographic scale respondents were asked to consider in the survey question. To maximize correspondence between measures, future research should ensure the same geographic scale for both. Interestingly, for females, positive associations between store intensity and BMI and negative associations between restaurant and BMI were weaker at 1000m buffers relative to 250m buffers. This finding may be related to the fundamental geographical principle of distance decay, the notion that individuals are less likely to interact with locations that are further away. For variables that were related at one scale but not another, it may reflect the fact that distance decay varies across contexts (237, 238). It is additionally interesting that increased store intensity predicted increased BMI and increased restaurant intensity predicted decreased BMI. This may reflect other considerations related to food purchasing behaviours and use of food outlets. For example, it may be that an increased number of small food stores within walking distance may increase individuals' food purchasing from these kinds of food stores, which tend to supply non-nutritious foods (239). Conversely, an increased number of restaurants within walking distance may not be as related to purchasing patterns in restaurants but instead may reflect walkability, which has been associated with increased physical activity and decreased weight status in some studies (240). Future research should examine whether and how food environment influences on food purchasing may vary across outlet types.

Third, differential findings for males vs. females were consistent with other results (233), and suggest that future research should use sex-specific models. For females, distance from home to the nearest convenience store best predicted BMI and WC – females of average height (1.65m, 5'5) were 6.1kg (15.2lbs) less and had 6.4cm smaller WC for every km increase in distance from home to the nearest convenience store after accounting for household income, car ownership, and individual age and education level. For males, convenience store proximity did not significantly predict BMI, but grocery store proximity did: for each one km increase in distance away from the nearest grocery store, average height males (1.78m, 5'10) were 1.6kg (4.1lbs) heavier after accounting for covariates. These sex-specific findings may reflect the gendered nature of relationships with food (241, 242), and should be further explored in qualitative and quantitative studies. On average, the NEWPATH participants had extremely high rates of car-ownership, representative of the broader study setting. It has been hypothesized that social or economic restrictions may render people more dependent on their immediate environments for food (92). In this context, where participants were generally not restricted to their immediate environments, it is remarkable that several features of the immediate food environments nevertheless emerged as powerful predictors of BMI and WC in particular.

4.3 Policy-oriented contributions

In terms of policy-oriented contributions, this study showed that perceptions predicted only diet quality for males, to the exclusion of all other diet-related outcomes, consistent with some research (184), but inconsistent with other research finding that perceptions are associated with better diet quality (160), food purchasing behaviours (43), and consumption behaviours (42). This study's findings seem to support policies that would increase objective access to nutritious food sources or restrict access to non-nutritious foods sources (e.g., through zoning regulations), rather than attempting to alter food environment perceptions through strategies aimed at increasing residents' knowledge of healthy, affordable foods in their neighbourhoods. One example of a land-use planning policy that would be supported by the current study is zoning regulations to limit convenience store access, since distance from home to the nearest convenience store was most strongly associated with increased BMI and WC among females. Another feasible strategy may be to alter the consumer nutrition environment within convenience stores. Corner store interventions may increase the availability and promotion of healthy foods, increase sales of certain healthy foods (243), and improve individual-level food-related consumer behaviours (244). Small food stores are important intervention settings because of their easy accessibility, high level of patronization by local residents, and relatively unhealthy food offerings (239, 245). Since the current study was cross-sectional, and therefore speculation on causation is precluded, the claim cannot be made that limiting access to convenience stores through zoning regulations or strategies targeted at improving nutritious food availability within convenience stores will cause healthier body weights. Certain jurisdictions, including the current study setting, have mandates to promote and sustain healthy food environments (19, 20). Therefore, despite their cross-sectional nature, the current findings can still support public health planners in their desire to use evidence to inform policies related to healthy food environments. While policies are not solely created as a result of evidence, in jurisdictions where policymakers are ready to approve or implement policies related to the food environment, the current study suggests that food *access* (measures for which are relatively inexpensive) and relative *affordability* of nutritious foods may be the most important features on which to act.

Descriptive food environment data may also be used to create buy-in among local policy-makers. In this setting, objective measures revealed an "obesogenic" food environment (246). Public health practitioners may well use these data to make the case to policy-makers that the current environment does not provide adequate opportunities for residents to engage in healthy eating. Policymakers seem reluctant to promote healthy eating environments (247), so using descriptive data to illustrate the extent of the obesogenic food environment could potentially be a first-step in creating buy-in among policymakers by framing the current food environment as problematic (248). For example, policymakers may be responsive to the message that on average, residents had over three times as much shelf-space dedicated to energy dense snack foods as to fruit and vegetables within 1km of their homes, or that the nearest convenience stores were almost twice as close to respondents' homes as the nearest grocery stores (526m away vs. 1001m away, respectively). Although food deserts have been the topic of much interest in Canada and elsewhere (3, 188, 249) the notion of "food swamps" – places containing "a plethora of fast food;

convenience stores selling calorie-dense packaged foods, super-sized sodas, and other sugar-loaded beverages; and other non-food retail venues selling junk food as a side activity" (249) (p. 1171) seems a more relevant frame for the current study context. In the Region of Waterloo, these descriptive data support public health planners and practitioners in terms of the need for policies to create healthy food environments and improved food access as stated in the current Regional Official Plan (19, 20).

The current study faced several limitations. In addition to being cross-sectional, the study also relied on buffer zones around homes to the exclusion of other places potentially relevant to diet-related outcomes. While this is common practice in the literature to date (5), recent studies have attempted to understand and quantify food environment exposure based on where people travel throughout the day (175-177), since people are not restricted to their local neighbourhood to procure food (250).The fact that features of the immediate food environment were still predictive of outcomes perhaps indicates the importance of local food environments as determinants of said outcomes. Second, while dietary data were collected throughout the year, food environment data were collected between May and August, a time when produce may be more available or affordable, given the growing season in the study region. NEMS-S protocol requires the "regular" price of all foods to be recorded, so sale prices that might be more likely in the summer due to increased volume of locally available fruits and vegetables would not have been captured regardless. Moreover, for the current study, data collection from respondents took place from 2009-2010 and food environment data collection took place in 2010, which is temporally closer than several previous studies attempting to link individual-level and food environment data (153, 201). Third, previous research examining food environment perceptions has either used perception and outcome data from the same individual (160, 184) and/or has used perceptions from neighbourhood informants (160); both methods have been found to predict diet quality. The current study gauged perceptions of the main food shopper and examined individual-level outcomes of all members of the household. While it is possible that individuals' perceptions may have better predicted outcomes, gauging perceptions of the main food shopper is theoretically important, given that the main food shopper would both likely be aware of the local food destinations and would also contribute to determining the household's food selection. Finally, there was a relatively high refusal rate among convenience store owners. However, while the process of imputing missing data from similar store types may have increased the chance of type II error, it would not have biased the findings, since refusals did not appear to be geographically clustered. These limitations are offset by the strengths of the study, which include the incorporation of eight different food environment assessment tools, the assessment of both community and consumer nutrition environments (1), three outcomes of interest (including a comprehensive index of diet quality), and varied geographic scale (250m buffers and 1000m buffers), all within the context of population-based sample. This is the first study to date that has incorporated multiple measures of food *availability* and *affordability* in particular.

Table 4-1: Description of food environment measures

Instrument	Outlet type assessed	Constructs Addressed	Methodology
Objective Community Nutrition Environment			
Proximity to the nearest food outlet of a certain type (153)	Stores and restaurants	Access	The network distance (m) from a respondent's home to the nearest grocery store, the nearest convenience store, and the nearest fast food outlet.
Intensity(153)	Stores Restaurants	Access	The number of food stores or restaurants within a given buffer zone
Diversity (153)	Stores and restaurants	Access	The number of diverse types of food outlets (five types of food stores (convenience, grocery stores, specialty food stores, pharmacies, and warehouse clubs and superstores) and two types of restaurants (limited-service and full-service)) within 1000m of home; min: 0; max: 7, with '7' indicating the presence of all types of food outlets
RFEI(15)	Stores and restaurants	Access	Geographic analysis of ratio of number of fast-food outlets and convenience stores to grocery and specialty stores
Objective Consumer Nutrition Environment			
Shelf-space measures (122)	Stores	Availability	Two variables: Cumulative linear shelf-space of fruits and vegetables (including fresh, frozen and canned varieties) (m), and the cumulative linear shelf-space of energy-dense snack foods (including candies, carbonated beverages, salty snack foods, cookies and crackers, donuts and pastries) (m)
NEMS-S Checklist (37)	Stores	Availability Affordability Quality	Objective audits of food stores: mean NEMS-S scores within 1000m of home for each construct (e.g., mean NEMS-S availability, mean NEMS-S affordability, and mean NEMS-S quality) were computed
NEMS-R Checklist (38)	Restaurant s	Availability Affordability Barriers and Facilitators	Objective audits of restaurants: mean NEMS-R scores within 1000m of home for each construct (e.g., mean NEMS-R availability, mean NEMS-R affordability, and mean NEMS-R barriers and facilitators) were computed.

Instrument	Outlet type assessed	Constructs Addressed	Methodology
Perceptual Variables			
Neighbourhood food environment perceptions(160, 196)	Stores and restaurants	Access Availability Affordability Quality	Agreement with the following statements on a 4-point Likert scale assessed residents' perceptions. **Access**: "There are no food outlets in my neighbourhood*"; "It is easy to purchase fresh fruits and vegetables in my neighbourhood"; "It is easy to purchase low-fat products (such as low-fat milk or lean meats) in my neighbourhood"; "There are a lot of fast food restaurants in my neighbourhood*" **Availability**: "There is a large selection of fresh fruits and vegetables available in my neighbourhood"; "There is a large selection of low-fat products available in my neighbourhood"; "It is easy to eat healthily at the restaurants in my neighbourhood." **Affordability**: "I shop elsewhere because the prices in my neighbourhood are too high*"; "The produce in my neighbourhood is more expensive than that in other neighbourhoods*"; "The low-fat products in my neighbourhood are more expensive than those in other areas.*" **Quality**: "The fresh produce in my neighbourhood is of high quality"; "The low-fat products in my neighbourhood are of high quality." (* items were reverse-scored)

Table 4-2: Food environment assessments

Outlet type	Number assessed	Number of unique locations included in buffer-zone analyses (including all chains)	Number of outlets found in PHI database not at given address or closed	Number of outlets found in PHI database not applicable*	Number found through direct observation	Refusal Rate§
Restaurant	611	912	58	18	37	0.1%
Grocery Store	47	47	0	5	1	0%
Convenience Store	169	289	10	17	4	39%
Pharmacy	9	22	0	0	0	0%
Superstore	3	13	0	0	0	0%
Specialty Store	47	51	1	3	2	7.8%

* Outlets selling no food or beverages or only selling a limited number of canned goods not rated by any tool

§ Store employees instructed raters not to conduct shelf-space or NEMS checklist measurements

Table 4-3: Perceptual measures predicted by objective measures

Objective Variables	Perceived Access, Availability, Quality	Perceived Affordability
Income	-0.064(0.028)*	-0.146(0.028)***
Car Ownership	0.060 (0.067)	-0.309(0.066)***
Community Nutrition Environment		
Distance to nearest grocery store (km) (SD)	-0.390(0.030)***	0.007(0.031)
Distance to nearest convenience store (km) (SD)	-0.068(0.053)	-0.112(0.052)*
Distance to the nearest fast food outlet (km) (SD)	-0.144(0.047)**	-0.146(0.046)**
Diversity (SD)	0.112(0.012)***	-0.013(0.012)
Intensity: Stores (SD)	0.014(0.005)**	-0.015(0.005)**
Intensity: Restaurants (SD)	-0.002(0.002)	0.005(0.002)**
RFEI (SD)	-0.004(0.004)	0.012(0.004)***
Consumer Nutrition Environment		
Fruit and Vegetable Shelf-Space (km) (SD)	2.31(0.18)***	-0.445(0.117)*
Energy Dense Shelf-Space (km) (SD)	0.517(0.060)***	-0.106(0.059)
NEMS-S Availability (SD)	0.044(0.006)***	0.003(0.006)
NEMS-S Affordability (SD)	-0.019(0.040)	0.002(0.039)
NEMS-S Quality (SD)	-0.071(0.020)***	0.003(0.019)
NEMS-R Availability (SD)	0.009(0.016)	-0.010(0.015)
NEMS-R Affordability	0.022(0.034)	0.014(0.033)
NEMS-R Barriers and facilitators to healthy eating	0.033(0.010)***	-0.017(0.010)
NEMS-R Access	0.018(0.012)	0.027(0.012)*
Mean Healthy Food Basket total price	0.014(0.001)***	-0.002(0.001)*

* significant at p<0.05; ** significant at p<0.01; ***significant at p<0.001

Table 4-4: Perceptions predicting diet-related outcomes

	Females			Males		
	Diet Quality	BMI	WC (cm)	Diet Quality	BMI	WC(cm)
Individual-level characteristics						
Age (Beta, SE)	0.04(0.02)	0.10(0.008)***	0.27(0.02)***	0.006(0.025)	0.10(0.008)***	0.36(0.02)***
Education level (Beta, SE)	1.39 (0.47)**	-0.84(0.18)***	-2.09 (0.46)***	1.26 (0.54)*	-0.18(0.15)	-0.07(0.39)
Household-level characteristics						
Income (Beta, SE)	0.66(0.63)	-0.58(0.26)*	-1.58(0.61)**	-0.77(0.71)	-0.11(0.22)	-0.92(0.59)
Car ownership (Beta, SE)	1.45(1.55)	-1.47(0.91)	-2.18(1.94)	-0.20(1.97)	1.71(0.77)*	3.19(1.93)
Perceptions						
Availability, Quality, Access	0.17(0.47)	-0.18(0.13)	-0.41(0.36)	1.09(0.46)*	-0.21(0.13)	-0.41(0.36)
Food affordability	0.24(0.49)	-0.04 (0.14)	-0.28(0.34)	0.31(0.46)	-0.04(0.14)	-0.29(0.35)

* significant at p<0.05; ** significant at p<0.01; ***significant at p<0.001

Table 4-5: Regression coefficients for multi-level analysis of household- and individual-level factors associated with diet quality, BMI, and WC

	Female			Male		
	DQ	BMI	WC	DQ	BMI	WC
Community Nutrition Environment						
Distance to nearest grocery store (km) (SD)	-1.56(1.06)	0.19(0.28)	0.10(0.70)	-1.41 (0.76)	0.52 (0.22)*	0.48 (0.59)
Distance to nearest convenience store (km) (SD)	2.19(1.95)	-2.23 (0.63)***	-6.41 (1.52)***	1.96(1.74)	0.09(0.52)	-0.98(1.35)
Distance to the nearest fast food outlet (km) (SD)	1.97(1.79)	-1.07(0.58)	-4.95 (1.42)***	0.019(1.53)	-0.49(0.51)	-1.73(1.310)
Diversity (SD)	-0.08(0.30)	-0.02(0.12)	0.01(0.29)	0.39(0.31)	-0.12(0.10)	-0.16(0.25)
Intensity: Stores (SD)	-0.04(0.10)	0.09(0.04)*	0.18(0.10)	-0.11(0.12)	0.05(0.04)	0.10(0.08)
Intensity: Restaurants (SD)	0.01(0.04)	-0.04(0.02)*	-0.06(0.04)	0.06(0.05)	-0.03(0.01)*	-0.05(0.03)
RFEI (SD)	-0.09(0.07)	0.04(0.04)	0.09(0.08)	-0.12(0.08)	0.07(0.04)	0.18(0.08)*
Consumer NE						
Log Shelf Space Ratio	-1.73(1.30)	0.12(0.38)	-0.34(0.98)	-1.84(1.02)	0.39(0.33)	-0.04(0.82)
Fruit and Vegetable Shelf-Space (km) (SD)	5.51(4.39)	-0.10(1.40)	1.17(3.33)	8.33(4.43)	-0.99(1.18)	-0.17(2.99)
Energy Dense Shelf-Space (km) (SD)	0.37(1.29)	-0.16(0.50)	0.29(1.21)	1.58(1.45)	-0.64(0.41)	-0.43(1.07)
NEMS-S Availability (SD)	0.07(0.15)	-0.09(0.05)	-0.14(0.11)	0.34(0.12)**	-0.06(0.04)	-0.12(0.09)
NEMS-S Affordability (SD)	0.89(0.87)	-0.60(0.26)*	-1.42(0.64)*	0.31(0.75)	-0.55(0.24)*	-1.42(0.59)*
NEMS-S Quality (SD)	0.11(0.42)	0.05(0.14)	0.33(0.35)	-0.50(0.35)	0.02(0.11)	-0.0007(0.30)
NEMS-R Availability (SD)	-0.45(0.33)	-0.32(0.12)**	-0.18(0.28)	0.13(0.29)	-0.16(0.10)	-0.17(0.26)
NEMS-R Affordability	-0.61(0.70)	-0.03(0.25)	0.21(0.58)	0.45(0.63)	-0.19(0.19)	-0.23(0.51)
NEMS-R Barriers and facilitators	0.29(0.27)	0.17(0.08)*	0.18(0.18)	-0.20(0.23)	0.10(0.06)	0.33(0.16)*
NEMS-R Access	-0.11(0.29)	0.17(0.09)	0.45(0.23)	0.17(0.25)	0.14(0.08)	0.23(0.22)
Mean Healthy Food Basket total price	0.02(0.03)	-0.001(0.01)	0.004(0.02)	0.04(0.02)	-0.06(0.01)	-0.001(0.02)

* significant at p<0.05; ** significant at p<0.01; ***significant at p<0.001

Chapter 4. Appendix A

Foods comprising the Health Food Basket, categorized by food group

Vegetables and Fruit: Apples (1lb), bananas (1lb), cantaloupe (1 melon), oranges (1lb), grapes (1lb), pears (1lb), broccoli (1 bunch), cabbage (1 head), carrots (2lb bag), celery (1 group of stalks), long English cucumber (1 whole), green bell peppers (1lb), iceberg lettuce (1 head), potatoes (5lb bag), sweet potatoes (1lb), field tomatoes (1lb), mixed vegetables (frozen, 1kg bag), peas (frozen, 1 kg bag), strawberries (frozen, 600g bag), corn (canned, 398 ml), peaches (canned, 398 ml), stewed tomatoes (canned, 796ml), apple juice (1L), orange juice (1L)

Grain Products: 100% Whole wheat bread (1 loaf, 425g), low-sugar cereal (1 standard box)

Milk and Alternatives: Plain skim milk (Carton, 1L)

Meat and Alternatives: lean ground beef (1kg)

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Chapter 5. Residents' perceptions do not mediate associations between objective food environment measures and diet-related outcomes

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1. Introduction

Recognition of “globesity” – an increasing global epidemic of overweight and obesity – as a serious public health concern has resulted in national and international agencies calling for strategies to prevent and reduce the overweight and obesity rates around the world (4, 251-253). To address the crisis of increasing obesity rates, an environmental perspective on dietary behaviours, specifically, a focus on “toxic” or “obesogenic” environments, has been advocated (69, 217, 246, 254). Food environments, characteristics of the built environment related to food consumption, may be particularly important drivers, since rising obesity prevalence seems primarily to be due to excess caloric consumption, rather than inadequate energy expenditure (22, 23). Indeed, the relationship between food environments and diet-related health outcomes including obesity is of great interest to both researchers (7-9, 219, 255) and policy makers, who are increasingly implementing policies and programs to improve food environments (19, 193, 256).

1.1 The promise of examining perceptions

Much of the food environment research to date has relied on readily-available secondary data sources, such as land use and parcel data (which are typically available in municipal Geographic Information Systems (GIS) databases), commercial data (for example, InfoUSA or Dun and Bradstreet, which contain information on types and locations of food outlets), or public health or other governmental department licencing data (for example, public health inspection databases)(94, 257, 258). Food outlet addresses obtained through these sources are geocoded (often with no verification through direct observation), and researchers are then able to use GIS to identify food outlets’ geospatial locations and to quantify food environment exposures, variously defined (e.g., the number of fast food outlets within 800m of a school, or the street network distance between survey participants’ homes and the nearest grocery store).

One major limitation of extant research is the inconsistent assessment methodology employed, which renders it difficult to compare findings across populations or geographic locales (8, 9, 219, 255). Although food access is increasingly being operationalized with spatial analyses using GIS (180, 219), some researchers are calling for the inclusion of perception-based measures in food environment research for three reasons. First, there are concerns about the accuracy of using secondary data sources since discrepancies between commercial business listings and the actual location and status of food stores may be significant (94, 257-259); residents' food environment exposures may thus be easily misclassified.

Second, and perhaps more important from a theoretical perspective, residents' perceptions might tap into broader, complementary constructs related to food access, such as the selection, quality, acceptability, and affordability of the local food supply, or even the residents' own mobility (43, 92, 260, 261).

Third, from a research perspective, understanding the relationship between objective and subjective measures can help to refine assessment methodologies, and facilitate the interpretation of food environment studies (18, 41, 160). A clearer understanding of the relationship between objective and perceived food environment measures is necessary to advance theoretical, research, and policy or program developments, as described below.

1.1.1 Advancing food environment theory

A widely-cited, early conceptual model of food environments distinguished between *community* and *consumer* nutrition environments, where *community* nutrition environments incorporate constructs of food access (geographic distribution of food sources), and *consumer* nutrition environments capture the availability, affordability, quality, and promotions of foods within food stores or restaurants (1). In this model, objectively measured food environment characteristics are hypothesized to both directly and indirectly influence eating patterns through residents' food environment perceptions. In other words, this model shows residents' perceptions as potential mediators of the association between objective food environment measures and diet-related outcomes. Mediating variables transmit the effect of an antecedent, independent variable to an outcome variable (25, 26) and are therefore identified as being situated in a causal sequence between the independent variable and the dependent variable. Several studies examined the relationship between objective and perceived measures (16-18, 41, 184, 185, 260), but none have directly tested perceptions as mediators of the association between objective measures and diet-related outcomes. Two systematic reviews have recommended that researchers explicitly test theoretically-justified mediators to further our understanding of how the built environment (including the food environment) influences health outcomes (5, 7) and to facilitate the development of more efficient interventions that target mechanisms by which features of the built environment affect diet-related outcomes. Indeed, examining mediating pathways can help to identify important determinants of perceptions, which themselves have been found to predict dietary behaviours (161, 260-263).

1.1.2 Advancing research

As mentioned, in traditional food environment assessments, researchers obtain data from secondary sources and use GIS to quantify food environment exposures based on food outlet types (e.g., supermarkets, convenience stores and fast food outlets are outlet types that have emerged as important to residents' diet-related outcomes (5, 7-9). Directly measuring features of the consumer nutrition environment (local food availability, affordability, or quality) is expensive relative to measuring the community nutrition environment using spatial analyses, although consumer nutrition environment measures have been identified as a 'gold standard' (41). The less expensive option of measuring community nutrition environments through, for example, determining grocery store proximity or fast food outlet density, relies on the potentially erroneous assumption that consumer nutrition environments are invariable across grocery stores, or that only grocery stores offer nutritious foods (18, 160). Moreover, as mentioned, secondary data quality represents a potentially serious concern in terms of research reliability, since discrepancies between different data sources exist (94, 257, 258). Therefore, further exploring the relationship between perceptions and objective measures of community and consumer nutrition environments remains an important question for advancing practical research considerations.

1.1.3 Advancing policy and practice

A window of opportunity may be open for food environment theory and research to make significant contributions to food environment policies, given that policies related to the food environment are already being implemented in the face of scant or conflicting evidence (19, 193). For example, Los Angeles has banned fast food outlets from opening in certain neighbourhoods (193), Comox, British Columbia has banned drive-thrus since they have been found to violate existing idling bylaws (264), and several municipalities in Quebec, Canada, are currently considering the use of zoning regulations to prohibit fast food outlets and convenience stores from opening within walking distance of schools (3). An examination of whether perceptions mediate associations between objective features and diet-related outcomes can help to identify points of intervention. If perceptions do not mediate these associations, then the argument for acting directly on objective food environment characteristics shown to predict dietary outcomes may be justified. If perceptions do mediate these associations, perceptions may represent an important point of intervention, and therefore increasing residents' awareness of nutritious, affordable foods in their neighbourhoods may be an effective strategy (16, 265).

1.2 Overview of existing evidence

Extant research has examined the extent to which objective and perceived measures are related (16-18, 41, 185), and the relative ability of objective vs. perceived measures to predict diet-related outcomes (43, 160, 184, 224, 260). Objective and perceived food environment measures are generally not highly correlated, although objective measures of the community nutrition environment (i.e., access) seems to be more predictive of perceived measures than do measures addressing aspects of the consumer nutrition environment (i.e., availability, affordability or quality)(16, 17, 184). Results from studies comparing the relative ability of objective vs. perceived measures to predict outcomes are mixed: two studies found perceptions to predict outcomes to the exclusion of objective measures (43, 260), two studies found objective (not perceived) measures to predict diet-related outcomes (184, 265), and two studies found both objective and perceived measures to predict outcomes (160, 224). Only two studies have incorporated perceptual and objective measures of both the community and consumer nutrition environments. One was conducted with 186 low-income women (184), the other was conducted with 4102 men and women from a population-based sample (265). Both of these studies found that objective community nutrition environment measures best predicted dietary and weight-related outcomes relative to objective measures of the consumer nutrition environment or to any perceived measures.

The aim of this study is to test the theoretical hypothesis presented by Glanz and colleagues (1) that perceptions mediate associations between the objective food environment and diet-related outcomes. It does so using a population-based sample, and incorporates several measures of the community and consumer nutrition environments, which allows for between-measure comparability, thereby filling a large gap in the current literature (7-9, 219).

2. Methods

The NEWPATH (Neighbourhood Environments in Waterloo Region: Patterns of Transportation and Health) project aimed to characterize associations between objective and subjective aspects of built environments including walkability, physical activity, dietary behaviours, and health outcomes in a population-based sample (30). Data collection for NEWPATH took place from May 2009 until May 2010; data from a separate but related project aimed at characterizing food environments in the three cities of Waterloo Region: Kitchener, Cambridge, and Waterloo, were collected between May and August, 2010 (220). The NEWPATH study received ethics clearance from the University of Waterloo Office Research Ethics and the Behavioural Research Ethics Board at the University of British Columbia. Ethics clearance was not necessary for the second study, as no data were collected from human participants.

2.1 Procedures

2.1.1 NEWPATH

The NEWPATH sample was stratified by neighbourhood walkability, household income and household size, with allocation to achieve high statistical power to detect hypothesized effects of walkability, consistent with NEWPATH's primary aim (30). Proportional sampling was employed to recruit a stratified random sample (N=4902 individuals in 2228 households) representative of the study area in terms of income and household size according to 2006 Canadian census data. Conditional response rates (proportion of households that completed the survey once recruited) varied between 56% and 64% over six phases of data collection (30). Households were recruited in day-pairs across all days of the week; everyone in the household over the age of 10 years participated in the study.

For the current study, data are considered two-level: individuals nested within households. Household level data included certain socio-demographic data (car ownership, household income) and perception data. Individual-level data included age, sex, dietary data, self-reported weight, height and waist circumference, and education level. Participating households were recruited to complete either a "simple" or "complex" survey package. The "simple" version included a telephone recruitment survey (which included demographic information on all household members) and a paper questionnaire that included food environment perceptions of the main food shopper in each household. All participants self-reported their weight, height, and waist circumference. Participants from households who completed a "complex" survey package additionally completed food records over the two day survey. All analyses presented in this study were restricted to participants 19 years of age and older, since children and youth may interact differently with the built environment than adults (12), and the number of children and youth in the dataset was insufficient to support age-specific analyses. Moreover, children and youth did not provide data on education level, which was considered a covariate in all regression analyses (discussed below).

Therefore, the sample comprised 4102 individuals within 2223 households (2932 individuals in 1533 households completed the "simple" survey package; 1170 individuals within 690 households completed the "complex" survey package) who had complete data on all variables of interest.

2.1.2 Food environment assessment

Food environment measures employed in the current study have been described in detail elsewhere (265). Table 5-1 summarizes the instruments used and the methodology of each of eight different types of food environment assessments employed in the current study. The Region of Waterloo's Public Health Inspection database was used to identify food stores and restaurants in the three cities of Kitchener, Cambridge and Waterloo, and follow-up systematic direct observation was employed to ensure accuracy of the food environment assessment (40). Food environment variables (described below) for each household were based on 1km Euclidean distance buffer zones around NEWPATH respondents' home address; variables based on store and restaurant scores were aggregated as outlined in Table 5-1.

Six observers, each with at least two years of university education, collected food environment data. The first author trained raters to use the Nutrition Environment Measures Survey – Stores (NEMS-S) (199) and shelf-space measures

(14, 122), and the Nutrition Environment Measures Survey – Restaurants (NEMS-R) (38). Training included classroom sessions and field work in food outlets, with feedback on results, and took approximately one week until raters consistently achieved all correct answers on measures. In an iterative process during debriefing sessions, decision rules were added to protocol handbooks, which trainers took to each outlet assessment to support precision in rating. The first author participated in all data collection. Inter-rater reliability was assessed using intraclass correlation coefficients for the shelf-space measure, and ranged from a mean ICC=0.858 for canned fruit to mean ICC=0.996 for fresh vegetables (mean ICC for all specific items assessed =0.940).

Measures of the consumer nutrition environment (described below) were implemented in every independently-owned store and restaurant. For every chain, one randomly-selected restaurant location (including full-service restaurants, fast-food outlets, buffet-style restaurants, coffee shops, bars open to the general public for at least part of the day) and one randomly-selected store location (including convenience stores, gas stations, pharmacies, and warehouse clubs or superstores) were assessed. All locations of each restaurant chain and store chain were given a number using a random number generator; the location that corresponded to the lowest number was assessed. Every grocery store in the three cities was assessed, given that consumer nutrition environments appeared to vary by grocery store size (L. Minaker, unpublished observation).

Within-outlets were carried out in 611 restaurants, representing 912 unique restaurant locations (301 of the 912 restaurants were chains for which exact scores were imputed from the assessed location), and 275 food stores, representing 421 unique store locations. Refusal rates were 0.1% for restaurants; 0% for grocery stores, pharmacies and superstores; 7.8% for specialty stores, and; 39% for convenience stores (265). A probability-based technique was used to randomly assign consumer nutrition environment data from similar store types to stores missing data (14). Buffer zone creation relied on this final dataset of 912 restaurants and 421 stores, representing all restaurants and food stores in the Region's three cities.

2.2 Measures

2.2.1 Outcome Variables

Diet Quality

Two-day food record data from participants completing the "complex" survey were used to calculate Healthy Eating Index adapted for Canada (HEI-C) scores (31), a comprehensive diet quality based on dietary adequacy (including the number of servings of vegetables and fruits, whole grains, number of grams of saturated fats) and moderation (including the proportion of energy intake from saturated fats and sodium intake). The HEI-C reflects Canadian food intake recommendations based on participants' age and sex, and ranges from 0 to 100 with increasing scores representing better diet quality (31). For the current study, mean HEI-C scores over the two days were used as a continuous individual-level indicator of dietary quality.

Obesity: body mass index and waist circumference

Body mass index (BMI) was calculated based on self-reported weight and height (kg/m^2), and waist circumference (WC) was considered mean self-reported WC from two measurements (to the nearest cm). Self-reported WC has been found to be a satisfactorily accurate proxy for measured WC (32). Survey respondents generally overestimate height and underestimate weight (33, 34, 266). Despite this, estimates of health risks associated with variations in self-reported BMI are comparable to those associated with variations in measured BMI (35). WC was additionally included as an anthropometric outcome of interest given that it has been shown to be clinically superior to BMI in terms of predicting mortality risk (36).

2.2.2 Socio-demographic covariates

Level-2 covariates included household income and car ownership; level-1 covariates included education and age (sex was not included as sex-specific analyses were conducted). Household income was categorized into low (<$35,000 per year), medium ($35,000 to $85,000 per year), and high (>$85,000 per year) based on the sample stratification. Car ownership (yes/no) was included as a covariate as it has been shown to be associated with food environments and with residents' BMI (93). Education among adults was classified as low (high school completion or lower), medium (some college, university, or other training), and high (at least university completed). Age was also included and was entered into all models as a continuous variable.

2.2.3 Food environment measures

Perceived food environment variables

Corresponding to the geographic scale at which objective measures were operationalized, for perceptual variables, the main shopper in each household was instructed to, “Please think of your neighbourhood as only the area within about a 10-15 minute walk (1 to 1.5 km) from your home” when responding to the food environment statements. Each statement (presented in Table 5-1) was assigned a score out of four (ranging from 1=strongly disagree to 4=strongly agree); therefore, *access* was scored out of 16; *availability* was scored out of 12; *affordability* was scored out of 12; *quality* was scored out of 8. Although perceptions were originally intended to reflect perceptions of the community (food access) and consumer (food availability, affordability and quality) nutrition environments, high correlations between *access*, *availability* and *quality* scores (Cronbach’s alpha based on standardized items for the three scores was 0.904) justified the creation of an “access-related” perceptual variable, with *access*, *availability*, and *quality* scores being summed and standardized. Perceptions of food *affordability* were not correlated with the other three measures, and therefore the affordability score was standardized on its own. The two perceptual variables were treated as continuous variables. In both cases, higher scores represent increased agreement with statements related to improved neighbourhood food *access*, *availability*, *quality*, or *affordability*.

Objective community nutrition environment measures

Objective measures of the community nutrition environment included: street-network distance from NEWPATH respondents’ homes to the nearest 1) grocery store; 2) convenience store; 3) fast food outlet; diversity (the number of diverse food outlet types within 1km of home); intensity of stores (number of food stores) and restaurants (number of restaurants) within 1km of home; and the Retail Food Environment Index (RFEI) within 1km of home, a ratio of the number of convenience stores and fast food outlets to the number of grocery stores and specialty stores (15, 267).

Objective consumer nutrition environment measures

Within-store measures included the NEMS-S, which purportedly assesses food availability, food quality, and food affordability (37), and linear shelf-space measures of energy-dense snack foods (salty snack foods, cookies and crackers, donuts and pastries, candy, and carbonated beverages) and of fruits and vegetables (fresh, canned and frozen), which purportedly assess food availability (14, 122). Restaurants were assessed using the NEMS-R, which purportedly assesses food access, food availability, food affordability, and barriers and facilitators to healthy eating in restaurants (38).

2.3 Data Analysis

Before proceeding with mediation analyses, BMI and diet quality score clustering within administratively-bound neighbourhoods (defined by postal forward sortation area (FSA)) was examined. The degree of dependence was measured by calculating the ICC between FSA and BMI (small ICC of 0.044, p=0.070), and FSA and HEI score (very small ICC of 0.002, p=0.471), suggesting that BMI and diet quality were independent -0.036 for availability perceptions, p=0.912; ICC= -0.040 for affordability, p=0.933, and; ICC= -0.038 for quality, p=0.926). Therefore, it was unnecessary to account for clustering within FSAs. SPSS 20.0 was used to determine the ICCs.

The contribution of residents' perceptions to diet quality, BMI and WC were examined using mediation tests described by Baron and Kenny (26). Series of multiple regression models evaluated various associations. *Path A* models examined associations between food environment variables and perceptions; *Path B* models examined associations between perceptions and outcomes; *Path C* models examined associations between objective food environment variables and outcomes; and *Path C'* models examined association between objective food environment variables and outcomes, controlling for perceptions (see figure 5-1). These series of models indicate mediated effects by which food environment variables affect outcomes through residents' perceptions.

Males and females have been found to respond differently to food environment features (5, 232, 233, 268), and indeed, preliminary analyses indicated that associations between food environment variables and outcomes differed by sex (265). Therefore models were sex-specific.

Analyses were conducted in four steps; all models described below were sex-specific and adjusted for age, highest education-level reached by adults, household income, and car ownership. First, Path A used linear regressions to regress food environment perceptions on objective food environment measures, since both variables were at the household level. Second, multilevel linear regressions were used to create Path B models, where perceptions were entered as predictors of individual-level outcomes (BMI, WC, and diet quality), which were considered continuous variables. In Path B models, diet quality, BMI and WC were regressed on all preceding variables (individual- and household-level covariates, perceptions, and objective measures) to determine the extent to which perceptual variables predicted outcomes given different objective measures. Third, Path C models employed multilevel linear regressions, with objective food environment variables entered as household-level predictors of individual-level outcomes (BMI, WC, and diet quality). Outcomes were considered continuous variables, since health risks associated with elevated BMI and WC or decreased diet quality are not dichotomous – they change incrementally. Different food environment variables were entered into separate models, but different scores from the same type of methodology (NEMS-S, NEMS-R, and intensity) were entered together, consistent with previous food environment research (153). Path C models therefore estimate the total, direct effect of objective food environment variables on individual-level diet-related outcomes.

Finally, Path C' models were created in the same manner as the Path C models, but additionally included both perceptual variables. Path C' models therefore estimate the indirect effect of objective food environment variables on individual-level outcomes mediated by perceptions. The Sobel test (269) was employed to examine whether mediation was statistically significant.

SPSS 20.0 was used for the Path A linear regressions; HLM 7 was used for the multilevel regression analyses. Because initial results indicated that BMI, WC and both perceptual variables were both slightly positively skewed, Box-Cox transformations were used to improve the normality of these variables (234). For all analyses, p=0.05 was considered statistically significant. In all models, data were weighted to reflect Census 2006 totals for the area.

3. Results

3.1 Food environment and study sample characteristics

Table 5-2 shows characteristics of the food environment variables assessed in the current study. On average, participants lived almost twice as far from the nearest grocery store as they did from the nearest convenience store and the nearest fast food outlet. Participants had an average of about nine stores and 20 restaurants within 1000m, and had an average of about four different kinds of food outlets available within 1000m of home. Mean RFEI score was 5.6, indicating that there were 5.6 times as many fast food and convenience stores as there were grocery stores and specialty stores within 1000m of home. Participants had an average of about 420m of shelf space dedicated to energy-dense snack foods, and 126m of shelf space dedicated to fruits and vegetables within 1000m of home. Mean NEMS-S and NEMS-R scores are additionally described in Table 5-2.

Table 5-3 outlines sample characteristics. The sample was fairly evenly split by sex (52.7% female, 47.3% male), and had high rates of car ownership (approximately 90% of households owned cars). The sample was fairly highly educated (42.1% of men and 40.3% of women had completed at least a university degree), and about one-third of households had incomes of over $85,000 per year.

3.2 Path A: Objective food environment variables predicting perceptions

Table 5-4 shows the strongest predictors (largest B values) of *access*-related perceptions were linear shelf space of fruits and vegetables ($B=2.31$, $p<0.001$), linear shelf-space of energy-dense snack foods ($B=0.52$, $p<0.001$), and distance to the nearest grocery store ($B=-0.39$, $p<0.001$). Other objective measures that significantly predicted *access* related perceptions included distance to the nearest fast food outlet, diversity, store intensity, NEMS-S availability and quality, NEMS-R barriers and facilitators to healthy eating, and the mean healthy food basket price.

The strongest predictors of *affordability* perceptions included distance to the nearest fast food outlet ($B=-0.15$, $p=0.002$), distance to the nearest convenience store ($B=-0.11$, $p=0.031$), and linear shelf-space of fruits and vegetables ($B=-0.45$, $p=0.012$). The only objective measure purportedly assessing food *affordability* that significantly predicted affordability perceptions was the healthy food basket price ($B=-0.002$, p=0.029). Other significant predictors of affordability perceptions included store and restaurant intensity, the RFEI, and the NEMS-R access score.

3.3 Path B: Perceptions predicting outcomes

Diet-related outcomes were not predicted by perceptual variables among males or females, with the exception of *access*-related perceptions significantly predicting diet quality among males in several models, including models that accounted for distance to the nearest convenience store, distance to the nearest fast food outlet, store intensity, and the RFEI (range across all Path B models: B=0.91, p=0.083 to B=1.09, p=0.035). Table 5-5 shows results from the Path B analyses; as mentioned, ranges represent regression coefficients for the perceptual variables across regressions for all objective measures (since Path B analyses regressed outcomes on perceptual variables and all preceding variables).

3.4 Path C: Food environment variables predictive of diet quality, BMI, and waist circumference

3.4.1 Diet quality

Table 5-6 shows results from all Path C models. For females, no food environment variables significantly predicted diet quality. For males, the only food environment variable that significantly predicted diet quality was NEMS-S availability (B=0.34, p=0.005), although three additional variables approached significance in terms of predicting diet quality: distance to the nearest grocery store (B=-1.41, p=0.065), shelf-space of fruits and vegetables (B=8.33, p=0.061), and the mean healthy food basket price within 1km of home (B=0.04, p=0.056).

3.4.2 Obesity: body mass index and waist circumference

Of objective community nutrition environment measures, for women, distance from home to the nearest convenience store was the strongest predictor of BMI (B=-2.23(0.63), p<0.001) and WC (B=-6.41(1.42) p<0.001). Store and restaurant intensity also significantly predicted BMI (B=0.09(0.04) p=0.027 and B=-0.04(0.02), p=0.014, respectively), and distance to the nearest fast food outlet significantly predicted WC (B=-4.95(1.42) p<0.001). Of the consumer nutrition environment measures, NEMS-S affordability predicted BMI and WC (B=-0.60 (0.26) p=0.022 and B=-1.42 (0.64) p=0.027, respectively) and NEMS-R availability and barriers and facilitators to healthy eating predicted BMI (B=-0.32(0.12) p=0.006 and B=0.17(0.08) p=0.023, respectively).

Of objective community nutrition environment measures, for men, distance from home to the nearest grocery store and restaurant intensity significantly predicted BMI (B=0.52(0.22) p=0.020 and B=-0.03(0.01) p=0.024), and the RFEI significantly predicted WC (B=0.18 (0.08) p=0.025). Of the consumer nutrition environment measures, NEMS-S affordability significantly predicted both BMI and WC (B=-0.55 (0.24) p=0.021 and B=-1.42 (0.59), p=0.016) and NEMS-R barriers and facilitators to health eating significantly predicted WC (B=0.33 (0.16) p=0.043).

3.5 Path C': Mediation

Table 5-7 presents results from Path C' models. In several cases, regression coefficients decreased and p values were higher between Path C and Path C' models; in these instances, the Sobel test was employed to examine whether mediation was statistically significant. In all cases, the Sobel test revealed insignificant mediation – that is, perceptions did not explain the relationship between objective food environment measures and diet-related outcomes. For example, whether the effect of distance from home to the nearest grocery store on males' diet quality was mediated by access-related perceptions was tested since the predictive value of distance to the nearest grocery store decreased after including the perceptual variables, but the Sobel test showed no significant mediation (-1.69 (0.22), p=0.090). Similarly, potential mediation of the association between fruit and vegetable shelf-space and males' diet quality by access-related perceptions showed an insignificant result from the Sobel test (1.69 (1.28), p=0.090).

5. Discussion

This study used data from a population-based sample in three spatially contiguous cities in Southern Ontario, Canada to test the theoretical hypothesis that perceptions mediate associations between the objective food environment and diet-related outcomes. Associations between objective measures and residents' diet-related outcomes did not appear to be mediated by residents' perceptions, which has implications for theory, research, and policy.

First, in terms of theory, several researchers have called for the inclusion of perceptual measures to aid our understanding of environmental influences on food choice, and have noted that testing mediators can help to identify intervention points (5, 7, 92, 219). Moreover, perceptions are thought to tap into constructs that may reflect residents' use of their food environments (43, 92, 260, 261). Glanz and colleagues' early, widely-cited conceptual model of community nutrition environments (1) identifies residents' perceptions as being potential mediators of the relationship between objectively-measured food environment characteristics and eating patterns; ours was the first study to our knowledge to directly test this theoretical link. In our study, perceptions did not, in fact, mediate the relationship between objective measures of the food environment and residents' diet-related outcomes, and results instead indicated direct effects of several objective food environment measures on these outcomes. Interestingly, although results from Path A models showed that residents' perceptions were indeed predicted by a number of objective food environment measures, perceptions were not predictive of diet-related outcomes (with the exception of access-related perceptions predicting diet quality among males). It would be interesting to know if perceptions predicted other psychosocial variables or food behaviours that were not assessed in the current study (for example, motivations for dietary choices or food purchasing). In other studies, where perceptions have been found to predict diet-related outcomes (161, 260-263), results may have differed, since mediators, by definition, predict the outcome of interest. Follow-up analyses using data from studies that have examined both objective and perceived measures in relation to one or more diet related health outcome, and have found that perceptions did significantly predict outcomes (e.g., (260, 270) are warranted.

Second, in terms of research, finding that perceptions did not mediate associations between objective food environment measures and diet-related outcomes indicates that future investigations into factors that do mediate these associations are needed. For example, food purchasing behaviours seem, theoretically, to be a likely mediator by which local food access or aspects of the consumer nutrition environment "get under the skin." For example, in the current study, distance from home to the nearest convenience store significantly predicted BMI and WC for females; the further females lived away from the closest convenience store, the lower their BMI and WC. It seems plausible that a potential mechanism by which convenience store proximity might impact females' weight is through increased food purchasing from convenience stores, which tend to have a plethora of energy dense snack foods available relative to other food outlet types (120, 239). No studies to our knowledge have examined food purchasing behaviours as mediators between food environment characteristics and diet-related outcomes; there is a clear need for this kind of research to contribute to our understanding of food environment theory and research.

While a better understanding of the relationship between objective and perceived measures can help to refine assessment methodologies and facilitate the interpretation of food environment studies (18, 41, 160), questions remain about the relationship between objective and perceived measures. Both access-related and affordability perceptions were predicted by respondents' income: at higher income levels, residents perceived poorer access, availability and quality, and poorer affordability in their neighbourhoods than elsewhere in their cities. These perceptions corresponded with objective access-related measures (e.g., grocery stores were 180m further from high- relative to low-income households and 171m further from car-owners than non-car-owners, $p<0.001$ for both). On the other hand, affordability perceptions were not reflected by objective measures: income level was unrelated to either mean healthy food basket cost ($B=0.009$, $p=0.902$) or NEMS-S affordability scores ($B<0.001$; $p=0.873$) and car-owners actually had lower mean healthy food basket cost within 1km of home ($B=-2.05$, $p<0.001$) (despite slightly lower NEMS-S affordability scores ($B=-0.02$, $p<0.001$)). It seems counterintuitive that higher income households would perceive worse food affordability, since food affordability is generally deemed to be relative to purchasing power, and also because objective food affordability data generally did not support these perceptions. That said, results from a multitrait-multimethod matrix examining convergent validity between residents' perceptions of affordability and the NEMS-S affordability score revealed very low correlation ($r=0.029$) (220), so the fact that perceptions did not reflect objective measures were not surprising. These results speak to the complex interplay of factors that may determine residents' perceptions. For example, the perceptual questions related to affordability were fairly general; residents were asked about the cost of "produce" and "low fat products" in their neighbourhoods relative to other neighbourhoods rather than specific fruits and vegetables or specific low-fat products. It is possible that the specific types of foods respondents thought about when responding to these questions differed by income level.

Finally, access-related perceptions were more strongly predicted by consumer nutrition environment measures (specifically linear shelf-space of fruits and vegetables) than by community nutrition environment measures, which reflects the importance of extending traditional examinations of community nutrition environments to consider consumer nutrition environments as well.

Third, from a policy and programming perspective, the results of this study indicate residents' perceptions would not be a meaningful point of intervention for diet-related outcomes, since perceptions were not on the "causal pathway" between objective measures and those outcomes. Given the cross-sectional nature of the current study, it is impossible to know whether acting on objective food environment features through zoning regulations or healthy corner stores programs would be an effective strategy in promoting healthy diets or weights among residents; nevertheless, it appears that improving the objective food environment may be a more promising strategy in this study setting than would increasing residents' awareness of local, nutritious options. While we recognize that the development of policies and programs depends on more than evidence, there are several policy priorities identified in the Region of Waterloo's Regional Official Plan related to improving food access for residents (19, 20). Therefore, the current study can help public health planners to determine policy or program solutions that will be both acceptable and evidence-based in a jurisdiction already supportive of healthy food environments.

Like most food environment research, this study was limited by its cross-sectional nature (5, 7-9). Because "neighbourhoods and individual behaviours evolve over time through complex, inter-related processes" (271)(p. e37), longitudinal studies are needed to observe changes in the food environment related to changes in residents' diet-related outcomes. Moreover, longitudinal studies can contribute to an understanding of neighbourhood health effects by addressing individual characteristics than contribute to the inter-related processes mentioned above (272). Another limitation of the current study was that only food environments around home were examined, to the exclusion of other potentially meaningful places. Although this is common practice (5), more theoretically sound ways of conceptualizing food environments should be tested (for example, recent work on activity spaces – evaluating individuals' travel patterns to see where they actually go throughout their daily lives – seems to hold promise for the field of food environment research (175, 177, 273)). These limitations, however, are outweighed by the strengths of the study, which include the use of a large, population-based sample from a range of incomes, the incorporation of a variety of objective community and consumer nutrition environment measures as well as perceptual variables, and the inclusion of diet quality, BMI, and WC as relevant outcomes of interest. Results from this study suggest that several objective food environment measures (notably convenience store access for women, grocery store access for men and relative food affordability in stores for both sexes) predict diet-related outcomes relevant to public health independent of how residents' perceive their food environments. These results can contribute to the development of policies or programs aimed at improving food environments in jurisdictions where policy makers are ready to act.

Table 5-1: Description of food environment measures

Instrument	Outlet type assessed	Constructs Addressed	Methodology
Objective Community Nutrition Environment			
Proximity to the nearest food outlet of a certain type (153)	Stores and restaurants	Access	The network distance (m) from a respondent's home to the nearest grocery store, the nearest convenience store, and the nearest fast food outlet.
Intensity(153)	Stores Restaurants	Access	The number of food stores or restaurants within a given buffer zone
Diversity (153)	Stores and restaurants	Access	The number of diverse types of food outlets (five types of food stores (convenience, grocery stores, specialty food stores, pharmacies, and warehouse clubs and superstores) and two types of restaurants (limited-service and full-service)) within 1000m of home; min: 0; max: 7, with '7' indicating the presence of all types of food outlets
RFEI(15)	Stores and restaurants	Access	Geographic analysis of ratio of number of fast-food outlets and convenience stores to grocery and specialty stores
Objective Consumer Nutrition Environment			
Shelf-space measures (122)	Stores	Availability	Two variables: Cumulative linear shelf-space of fruits and vegetables (including fresh, frozen and canned varieties) (m), and the cumulative linear shelf-space of energy-dense snack foods (including candies, carbonated beverages, salty snack foods, cookies and crackers, donuts and pastries) (m)
NEMS-S Checklist (37)	Stores	Availability Affordability Quality	Objective audits of food stores: mean NEMS-S scores within 1000m of home for each construct (e.g., mean NEMS-S availability, mean NEMS-S affordability, and mean NEMS-S quality) were computed
NEMS-R Checklist (38)	Restaurants	Availability Affordability Barriers and Facilitators	Objective audits of restaurants: mean NEMS-R scores within 1000m of home for each construct (e.g., mean NEMS-R availability, mean NEMS-R affordability, and mean NEMS-R barriers and facilitators) were computed.

Instrument	Outlet type assessed	Constructs Addressed	Methodology
Perceptual Variables			
Neighbourhood food environment perceptions(160, 196)	Stores and restaurants	Access Availability Affordability Quality	Agreement with the following statements on a 4-point Likert scale assessed residents' perceptions. **Access**: "There are no food outlets in my neighbourhood*"; "It is easy to purchase fresh fruits and vegetables in my neighbourhood"; "It is easy to purchase low-fat products (such as low-fat milk or lean meats) in my neighbourhood"; "There are a lot of fast food restaurants in my neighbourhood*" **Availability**: "There is a large selection of fresh fruits and vegetables available in my neighbourhood"; "There is a large selection of low-fat products available in my neighbourhood"; "It is easy to eat healthily at the restaurants in my neighbourhood." **Affordability**: "I shop elsewhere because the prices in my neighbourhood are too high*"; "The produce in my neighbourhood is more expensive than that in other neighbourhoods*"; "The low-fat products in my neighbourhood are more expensive than those in other areas.*" **Quality**: "The fresh produce in my neighbourhood is of high quality"; "The low-fat products in my neighbourhood are of high quality." (* items were reverse-scored)

Table 5-2: Descriptive food environment characteristics

Food environment characteristic	Mean (SD) or %
Distance from home to nearest grocery store (m)	1001 (649)
Distance from home to nearest convenience store (m)	526 (374)
Distance from home to nearest fast food outlet (m)	582 (410)
Store intensity within 1000m	8.6 (8.8)
Restaurant intensity within 1000m	19.9 (25.1)
Diversity within 1000m	4.3 (1.8)
RFEI within 1000m	5.6 (5.4)
Shelf space of energy-dense snack food (m) within 1000m	419.5 (368.2)
Shelf space of fruits and vegetables (m) within 1000m	126.4 (119.0)
NEMS-S mean availability score within 1000m	11.8 (5.3)
NEMS-S mean affordability score within 1000m	-0.5 (0.6)
NEMS-S mean quality score within 1000m	2.3 (1.5)
NEMS-R mean availability score within 1000m	7.0 (2.8)
NEMS-R mean affordability score within 1000m	-1.3 (0.8)
NEMS-R mean facilitators and barriers score within 1000m	3.7 (2.9)
NEMS-R mean access score within 1000m	10.4 (3.3)

Table 5-3: Sample characteristics

	Female: Mean (SD) or %	Male: Mean (SD) or %
High household income (%)	31.3	31.4
Car Ownership (%)	92.4	86.5
Age (mean (SD))	41.4 (18.0)	40.9 (17.7)
Adults with at least a university degree (%)	40.3	42.1
Average HEI score (mean (SD))	54.6 (9.8)	50.8 (9.5)
BMI (mean (SD))	26.8 (6.3)	27.6 (5.5)
WC (mean (SD))	86.2 (16.1)	94.1 (15.3)

Table 5-4: Path A results, objective food environment variables predictive of perceptions

Objective Variables	Perceived Access, Availability, Quality	Perceived Affordability
Income	-0.064(0.028)*	-0.146(0.028)***
Car Ownership	0.060 (0.067)	-0.309(0.066)***
Community Nutrition Environment		
Distance to nearest grocery store (km) (SD)	-0.390(0.030)***	0.007(0.031)
Distance to nearest convenience store (km) (SD)	-0.068(0.053)	-0.112(0.052)*
Distance to the nearest fast food outlet (km) (SD)	-0.144(0.047)**	-0.146(0.046)**
Diversity (SD)	0.112(0.012)***	-0.013(0.012)
Intensity: Stores (SD)	0.014(0.005)**	-0.015(0.005)**
Intensity: Restaurants (SD)	-0.002(0.002)	0.005(0.002)**
RFEI (SD)	-0.004(0.004)	0.012(0.004)***
Consumer Nutrition Environment		
Fruit and Vegetable Shelf-Space (km) (SD)	2.31(0.18)***	-0.445(0.117)*
Energy Dense Shelf-Space (km) (SD)	0.517(0.060)***	-0.106(0.059)
NEMS-S Availability (SD)	0.044(0.006)***	0.003(0.006)
NEMS-S Affordability (SD)	-0.019(0.040)	0.002(0.039)
NEMS-S Quality (SD)	-0.071(0.020)***	0.003(0.019)
NEMS-R Availability (SD)	0.009(0.016)	-0.010(0.015)
NEMS-R Affordability	0.022(0.034)	0.014(0.033)
NEMS-R Barriers and facilitators to healthy eating	0.033(0.010)***	-0.017(0.010)
NEMS-R Access	0.018(0.012)	0.027(0.012)*
Mean Healthy Food Basket total price	0.014(0.001)***	-0.002(0.001)*

* significant at p<0.05; ** significant at p<0.01; ***significant at p<0.001

Table 5-5: Path B, diet quality, body mass index (BMI) and waist circumference (WC) regressed on perceptions (ranges from all path B regressions)

	Females			Males		
	Diet Quality	BMI	WC (cm)	Diet Quality	BMI	WC (cm)
Individual-level characteristics						
Age (Beta, SE)	0.04(0.02)	0.10 (0.008)***	0.27 (0.02)***	0.006(0.025)	0.10 (0.008)***	0.36 (0.02)***
Education level (Beta, SE)	1.39 (0.47)**	-0.84 (0.18)***	-2.09 (0.46)***	1.26 (0.54)*	-0.18(0.15)	-0.07(0.39)
Household-level characteristics						
Income (Beta, SE)	0.66(0.63)	-0.58(0.26)*	-1.58(0.61)**	-0.77(0.71)	-0.11(0.22)	-0.92(0.59)
Car ownership (Beta, SE)	1.45(1.55)	-1.47(0.91)	-2.18(1.94)	-0.20(1.97)	1.71(0.77)*	3.19(1.93)
Perceptions						
Access-related (Beta, SE)	-0.06(0.49) p=0.901 to 0.31(0.48) p=0.522	-0.10(0.16) p=0.560 to -0.05(0.17), p=0.766	0.19(0.42) p=0.659 to 0.26(0.42) p=0.544	0.91(0.52) p=0.083 to 1.09(0.52) p=0.035	-0.20(0.14) p=0.163 to -0.09(0.15) p=0.541	-0.53(0.36) to -0.35(0.36) p=0.343
Food affordability (Beta, SE)	0.16(0.50) p=0.736 to 0.26(0.49) p=0.596	-0.16(0.16) p=0.307 to -0.12(0.16) p=0.434	-0.05(0.38) p=0.892 to 0.07(0.38) p=0.847	0.69(0.50) p=0.174 to 0.73(0.50) p=0.147	-0.05(0.14) p=0.697 to -0.02(0.14) p=0.861	-0.32(0.34) p=0.342 to -0.25(0.35) p=0.476

* significant at p<0.05; ** significant at p<0.01; ***significant at p<0.001

Table 5-6: Path C regression coefficients for multi-level analysis of household- and individual-level factors associated with diet quality, body mass index (BMI), and waist circumference (WC)

	Female			Male		
	DietQuality	BMI	WC	Diet Quality	BMI	WC
Community Nutrition Environment						
Distance to nearest grocery store (km) (SD)	-1.56(1.06)	0.19(0.28)	0.10(0.70)	-1.41 (0.76)	0.52 (0.22)*	0.48 (0.59)
Distance to nearest convenience store (km) (SD)	2.19(1.95)	-2.23(0.63)***	-6.41(1.52)***	1.96(1.74)	0.09(0.52)	-0.98(1.35)
Distance to the nearest fast food outlet (km) (SD)	1.97(1.79)	-1.07(0.58)	-4.95(1.42)***	0.019(1.53)	-0.49(0.51)	-1.73(1.310)
Diversity (SD)	-0.08(0.30)	-0.02(0.12)	0.01(0.29)	0.39(0.31)	-0.12(0.10)	-0.16(0.25)
Intensity: Stores (SD)	-0.04(0.10)	0.09(0.04)*	0.18(0.10)	-0.11(0.12)	0.05(0.04)	0.10(0.08)
Intensity: Restaurants (SD)	0.01(0.04)	-0.04(0.02)*	-0.06(0.04)	0.06(0.05)	-0.03(0.01)*	-0.05(0.03)
RFEI (SD)	-0.09(0.07)	0.04(0.04)	0.09(0.08)	-0.12(0.08)	0.07(0.04)	0.18(0.08)*
Consumer NE						
Fruit and Vegetable Shelf-Space (km) (SD)	5.51(4.39)	-0.10(1.40)	1.17(3.33)	8.33(4.43)	-0.99(1.18)	-0.17(2.99)
Energy Dense Shelf-Space (km) (SD)	0.37(1.29)	-0.16(0.50)	0.29(1.21)	1.58(1.45)	-0.64(0.41)	-0.43(1.07)
NEMS-S Availability (SD)	0.07(0.15)	-0.09(0.05)	-0.14(0.11)	0.34(0.12)**	-0.06(0.04)	-0.12(0.09)
NEMS-S Affordability (SD)	0.89(0.87)	-0.60(0.26)*	-1.42(0.64)*	0.31(0.75)	-0.55(0.24)*	-1.42(0.59)*
NEMS-S Quality (SD)	0.11(0.42)	0.05(0.14)	0.33(0.35)	-0.50(0.35)	0.02(0.11)	-0.0007(0.30)
NEMS-R Availability (SD)	-0.45(0.33)	-0.32(0.12)**	-0.18(0.28)	0.13(0.29)	-0.16(0.10)	-0.17(0.26)
NEMS-R Affordability	-0.61(0.70)	-0.03(0.25)	0.21(0.58)	0.45(0.63)	-0.19(0.19)	-0.23(0.51)
NEMS-R Barriers and facilitators to healthy eating	0.29(0.27)	0.17(0.08)*	0.18(0.18)	-0.20(0.23)	0.10(0.06)	0.33(0.16)*
NEMS-R Access	-0.11(0.29)	0.17(0.09)	0.45(0.23)	0.17(0.25)	0.14(0.08)	0.23(0.22)
Mean Healthy Food Basket total price	0.02(0.03)	-0.001(0.008)	0.004(0.02)	0.04(0.02)	-0.006(0.006)	-0.001(0.02)

* significant at p<0.05; ** significant at p<0.01; ***significant at p<0.001

Table 5-7: Path C’, diet quality, body mass index (BMI) and waist circumference (WC) regressed on all covariates, perceptions, and objective measures

	Female			Male		
	Diet Quality	BMI	WC	Diet Quality	BMI	WC
Community Nutrition Environment						
Distance to nearest grocery store (km) (SD)	-1.62(1.11)	0.17(0.29)	0.27(0.71)	-0.94(0.83)	0.47(0.23)*	0.32(0.61)
Distance to nearest convenience store (km) (SD)	2.24(1.96)	-2.25(0.63)***	-6.40(1.51)***	2.00(1.70)	0.10(0.53)	-0.96(1.35)
Distance to the nearest fast food outlet (km) (SD)	2.12(1.81)	-1.15(0.58)*	-5.08(1.44)***	0.16(1.52)	-0.54(0.51)	-1.88(1.32)
Diversity (SD)	-0.06(0.27)	-0.01(0.12)	-0.05(0.35)	0.29(0.33)	-0.10(0.10)	-0.13(0.25)
Intensity: Stores (SD)	-0.03(0.10)	0.09(0.04)*	0.18(0.10)	-0.12(0.12)	0.05(0.04)	0.09(0.09)
Intensity: Restaurants (SD)	0.01(0.04)	-0.04(0.02)*	-0.06(0.04)	0.06(0.05)	-0.03(0.01)*	-0.05(0.03)
RFEI (SD)	-0.09(0.07)	0.04(0.04)	0.09(0.08)	-0.11(0.07)	0.07(0.04)*	0.18(0.08)*
Consumer NE						
Fruit and Vegetable Shelf-Space (km) (SD)	5.60(4.38)	0.05(1.49)	0.62(3.43)	7.01(4.58)	-0.64(1.23)	0.61(3.07)
Energy Dense Shelf-Space (km) (SD)	0.33(1.27)	-0.14(0.53)	0.14(1.24)	1.41(1.47)	-0.57(0.42)	-0.28(1.09)
NEMS-S Availability (SD)	0.06(0.15)	-0.08(0.05)	-0.15(0.11)	0.29(0.12)*	-0.05(0.04)	-0.10(0.09)
NEMS-S Affordability (SD)	0.93(0.87)	-0.60(0.26)*	-1.43(0.64)*	0.42(0.73)	-0.58(0.24)*	-1.46(0.59)*
NEMS-S Quality (SD)	0.13(0.43)	0.05(0.14)	0.34(0.35)	-0.37(0.37)	0.01(0.11)	-0.03(0.28)
NEMS-R Availability (SD)	-0.44(0.33)	-0.32(0.11)**	-0.18(0.28)	0.18(0.29)	-0.17(0.10)	-0.18(0.26)
NEMS-R Affordability	-0.60(0.71)	-0.03(0.25)	0.21(0.58)	0.30(0.62)	-0.19(0.19)	-0.22(0.51)
NEMS-R Barriers and facilitators to healthy eating	0.31(0.26)	0.17(0.08)*	0.19(0.18)	-0.20(0.22)	0.10(0.06)	0.34(0.16)*
NEMS-R Access	-0.13(0.29)	0.18(0.09)	0.44(0.23)	0.08(0.25)	0.15(0.13)	0.24(0.22)
Mean Healthy Food Basket total price	0.02(0.03)	-0.0002(0.008)	0.0006(0.02)	0.03(0.02)	-0.004(0.007)	0.003(0.02)

* significant at p<0.05; ** significant at p<0.01; ***significant at p<0.001

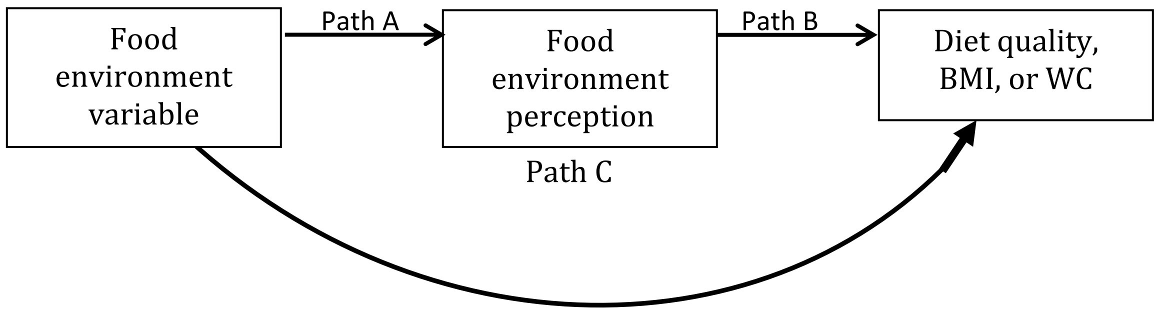

Figure 5-1: Path A, Path B, and Path C tested in the mediation analyses

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Chapter 6. Contributions, implications for policy and practice, and future directions

1. Introduction

The preceding chapters have evaluated both operational and syntactical components of the construct validity of food environment assessment methods, and have contributed to our understanding of how food environments "get under the skin" of residents by explicitly testing conceptual pathways identified in Glanz and colleagues' conceptual model (1). These studies have contributed to knowledge advancement by addressing some of the most prominent gaps in the extant literature, and have implications for policy and practice. This chapter will identify this dissertation's main contributions to theoretical and methodological advancement, will describe implications for policy and practice, and will outline directions for future research.

2. Contribution to knowledge development

2.1 Theoretical contributions: Refining the conceptual model

Glanz and colleague's conceptual model (1)was refined based on the following discussion; the refined model is shown in Figure 6-1. Specific refinements include the modification of food environment constructs identified within the community and consumer nutrition environments, the inclusion of weight outcomes as outcomes of interest, and the inclusion of "food procurement" as a mediator between environmental variables and outcomes of interest. This section will first discuss how specific features of Glanz and colleagues' model were evaluated by the research presented in this dissertation. Next, the extent to which separate food environment constructs identified by Glanz and colleagues appeared to actually be separate and distinct will be discussed. The addition of weight outcomes to the model will next be described. Finally, the inclusion of food procurement as a mediator will be explained.

2.1.1 Using Glanz and colleagues' model to inform the research

As outlined in the introductory chapter, this dissertation aimed to examine aspects of the *community* nutrition environment (operationalized using various food access measures including proximity, density, variety (274), and the retail food environment index (RFEI) (15)), the *consumer* nutrition environment (operationalized using within-outlet measures, including shelf-space measures (14, 122), the Nutrition

Environment Measures Survey – Stores (NEMS-S)(37), and the Nutrition Environment Measures Survey – Restaurants (NEMS-R)(38)), and the *perceived* nutrition environment in relation to residents' diet related outcomes. As per the original conceptual model, in Chapter 4, measures purportedly assessing aspects of the community, consumer, and perceived nutrition environments were examined as direct predictors of diet-related outcomes, such as diet quality and weight status. In Chapter 5, objective measures of the community and consumer nutrition environments were examined as indirect predictors of outcomes mediated by perceptions.

As described in Chapter 2, Glanz and colleagues' parsimonious model was used to inform the design of the research described in this dissertation because it was seen to be particularly helpful in terms of categorizing food environment exposures and specifying hypothesized pathways by which features of the food environment affect diet quality and weight-related outcomes. In addition, Glanz and colleagues' model presented clear conceptual pathways from which specific statistical procedures could be inferred (such as statistical tests for mediation, as outlined in Chapter 5, or the use of multilevel models, as implied by the model's inclusion of different levels of influence). Ecological models can be useful for conceptualizing the interdependence of people, health outcomes, and their environments (216), and the previous chapters reveal several features of Glanz and colleagues' model that could be refined based on the empirical evidence presented here. These three key refinements will be presented in more detail below.

2.1.2 Teasing out food environment constructs

In terms of measuring constructs, four food environment constructs emerged from the literature presented in Chapter 2 and Glanz and colleagues' conceptual model: food access, food availability, food affordability, and food quality. Food access represents the community nutrition environment described by Glanz and colleagues, whereas food availability, affordability and quality comprise the consumer nutrition environment. Findings from the multitrait-multimethod (MTMM) matrices presented in Chapter 3, however, revealed low convergent validity among measures purportedly assessing the same constructs, indicating that measures purportedly assessing the same constructs may in fact have been measuring different underlying constructs (implications of these findings are discussed below). Further, residents' perceptions showed low correlations with objective measures along the same constructs (e.g., convergent correlation coefficients ranged from 0.029 to 0.262 for correlations between objective and perceptual variables at 1000m). Low convergent validity was found both between objective measures purportedly assessing the same constructs and between objective and perceived measures purportedly assessing the same constructs. On the other hand, discriminant validity coefficients between food availability and food quality were more highly correlated than any of the convergent validity coefficients for both the NEMS-S measure (r=0.427) and perceptual variables (r=0.830), indicating that these two constructs may not be as separate and distinct as previously hypothesized. Finally, in Chapters 4 and 5, two perceptual variables ("access-related" and "affordability") were created from questions initially intended to create perceptual variables along each of the four constructs, since food access, availability, and quality perceptions were all highly correlated (Cronbach's alpha based on standardized items for the three scores was 0.904).

Findings from the research presented here indicate that in this study setting, residents tended to perceive access, availability and quality similarly, while affordability perceptions were unrelated to the other perceptions. While Glanz and colleagues hypothesized that community and consumer nutrition environments are separate, findings indicate that objective measures may not distinguish well between quality and availability, and perceptual measures may not distinguish well between food access, availability and quality, although affordability seems to represent a separate and distinct construct. Based on these findings, refinements made to Glanz and colleagues' model include the addition of "food availability and food quality" to the community nutrition environment, and the deletion of "available healthy options" from the consumer nutrition environment (figure 6-1).

As mentioned above, it is unclear which underlying constructs are actually being measured by the food environment assessment methods employed in this dissertation. In her thoughtful paper on the state of the science in measuring food environments, Lytle (36) presented an example of a causal model linking an environmental attribute with population-level disease. In this model, the food environment assessment (store availability of low-fat milk relative to high-fat milk) is linked through a number of sequential arrows to low-fat milk purchases, low-fat milk consumption, dietary fat intake of store customers, and, finally, to population-level disease related to fat in the diet. In order to "tease out" pertinent food environment constructs, it will be necessary to examine mediators hypothesized to transmit the effect of the food environment feature to individual health or diet-related outcomes, as described below. In Chapters 4 and 5, by including objective food environment variables in predictive models, objective measures were treated as if they actually assessed what they purported to assess, despite the low convergent validity seen in Chapter 3. This is because specific mediators were not examined in this research and because of the vast number of extant food environment assessment methods, it was still an important contribution to examine which of the many food environment measures employed predicted diet- and weight-related outcomes. A substantial contribution to the field of food environment assessment could be made by future research that examines mediators to further clarify constructs of interest. Hypothesized mediators are described below, in section 2.1.4.

2.1.3 Including weight outcomes

The research presented in this dissertation deviated from Glanz and colleagues' original model by examining weight outcomes as outcomes of interest in addition to "eating patterns", which were operationalized in these studies using a comprehensive indicator of diet quality. As stated in Chapter 1, one of the goals of this dissertation was to examine the extent different food environment assessment methods predicted a variety of diet-related outcomes; therefore, diet quality was not tested as a mediator between food environment features and weight outcomes, as would be indicated by figure 6-1. Specifically, in figure 6-1, weight outcomes are seen as being indirectly (i.e., through eating patterns) (22-24) affected by the food environment, and therefore eating patterns could be tested as mediators in future research. Eating patterns may be considered a more proximal outcome of interest (after all, food environment characteristics are expected to act through dietary mechanisms to affect obesity outcomes); as such, it would be expected that food environment features would more strongly predict eating patterns than obesity measures. A previous systematic review found food environment features to more strongly predict weight outcomes than dietary outcomes (8) consistent with findings from this dissertation. For example, results from this dissertation indicated that while several food environment features predicted weight outcomes among both men and women, diet quality was only significantly predicted by NEMS-S availability at 1000m buffers among males (B=0.34 (0.12), $p<0.01$). This is perhaps explained by the diet quality measure reflecting the quality of the diet rather than the overconsumption of calories, which might be better reflected by the obesity measures employed. Perhaps alternative methods by which to operationalize "eating patterns" would have been better predicted by food environment features.

2.1.4 Adding food procurement as a mediator

Empirical evidence from this dissertation did not support the hypothesized indirect pathways through which objective community and consumer nutrition environment features would predict outcomes. Specifically, Glanz and colleagues' conceptual model presented residents' perceptions as mediators between objective measures and eating patterns. Findings from this research suggest that, in fact, objectively-measured features of the food environment have direct effects on weight outcomes, and are not mediated by residents' perceptions. It is possible that perceptions of usual shopping locations, rather than perceptions of the neighbourhood food environment, would indeed act as mediators between food environment characteristics. Moreover, several studies have found food environment perceptions to predict diet-related outcomes (43, 163, 260, 275). For these reasons, the "perceived nutrition environment" is retained in figure 6-1 to indicate the need for future investigation.

In the text of Glanz and colleagues' conceptual paper, they suggested that perceptions, along with other "individual" variables, may act as mediators *or* moderators (1). Perceptions as *moderators* of the relationship between objective measures and outcomes were not tested in this research, nor have they been tested as moderators in any studies of which I am aware; therefore, the following thoughts are purely speculative. It is difficult to imagine how food environment perceptions would act as moderators. Moderators are variables that change the direction and/or strength of a relationship between an independent and dependent variable (26). Is it plausible, for example, that someone who perceived a high-quality food environment would respond differently to a convenience store located at the end of their street than their next-door neighbour who perceived a low-quality food environment? It does not seem intuitive that perceptions would moderate associations between objective food environment variables and residents' diet-related outcomes. It is instead likely that in some populations, food environment perception do act as mediators; alternatively, as mentioned, different food environment perceptions (e.g., perceptions of usual shopping locations rather than neighbourhood food environments) may have predicted outcomes and may indeed have acted as mediators.

As mentioned in Chapter 5, two studies to my knowledge have employed objective food environment measures, gauged residents' perceptions, and collected data on diet-related outcomes, and unlike the research presented here, both studies found perceptual measures to significantly predict outcomes (260, 270). Mediation analyses with these datasets would be interesting to see whether, in those populations, residents' perceptions explained associations between objective measures and diet-related outcomes. Regardless, finding that perceptions did not mediate associations between objective food environment measures and diet-related outcomes in this dissertation means that the question remains, "If not perceptions, what factors *do* mediate these associations?" On this point, Glanz and colleagues' model remains relatively silent, other than suggesting that a variety of psychosocial factors may mediate or moderate environmental effects, representing an important limitation of the model.

As presented in Chapter 5, describing mediation is one way of explaining a mechanism by which one variable affects another (25). The following discussion will propose "food procurement" as a mediator that should be examined in future research to further elucidate mechanisms by which food environments affect diet-related outcomes, to clarify underlying food environment constructs, and to refine Glanz and colleagues' conceptual model.

Food procurement through commercial or alternative means seem to be an obvious conceptual mediator between food environments and diet-related outcomes. When food environment measures consist of evaluating food sources where foods are purchased (rather than given away or procured through other, non-monetary means), food purchasing patterns may hold promise as important mediators of the associations between objective food environment measures and diet-related outcomes . Several studies have examined food purchasing patterns as an outcome predicted by food environment exposure (variously defined) (43, 275-279), and several more have examined how purchasing foods from different types of outlets impact dietary behaviours (43, 163, 280) and weight status (281, 282). No studies to my knowledge have directly examined food purchasing as a mediator of associations between food environment features and diet-related outcomes. Examining household food purchasing as a mediator of the relationship between food environments and diet-related outcomes thus represents an important direction for future research.

Traditional food environment assessments (including those described in this dissertation) are restricted to food outlets where foods are sold (e.g., grocery stores, convenience stores, and restaurants), rather than where foods are given away (e.g., food banks), grown (e.g., gardens or u-pick farms), or procured through food sharing, hunting, or gathering. Examinations of these types of non-monetary food procuring practices as mediators between food environment features and diet-related outcomes have been virtually ignored to date. Different food environment assessment measures are based on different underlying assumptions and different theories about mechanisms by which environmental features affect individuals' diet-related outcomes. Unfortunately, to date, these assumptions have been mostly implicit in the literature. Adding food procurement as a mediator to Glanz and colleagues' conceptual model helps to refine it by providing researchers with more explicit hypotheses about how food environments "get into" the body; these explicit hypotheses should be reflected by researchers' selection of food environment assessment methods, and how food procurement is operationalized. Indeed, researchers should clearly justify their choice of assessment methods and should explicitly describe the theoretical relationships being tested.

2.2 Methodological and substantive contributions

Major methodological and substantive contributions were made by this dissertation in the area of food environment assessment methodology. Specific contributions included the adaptation of a MTMM matrix for environmental measures, determining how perceptual and objective measures were related, and using a number of different assessment tools to characterize food environments.

2.2.1 Adapting traditional psychometric procedures

Chapter 3 presents an adaptation of a MTMM matrix for use with environmental measures. To my knowledge, this was the first study that assessed the construct validity of environmental measures using a MTMM matrix. The field of psychometrics is more advanced than that of ecometrics or validity and reliability testing of environmental measures (196); the study presented in Chapter 3 showed that traditional psychometric procedures can successfully be adapted to evaluate the operational component of construct validity of environmental measures. In general, findings from the MTMM matrices suggested that while there is some evidence that commonly-used assessment methods agree in terms of distinguishing between the presence and absence of food outlets, they do not agree as much in how food environments should be ranked along the constructs of interest. The transferability of psychometric perspectives and understandings to the assessment of environmental measures is important because, as stated previously, assumptions about how environmental features "get under the skin" of residents are often unstated, and only become clear through the environmental measurements employed. Because the field of food environment assessment is still nascent, lessons from psychometrics can help food environment researchers to organize their assumptions and theories about different assessment methods. Using lessons from the field of psychometrics will help researchers to refine food environment measures – a recommendation made by many of the literature reviews to date (5, 7, 8, 117); pertinent findings and implications for the field of food environment assessment are described in more detail below.

Results from the MTMM matrices suggest a method effect, i.e., what is actually being measured by these instruments differs substantially by method. For example, the multi-method assessment of food availability by the RFEI and the NEMS-S showed low convergent validity, which may not be surprising, considering that the RFEI takes fast food outlets into account in addition to food stores, while the NEMS-S only accounts for food stores. Similarly, the relatively low convergent validity between shelf-space and NEMS-S may be due to the tools' measurement of different "healthy" foods: while the shelf-space measure only assessed fruits and vegetables, the NEMS-S collected data on a number of low fat and whole grain products as well.

In previous research, all of the methods examined in the MTMM matrices showed some correlation with weight status (14, 15, 140, 153), or diet quality (41, 160, 201). Low convergent validity among the examined tools might indicate different pathways through which the actual constructs measured are associated with weight status or diet quality. The different measures may be tapping into constructs that exhibit different (and even contradictory) effects on outcomes, or may tap into different mechanisms by which outcomes occur.

Results from the MTMM matrices do not support the argument that benefits of environmental assessments include less bias from self-reports and increased sensitivity to early program effects (54). Findings indicate that environmental assessment method selection will indeed influence how food environments are ranked or categorized, and that different measures purportedly assessing the same constructs may be measuring different, as yet undefined, constructs. As described above, construct definitions may become clearer through future research examining mechanisms by which food environment effects are transmitted to individual-level outcomes (e.g., through examining food procurement as a mediator).

One further methodological point regarding the adaptation of the MTMM for environmental measures is worthy of discussion. The adaptation of the MTMM matrix in Chapter 3 was potentially limited by the violation of the assumption of independent data. Using food environment measures summed or averaged at the buffer zone level resulted in a violation of the assumption of independence (since buffer zones likely overlapped), and this violation would have increased with increasing buffer zone size, since bigger buffer zones have more area to overlap. One potential method of reducing or eliminating this violation would be to use food environment variables at the administrative-boundary level. For example, discrete census tracts or forward sortation areas (FSAs) do not overlap, and therefore assumptions of independence would not be violated. That said, postal-oriented administrative boundaries are likely less meaningful to individual-food environment interactions than ego-centred buffer zones. Moreover, in the current study, one of the objectives was to examine how changing geographic scales might influence the convergent and discriminant validity coefficients in the MTMM matrices. In addition, the subsequent studies (described in Chapters 4 and 5) used buffer zones as the geographic scale of interest. Therefore, buffer zones were appropriate to operationalize the geographic scales examined in Chapter 3. Although buffer zones were chosen as appropriate geographic scales in which to aggregate food environment exposure data in this dissertation, the development of “activity spaces” as a more theoretically-grounded geographic area hypothesized to capture individuals’ food environment interactions will be described in section 4, Future Work.

One of the substantive contributions of the study presented in Chapter 3 was the finding that convergent validity coefficients between residents’ perceptions and objective measures increased with increasing geographic scale: residents’ perceptions were most strongly correlated with objective measures at the geographic scale they were asked to imagine (1-1.5km around home). This might indicate that residents are indeed able to fairly accurately conceptualize a 10-15 minute walk (i.e., 1 km) buffer zone around their homes.

A final substantive contribution in terms of implications for practice relates to the relevance of the findings of the MTMM matrices for policymakers and practitioners interested in policies aimed at improving food environments. Specifically, results did not support the notion that all food environment assessment methods purportedly measuring the same constructs, do, in fact, measure the same constructs. In the context of restricted resources and competing priorities in local public health departments, if measures were highly correlated, a recommendation could be made to use the least expensive method, since all measures assess the same construct. Based on findings from the MTMM matrices, however, it does not seem to be the case that less resource-intensive methods (e.g., the RFEI) should be used over more resource-intensive methods (e.g., the NEMS-S), since the measures seem to be assessing different constructs. To further explore these implications, Chapter 4 set out to examine the *syntactic* component of construct validity, by examining how well different measures predict diet-related health outcomes, to elucidate the question of whether simpler, less expensive measures predict outcomes as well as (or better than) more comprehensive measures. As presented in Chapter 4, several inexpensive food access measures (specifically, convenience store proximity and fast food outlet proximity for women and grocery store proximity and the RFEI for men) significantly predicted weight outcomes. For women, these measures more strongly predicted weight outcomes relative to other, more complex and expensive measures. For men, the NEMS-S affordability score most strongly predicted weight outcomes (and also significantly predicted weight outcomes for women), indicating that in this setting, considering relative affordability in food environment assessment provides additional, important information regarding associations between food environment features and weight outcomes. In jurisdictions where there is capacity for and interest in describing simple food access, results indicate that these measures are still useful in terms of predicting individuals' weight outcomes, despite not giving the whole picture of food environment features relevant to weight status. Future research on the cost of implementing different food environment assessment methods compared to data return are warranted.

2.2.2 Perceptual and objective measures

Questions in the thread of research that compares objective vs. perceptual measures include, "To what extent are perceptions and objective measures related?", and, "Which kinds of measures are more predictive of actual behaviours or outcomes of interest?" Findings relevant to these two questions will be presented next, followed by a discussion about hypothesized pathways.

In Chapter 3, correlations between residents' perceptions and objective measures of the food environment were presented, and showed that very low correlations existed: residents' perceptions were not strongly related to objective measures along any of the constructs examined. The study presented in Chapter 4 showed that residents' perceptions were indeed predicted by several objectively-measured food environment constructs, although a large proportion of variance remained unexplained by the models, and patterns of prediction were not straightforward (e.g., it was not the case that only objective affordability measures predicted affordability perceptions). Findings from Chapter 4 also showed that objective food environment measures predicted measures of obesity far more strongly than perceptual variables after controlling for pertinent individual- and household-level factors. The research presented in Chapter 5 extended the examination of syntactical definitions by exploring whether perceptions mediate the association between objective measures and diet-related outcomes. Results indicated that residents' perceptions did not mediate the associations; instead, objective food environment characteristics seemed to have a direct effect on outcomes. Findings from Chapters 3, 4 and 5 reveal that the field of food environment research is currently facing some fundamental measurement questions, particularly since several features of Glanz and colleagues' model were not supported by the research presented here. The final section of this chapter follows up with several of the remaining questions by addressing areas for future work.

The strongest predictor of obesity measures for females was convenience store proximity and fast-food outlet proximity (increasing proximity predicted increased obesity), while for males, obesity was most strongly predicted by relative affordability, followed by grocery store proximity (increased proximity predicted lower obesity). In terms of examining food procurement as a mediator, future research to determine whether convenience store and fast-food outlet access are associated with food purchasing from these outlets is warranted; it seems plausible, for example, that convenience store proximity would be associated with increased convenience store patronage, and since convenience stores tend to stock predominantly non-nutritious snack foods, increased purchasing (and subsequent consumption) of these types of foods might lead to increased obesity rates.

Extant literature suggests that obesity-promoting features of food environments (e.g. close proximity to fast food outlets and convenience stores or high density of fast food outlets) are indeed associated with increased purchasing from fast food outlets and convenience stores (276). Perceptual measures have also been associated with purchasing frequency, with perceived longer time to get to food outlets associated with less frequent purchasing of food purchased away from home (275). In an Australian study, the number of diverse brands of fast food outlets within 3km of home was positively associated with fast food purchasing frequency (278). Another study found that the number of diverse fast food brands within 3km of home may partially explain the association between area-level disadvantage and fast food purchasing (277), although several studies have found no or limited impact of the food environment on fast food purchasing (279, 283, 284).

In terms of explaining why perceptions did not predict outcomes, contrary to previous research (42, 43, 160), it is possible that respondents who do not shop within their neighbourhoods may be less aware of their immediate food environments than people who do shop within their neighbourhoods. That said, one of the strengths of the study presented in Chapter 4 was the geographic convergence between residents' perceptions (e.g., "Please think about your neighbourhood as only the area within about a 10-15 minute walk (1 to 1.5 km) from your home") and the food environment variables assessed at 1km buffer zones around respondents' homes. This geographic convergence should have limited the potential that respondents would be thinking of their usual shopping locations when answering the questions, and increased the likelihood that their assessment of their neighbourhood food environments would correspond to the geographic scale at which objective measures were aggregated. It is possible that gauging residents' perceptions about food environments in usual food shopping locations would be more relevant to diet-related outcomes, as discussed above. The studies presented here were potentially limited by only assessing perceptions around homes to the exclusion of other, potentially relevant places.

Several limitations of the current research were presented above and reasons for discrepancies between Glanz and colleagues' conceptual model and the findings described in this dissertation were provided. Section 4 continues this discussion by presenting these limitations as leaping off points for future work.

2.2.3 The use of multiple assessment methods

One of the major methodological contributions made by this dissertation was the incorporation of eight different types of food environment measures: proximity; density; intensity; RFEI; shelf-space; the NEMS-S; the NEMS-R; and perceptions. To my knowledge, the study that comes closest in terms of the inclusion of a number of different types of food environment assessment methods was published in 2012 and included residents' perceptions, the NEMS-S, and one food access measure (41). The studies presented here contribute substantially to food environment methods by comparing a number of diverse tools, which is a priority in the field given that over 500 food environment measures currently exist (13), and there is no "gold-standard."

Findings from this dissertation suggest that in this population, food *access* measures, particularly convenience store proximity, and relative food *affordability* measures best predicted obesity. While this finding might not hold in all cases (for example, in areas where access to high-quality, nutritious foods is limited, such as in Detroit or Chicago (158, 163), grocery store access might be a more important predictor), these results may be generalizable to other mid-sized Canadian urban municipalities of similar demographic profile.

3. Implications for Policy and Practice

This section discusses implications for policy and practice, and begins with a description of cities as both theoretically and jurisdictionally appropriate settings for food environment policies and interventions. Next, a general discussion about theoretical and practical considerations in the development of policies and programs related to food environments will be presented. Specific recommendations based on the findings of the preceding chapters will be concurrently presented. The final subsection will discuss specific stakeholders to whom knowledge generated by this dissertation will be translated.

3.1 Cities as Theoretically and Jurisdictionally Appropriate Settings

The World Health Organization's Healthy Cities movement began in the mid-1980s and has been gaining traction, particularly in Europe (285, 286). Healthy Cities research is often based on the theoretical understanding that health is determined by distal, structural factors, and that health determinants are embedded in complex, reciprocal chains of causality, consistent with an ecological approach (286). Moreover, municipal actors (including municipal governments, community organizations and other local partners) are seen as the most likely actors to effectively impact the complex array of health determinants, given that they have legitimate institutional roles in promoting health (286). Moreover, relative to provincial or federal governments, "City governments are often the closest level of government to people that have the mandate, the authority, and the administrative resources needed to bring together the wide variety of skills and resources needed for a multi-sectoral approach to health." (287)(p. 15). Stokols argued that community health promotion strategies based on an ecological perspective should be "middle-range", based on "theories of the specific circumstances that account for the occurrence and prevalence of particular health problems, and a corresponding analysis of the contextual factors that are likely to influence the effectiveness of health promotive interventions designed to reduce those problems." (288)(p. 288). The middle-range theories and health promotion strategies advocated by Stokols, therefore, are theoretically consistent with a Healthy Cities approach. The reason policies related to community and consumer nutrition environments can appropriately be theoretically situated within a Healthy Cities approach is because focusing on food environment characteristics as determinants of diet-related outcomes represents a middle-range ecological theory, and can also be addressed by municipal actors. Cities as appropriate jurisdictions for addressing community and consumer nutrition environments are discussed below.

Municipalities are appropriate jurisdictions for programs and policies aimed at improving food environments. In Canada, municipalities are referred to as “creatures of the provinces”, given that they are the constitutional responsibility of the provinces (289). In other words, the function, finances, and governing structure of municipalities fall under provincial jurisdiction. In Canada, provincial legislation mandates that municipalities must prepare official plans for growth (often called Regional Official Plans)(20). While Regional Official Plans must, at the very least, conform to provincial policy statements on planning (see, for example, Ontario’s Planning Act (290)), they can go above and beyond provincial policy requirements, by, for example, including considerations of food access into land use bylaws (19). Employing land use planning strategies such as zoning restrictions that would potentially improve food environments (e.g., banning drive-thrus, restricting the development of fast food outlets around schools) is a regulatory approach currently underway in Canada. For example, the development of new drive-thru windows have been banned in Comox, British Columbia, because they were found to violate existing idling bylaws (264). City councillors in Saskatoon are currently considering a ban on drive-thrus because of traffic snarls caused by long drive-thru lineups (291). The Coalition Québécoise Sur la Problématique du Poids (Quebec Coalition on Weight-Related Problems), a provincial advocacy group sponsored by the Association pour la Santé Publique du Québec (ASPQ), conducted a legal review of a number of countries where municipalities have used zoning regulations to change food environments. The report concluded that zoning regulations were both a legal and potentially effective way to improve food environments in Canada (292).

Several American authors have also examined the legality of local governments using land-use tools, economic incentives, and local ordinances to increase residents' access to healthy foods or restrict their access to unhealthy foods (293-295), and have found that zoning restrictions are generally upheld in U.S. courts. In addition to restricting specific outlet types, one legal scholar argued that zoning laws can be used to "define" convenience stores "in such a way that the shops must carry healthy foods in order to locate in certain areas." (293), (p. 892). More work needs to be done to examine the legality and potential legal challenges of using land-use tools to restrict access to certain types of food outlets in a Canadian context, since the U.S. and Canadian legal systems are not equivalent. Further, there has been no research to my knowledge examining the economic implications of food environment policies; such research would be invaluable in terms of putting the food environment on the policy agenda, since economic impact is an important consideration of most public policies, as described below.

3.2 Developing food environment policies in cities: theoretical and practical considerations

The previous section presented cities as theoretically and jurisdictionally appropriate settings in which to develop policies related to community and consumer nutrition environments. This section describes theoretical and practical considerations related to implementing food environment policies. Population diet quality and obesity are first presented as "wicked" problems. The social validity of food environment policies will then be discussed, along with the importance of framing. Specific strategies in the International Obesity Task Force's proposed framework for translating evidence into action on obesity prevention relevant to food environment policies will then be described.

3.2.1 Population diet quality and obesity as "wicked" problems

Distinctions between "wicked problems" and "tame problems" began to be articulated in the early 1970s (296). Wicked problems are illusive and influenced by complex social, political and economic factors which can change during the process of developing a solution (297). The nature of wicked problems is generally viewed differently depending on stakeholders' various perspectives and biases, which leads to differences in opinions about solutions. That population diet quality and obesity can easily be considered wicked problems requires little explanation, since, as outlined preceding chapters, diet quality and obesity are influenced by a multitude of different factors at different ecological levels, and attempts to improve diet quality or obesity rates depend on stakeholders' perceptions of the root causes of poor diet quality or rising obesity rates. For example, it is easy to imagine that in a community meeting to discuss actions on reducing obesity prevalence in a particular community, stakeholders representing the media, the food industry, local businesses, schools, the public health department, and elected officials would all have differing perspectives on how to prevent or reduce the prevalence of obesity. Unsurprisingly, expert opinion and technical skill are insufficient to address wicked problems including obesity (297, 298); addressing wicked problems using particular strategies requires the strategies to have "social validity."

3.2.2 Social validity and framing

Stokols (288) has defined social validity in terms of its societal value and practical significance, and presents several interrelated criteria for social validity:

> the epidemiologic prevalence of particular health problems in the community, the economic costs and sustainability of programs designed to alleviate those problems, the number of people who are likely to benefit from or be adversely affected by the intervention program, the possible occurrence of undesirable side effects from the program, and public opinion about community health priorities. (p. 294)

Stokols suggests that health promotion interventions are more likely to be implemented if they are consistent with public priorities and commitments (288), which is unfortunately not the case with food environment policies in many jurisdictions (247), perhaps because obesity is still seen to be within an individual's control (299). Although most developed nations now readily recognize obesity and poor diets as a global epidemic (4, 251-253), there is still substantial resistance to public health interventions, particularly those seen as limiting civil liberties, such as restricting access to sources of unhealthy foods (300). Given the importance of public opinion and public support for the implementation of food environment interventions, lessons from the literature on framing are next discussed.

Frames are ways of presenting problems that define the problems, diagnose the cause(s) of the problem, make moral judgments about the problem, and suggest solutions (248). In policy debates on solutions to wicked problems, the public is subjected to a competition between stakeholders who wish to promote their frame as the accepted one (301). When frames change, previous understandings of problems are changed concurrently with policymaking environments, since the way problems are framed determines acceptable policy options (302). In the academic literature, key determinants of obesity have been reframed from biological and individual in nature to a more ecological understanding (216), but a concomitant reframing has not occurred in the public discourse (57), which has implications for obesity prevention policies, since framing determines acceptable policy options, as described above (68).

3.2.3 International Obesity Task Force framework for evidence-based obesity prevention

In 2005, members of the International Obesity Task Force (IOTF) published a framework for evidence-based obesity prevention (298). Five key policy and program issues were identified in this framework: stage I, building a case for action on obesity; stage II, identifying contributing factors and points of intervention; stage III, defining the opportunities for action; stage IV, evaluating potential interventions; and stage V, selecting a portfolio of specific policies, programmes, and actions.

Although framing is not explicitly mentioned in the framework, many of the key components of framing are identified. For example, "Building a case for action on obesity" recommends that public health researchers and practitioners make the case for prioritizing actions to reduce obesity – that is, framing obesity as an urgent matter of public health. Further, the framework urges researchers and practitioners to identify causative and protective factors that could be targeted by interventions, consistent with the notion that framing can diagnose the causes of problems. Finally, the framework argues for defining the range of opportunities for action, which represents another key component of framing: suggesting solutions (248). The framework's authors point out that framework's main headings need not be sequential, and in fact acknowledge that outputs from one issue inform the others in an iterative process.

Given the previous discussion on diet quality and obesity as wicked problems, social validity and framing, and the framework for evidence-based obesity prevention, a few suggestions for framing food environments as important points of intervention based on the findings of this dissertation are described below. Subheadings below are consistent with the key issues identified in the IOTF framework.

Stage I. Building a case for action on obesity

The IOTF recommends presenting epidemiological evidence to show prevalence and trends in obesity. In Chapter 4, descriptive sample data were presented, and indicated that mean diet quality scores were lower for both males and females than the Canadian average (31). Moreover, the prevalence of obesity among both men and women was higher in our sample than the national average (303). This epidemiological evidence can be presented to local policymakers to indicate the need to act on obesity in this setting; residents of the Region of Waterloo seem to have poorer diet quality and increased rates of obesity relative to the national average. At a national (or even international) level, high rates of obesity and poor diet quality are fuelling interest in developing strategies to combat obesity.

Stage II. Identifying contributing factors and points of intervention

Descriptive analyses showed that on average, residents in Kitchener, Cambridge, and Waterloo lived about twice as far from grocery stores (1001m) as they did from convenience stores (526m) and fast food outlets (586m). Moreover, they had over three times as much shelf-space dedicated to energy-dense snack foods as to fruits and vegetables within 1000m of home. These data are important to framing food environments as currently unsupportive of residents' healthy diets and body weight maintenance, and to framing obesity and poor diet quality as logical responses to the current food environment, rather than individual choices or failures.

Stage III. Defining the range of opportunities for action

Findings from research presented in this dissertation indicate several opportunities for action, including focusing on objective features of the food environment rather than residents' perceptions, restricting access to convenience stores, and promoting the relative affordability of healthier foods.

Focusing on objective features rather than residents' perceptions

First, results from Chapters 4 and 5 indicate that objective measures better predicted diet-related outcomes relative to residents' perceptions, and that perceptions do not mediate the association between objective measures and outcomes in this setting. The framework suggests that intervention targets need to be identified; in this case, it would appear that public health campaigns to increase residents' awareness of affordable, nutritious foods in their areas may be less effective than targeting the objective food environment, for example, through restricting convenience store access, or making nutritious foods more affordable relative to non-nutritious foods, as described below.

Altering access to convenience stores

Distance from home to the nearest convenience store was most strongly associated with BMI and WC for females after controlling for pertinent individual and household factors. For females, every one km further from home to the nearest convenience store predicted decreased body weight by 5.9kg (13.2lbs) for an average height female (1.63m; 5'4), and a decreased waist circumference of 6.4cm. In terms of public health significance, the 2.23 unit decrease in BMI for females with every one km further from the nearest convenience store they lived is clinically significant (304): a weight loss of 5-10% of body weight has been shown to prevent diabetes (305, 306), improve quality of life (307), and decrease mortality (308). For an average height woman, a 2.23 unit decrease in BMI corresponds to 13.2lbs, which corresponds to 5% of the body weight of a woman who weighs 264lb and 10% of the body weight of a 132lb woman; beyond statistical significance, convenience store proximity clearly predicts a clinically significant increase in females' weight. For both males and females, increasing distance from home to the nearest convenience store was associated with improved diet quality, although these associations were not statistically significant.

One potential mechanism to address convenience store proximity is the inclusion of a "food environment" component to a complete development application for new residential developments in municipalities:

> Municipalities are increasingly requiring developers to submit complete development applications before the review process begins (see, for example, Section 10.D.3 of ROP) in order to avoid delays in approving applications with incomplete information. Pre-submission consultation meetings are often held with municipal staff and the developer to ensure that the developer is aware of the municipality's various policy requirements for a proposed development. Specifically, local planners identify the developer's responsibilities for submitting relevant supporting studies, surveys, and information, including studies on transportation impact, environmental impact, and watershed implications. Measuring how the proposed development would support or enhance a healthy food environment is an additional study that could be required of the developer (20), p. 10.

As described above, Regional Official Plans must meet provincial planning requirements but can go above and beyond (for example, by including a requirement for developers to fill out a complete development application related to the food environment). In keeping with our understanding of wicked problems and competing frames, foreseeable opposition to such a complete development application would emerge from regional councillors, due to lost municipal revenue through business taxes, from convenience store chains, who would have a vested interest in such a policy decision, and from developers, since they tend to have strong ideas about the desires of their target markets in terms of neighbourhood amenities. Recommendations must be presented with other, corresponding data to make the case for action, particularly with respect to other considerations of urban planning, such as the tax-base, mixed land-use requirements outlined in municipalities' Official Plans, and developer concerns, to name a few. The Region of Waterloo is admittedly a unique case, since food systems considerations have already been included in the Regional Official Plan (19), both to promote the local economy and to promote public health goals. In other jurisdictions that are less ready to act, the initial step of building a case for action to create buy-in from policymakers might be more pressing of a concern.

The inclusion of a food environment component in a complete development application may entail specific restrictions on the number or placement of convenience stores in new developments. While this approach will not affect convenience stores that already exist, alternate approaches to improving the consumer nutrition environments within conveniences stores would also be supported by the evidence presented in preceding chapters. Changing the consumer nutrition environment within convenience stores could be done through zoning as described above (293), or could be done through Healthy Corner Stores initiatives, which have had positive impacts on the availability and promotion of nutritious foods as well as consumer behaviours (243, 244).

Relative affordability as a target

Third, absolute affordability (defined as the mean cost of the Healthy Food Basket in different areas) did not predict diet quality or obesity measures among men or women, but relative affordability (defined as the NEMS-S affordability scores) did predict obesity measures for both men and women. Therefore, strategies targeting the cost of more nutritious options of the same foods (e.g., whole grain rather than white bread, low-fat dairy products rather than high-fat dairy products, lean ground meat rather than regular ground meat) may be more effective than strategies targeting overall food cost.

The problem with this recommendation, of course, is that neither public health practitioners nor zoning regulations can control the prices of food sold in stores. That said, public health departments could provide subsidies for nutritious foods, and could also support Healthy Corner Stores initiatives. Additionally, in terms of acting on this recommendation in a regional setting, it is possible that public health practitioners could engage with local business owners to determine the feasibility of altering the relative affordability of nutritious foods in stores and restaurants. For example, a study to determine the feasibility of implementing a Healthy Corner Stores program, which would make nutritious foods more affordable in convenience stores, is currently underway in Toronto (personal communication, Brian Cooke, Toronto Public Health).

The opportunities for action outlined above could be presented to municipal bodies, including regional councils, local public health departments, and community advocacy groups interested in food systems to create buy-in. To that end, in early November, 2012, results of this dissertation will be presented to members of the

Food Systems Roundtable in the Region of Waterloo, and to the Chief Medical Officer of Health. The presentation will be revised according to their suggestions, and arrangements are underway for me to then present findings to the Regional Council. These are but examples of specific actions that can be taken create links and highlight overlapping areas between existing plans, policies and programmes, as recommended by the IOTF framework. Moreover, these activities feed into the IOTF framework's fifth stage, "Selecting a portfolio of specific policies," since these actions (presenting findings to different stakeholder groups) will facilitate conversations with stakeholder to gain their input into judgements on the potential policies and implications for implementation, as recommended by the IOTF framework.

The only IOTF framework not identified in this section was stage 4, "Evaluating potential interventions". This particular stage will be discussed in the fourth section of this chapter, which describes future research priorities.

3.3 Stakeholders to whom findings of this dissertation are relevant

Federal, provincial, and territorial governments are interested in the effects of food environment features on the dietary behaviours and health of the population, as evidenced by the 2012 report, *Measuring the Food Environment* (3) commissioned by the Office of Nutrition Policy and Promotion, Health Canada. Indeed, federal, provincial and territorial Ministers of Health and of Health Promotion/Healthy Living have explicitly identified increasing the availability and accessibility of nutritious foods, particularly among vulnerable populations, as a governmental policy priority for reducing childhood obesity (4). Since healthy diets are essential for maintaining health and preventing chronic disease, municipal and regional governments have begun to consider policies that would limit residents' exposure to less nutritious foods or programs that would increase access to nutritious foods within food outlets.

One of the key features of this research was close collaboration between the research team and end-users (in this case, the Region of Waterloo). Because the Region is already supportive of creating healthy food systems (19, 20), results from this research will serve to directly inform local policies. Regional and provincial public health planners and dietitians are also interested in the results of this research; as mentioned, over the next weeks, I will be presenting findings to the Food Systems Roundtable and the Chief Medical Officer of Health in the Region. Over the past two years, I have been approached by several regional public health departments in Ontario and by the Provincial Health Services Authority in British Columbia to consult about provincial and regional measurement of food environments, and direction and action related to the food environment. The Ontario Provincial Planners' Institute (OPPI) has additionally identified healthy food systems as a priority for urban planners (309); results from this dissertation will be disseminated to provincial professional planners bodies to inform planning for food systems. More broadly, findings from this research will be of interest to provincial Healthy Cities or Healthy Communities governmental and non-governmental organizations, as food systems are becoming an increasingly important consideration in communities across the country.

4. Future Work

This final section will address implications for future research. Two specific issues will be discussed, including establishing a program of research to more fully address how food environments "get under the skin" of residents, and advancing food environment methodology through cross-Canada research partnerships.

4.1 Establishing a program of research

The previous discussion has outlined several fundamental gaps in the existing food environment scholarship, including the inconsistent assessment methods used, the lack of articulation of mediators and mechanisms by which food environments are hypothesized to "get under the skin" of residents in much of the extant research, the lack of theoretically-grounded geographic scale operationalization, and the high prevalence of cross-sectional (rather than longitudinal or quasi-experimental) studies. All of these issues should be examined in future food environment research. Continuing to understand how food environments "get under the skin" of residents will require two separate and complementary avenues of inquiry, including activity space research, and research on food environment interventions. Both components are described in more detail below, and address the four fundamental gaps outlined above.

4.1.1 Activity space research

Activity space research has been used to examine individuals' movements and travel within their environments, and can be used to examine accessibility to services based on travel patterns rather than residential locale. Recently, activity space research methods have been applied to food environments, and has been identified as being on the forefront of food environment research advancements (183). Moreover, in examining where people go to procure food, examining activity spaces is a novel way of examining the mediator added to Glanz and colleagues' model, food procurement (see figure 6-1).

The two data sources for the research presented in this dissertation (NEWPATH data and the primary food environment data collection) will be used to begin to examine activity spaces related to food environments. Preliminary research questions include:

1) How do individuals navigate their built environments to procure food, and how do these activity spaces differ by socio-demographic factors such as age, sex, income, education level, car-ownership, and household structure?
2) To what extent are individuals' activity spaces associated with relevant diet-related outcomes, such as diet quality and weight status, and food purchasing behaviours?

As mentioned, inconsistencies in food environment assessment, and the use of inconsistent geographic scales are two major research gaps in the extant literature (5, 8, 119). Four studies to date have examined where people go for food (i.e., their activity spaces in relation to diet-related health outcomes. Three relied on the same data set, which combined Canadian Community Health Survey (CCHS) data and travel diary data from two different surveys to estimate activity space exposures of CCHS participants (176, 177, 273); one linked activity space data derived from participants who wore GPS devices for seven days with dietary intakes of the same participants (175). The Canadian studies relied on large, population-based samples, but were unable to directly link activity space data with weight status, since CCHS data came from different participants than the travel data (and thus, activity space data). Additionally, all three studies were conducted in one region in Quebec. In one U.S. study, Zenk and colleagues were able to link travel data with dietary intake in the same population in Detroit, but given that their sample included 120 participants who were mostly female, African American or Latino, and of low socioeconomic status, there are concerns about the generalizability of their findings (175). None of the studies to date have used within-food outlet measures of food availability, affordability or quality; all used food access measures such as fast food outlet density or supermarket availability.

In addition to the previously described NEWPATH data employed in this dissertation, NEWPATH collected detailed travel data over a two-day survey period from every household member over 10 years and household food purchasing data, including the frequency of household shopping at different outlet types. The travel data include the address of each location visited during the two-day survey, the mode of travel, purpose, arrival time, and activity at destination (310). Travel surveys took place on day-pairs throughout the week to provide mobility information across the whole week. Geocoded locations visited by participants were entered into ArcGIS software. To develop activity spaces for each individual, the locations visited by participants (including home) will be defined as the anchor points for deriving activity space exposures. To develop the activity spaces, Kestens and colleagues' methodology to develop "Activity space experienced foodscapes" will be employed, since it uses similar travel data and is also consistent with the only other Canadian research to date examining activity spaces (176, 177, 273). One exception to Kestens and colleagues' methodology will be that instead of relying solely on local food store density (e.g., density of fast food outlets), this proposed research will additionally employ scores derived from the shelf-space measures, the NEMS-S, and the NEMS-R; scores from these measures can be categorized as relating to food availability, food affordability, and food quality, thereby creating activity spaces reflecting a variety of consumer nutrition environment constructs. Using within-outlet scores represents a major innovation in this nascent field; researchers to date have only used food outlet density measures in activity space development.

Outcomes will include diet quality, self-reported BMI and WC, and food purchasing frequency from different outlet types. Covariates will include individual age, sex, education level, and household-level car ownership and income.

From a policy and programming perspective, activity space research will help to identify neighbourhoods where residents might especially benefit from food environment interventions because of restricted mobility (i.e., smaller activity spaces). Moreover, activity space research will help to inform the field of food environment research by examining mediators, such as food procurement, which will allow for further refinement of conceptual models and will also contribute to the clarification of underlying food environment constructs. Finally, using activity spaces to geographically operationalize food environment exposures represents a large methodological contribution to the field of food environment research.

4.1.2 Evaluating Food Environment Interventions

The evaluation of food environment interventions falls under stage four of the IOTF framework, "Evaluating potential interventions", since it will answer the question, "What are the specific, potential interventions and their likely effectiveness and cost-effectiveness," as identified in the framework. As evidenced through the literature reviewed in Chapter 2 and all subsequent chapters, the fact that most food environment studies are cross-sectional in nature represents a major barrier to understanding mechanisms and causality related to food environments. As noted, of the five longitudinal studies published to date, all have examined community nutrition environments to the exclusion of consumer nutrition environments, and all have found a limited impact of food outlet exposure on adults' and children's diet-related outcomes (129-133).

A small number of studies have examined neighbourhood food environment interventions. Extant interventions have targeted the consumer nutrition environment within convenience stores (243, 311, 312) or have examined changes in residents' dietary behaviours after the opening of grocery stores in deprived areas in Scotland (174, 313) or England (314, 315). Limitations of interventions in convenience stores include low rates of exposure to the intervention (e.g., a healthy corner stores program was implemented in only nine of 100 stores in one study (312)), and all studies to date have recommended increased "dose" – comprehensive and sustained food environment interventions at multiple levels.

Recently, I have been invited to lead the quantitative evaluation component of a mobile food vending project and a healthy corner store initiative in Toronto, Ontario. My specific role will be to examine whether a) increasing access to affordable fruits and vegetables in underserved neighbourhoods (identified as food deserts by the Toronto Food Strategy (316)) will be associated with local residents' dietary outcomes, such as diet quality and fruit and vegetable consumption, and b) whether improving the consumer nutrition environment within convenience stores (through increasing availability and relative affordability of nutritious foods) will be associated with residents' dietary outcomes. Over the next few months, I will be helping to create a proposal to rigorously evaluate the effect both of these food environment interventions, which will represent a substantial contribution to the field.

The evaluation of food environment interventions is a crucial next step that has practical, theoretical, and methodological implications. First, the implementation of the two programs mentioned above is being documented by a policy researcher at the University of Toronto, which has implications for how other jurisdictions may choose to go about adopting or adapting food environment programs. Second, as outlined, the evaluation of food environment interventions will be longitudinal and will also provide the opportunity to examine mediators (specifically, food procurement), which is necessary to clarify pathways by which food environment features affect diet-related outcomes, and also to further elucidate underlying constructs of food environments. Third, as mentioned above, applying a quasi-experimental design to study these food environment interventions will contribute to the currently small but important evidence base outlined by Stage IV of the IOTF framework.

4.2 Advancing Research through Partnerships

In early 2012, I was commissioned by the Office of Nutrition Policy and Promotion at Health Canada to write a report entitled, "Measuring the food environment" (3). Briefly, the federal, provincial, and territorial (FPT) Ministers of Health and of Health Promotion/Healthy living endorsed a *Declaration on Prevention and Promotion* and *Curbing Childhood Obesity: A Federal, Provincial and Territorial Framework for Action to Promote Healthy Weights* (*Framework*) at the November 2010 Health Ministers' meeting. One of the policy priorities identified in the *Framework* was to increase the availability and accessibility of nutritious foods, particularly among vulnerable populations. Because the food retail environment plays an important role in influencing the availability of nutritious foods, a report was commissioned to: (i) facilitate an understanding of food environments and their impact on Canadians' diets and body weights; (ii) assess the existence of 'food deserts' in Canada, and; (iii) identify specific Canadian challenges in the availability and accessibility of nutritious foods for different populations. The report includes a literature synthesis, with a particular emphasis on Canadian evidence, as well as an environmental scan and findings from interviews with 19 key informants from across the country to determine how food environments are being conceptualized, researched, and how findings from the research are being used.

The key informant interviews were particularly illuminating. One of the key findings that emerged from the interviews was particularly relevant for moving the field of food environment research forward: the essential nature of collaboration between researchers and practitioners. In addition to collaboration being a mechanism by which knowledge translation happens more readily, collaboration between researchers and practitioners is necessary to take advantage of opportunities to evaluate the health impacts of policies that affect food environments, even if the policy's intention falls outside the realm of promoting public health. The examples outlined above of both Comox, British Columbia and Saskatoon Saskatchewan banning (or attempting to ban) drive-thru windows are pertinent here (264, 291). Working with practitioners from a variety of backgrounds can help to determine not only research areas that are timely and useful, but also potential ways of framing research or public health policies that would increase public support and buy-in from policymakers.

5. Conclusion

This dissertation has examined the construct validity of food environment measures and has begun to examine how food environments "get under the skin" of local residents, and has made theoretical, methodological, and substantive contributions along the way. Implications for policy and practice have been discussed, and areas for future research have been identified. Recognizing that much work needs to be done to provide interested policymakers with solid evidence upon which to base food environment policies, the research described in this dissertation was intended to provide a strong methodological foundation for rigorous evaluation of food environment policies using valid and reliable assessment methods. It is my hope to continue in the field of food environment research and to contribute to the development of policies that will ultimately promote healthy diets in Canada.

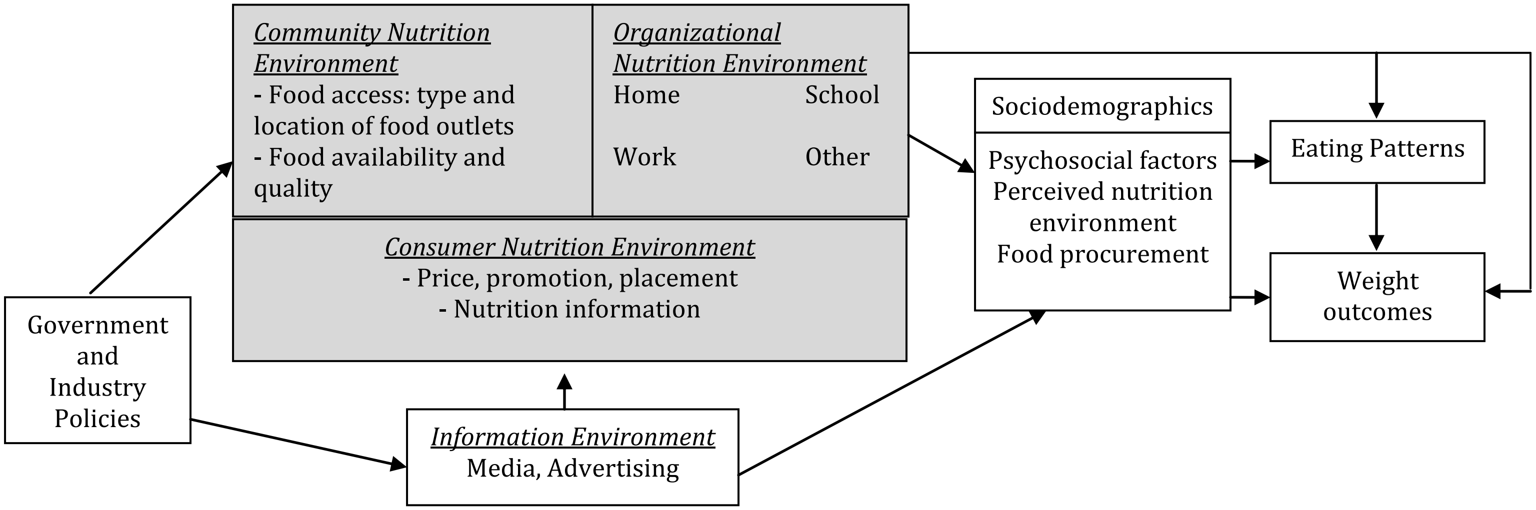

Figure 6-1: Adaptation of Glanz and colleagues' conceptual model of Community Nutrition Environments (1)

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Appendix A: Nutrition Environment Measures Survey - Stores protocol

Nutrition Environment Measures Survey (NEMS)
Store measures (Canadian)

Survey Instructions

These measures are designed to rate the nutrition environments of grocery and convenience stores. There are other establishments that may offer food products to purchase that fall into an exclusions category (see below) and may be enumerated but not necessarily rated. However, based on your survey purposes, you may decide to set different exclusion criteria.

Exclusions for General Use

- Establishments that are not open to the general public, or those where you have to pay a charge just to enter. Establishments that sell a limited variety of food and are not mainly food or convenience stores.
  - Costco

Instructions

The basic principle of these measures is to gather information on comparable items across stores and types of food, so when possible, rate items within the same brand or exactly as specified.

Layout

The majority of the measures have a similar layout.

1. There are "healthier" and "regular" options listed. The healthier option is always listed first.
2. Bold thick lines divide the healthier and regular options.
3. For the measures that have healthier and regular options, the preferred item, which is the item that you would ideally like to rate if it is available, is listed first. The preferred item is followed by alternate items that are in shaded grey boxes.
4. For the milk and frozen dinner measures, there is a section titled "Reference Brand". This refers to the brand name of the food items that will be rated.
5. There is a Measure Complete box at the top right of each page for you to mark when you have completed a measure.

Time

1. Complete grocery store measures between 9 am and 4 pm. (This helps to ensure that items have been stocked for the day and are not sold out.)
2. Complete convenience store measures before 4:30 pm or after 6 pm. (This helps to ensure that you are not in the way during a busy time as these stores are small.)

Availability

1. Before recording any information, first look for the preferred healthier item and the comparable regular item of the same brand.

2. If only one is available, look for the first healthier alternate listed to see if a comparison within the same brand is possible.
3. Once a comparable pair is identified, record the information. You may choose to include recording the information for the one item that is available, in addition to the alternate comparable pair information. If so, write in comments "no comparable pair".
4. If a comparable pair cannot be found, record a healthier and regular item that are as similar as possible.
   - If an item is sold out, write "sold out" in the Comments section and record any available information. Continue down the list until an item is available or the list has been exhausted.

Pricing

1. If price is not available, ask an employee at the cash register or at customer service. Wait until all of the measures have been completed before asking the price of the items that are needed. There may be exceptions to this (i.e., you are in the produce section and there is no price shown but an employee is working there), so use your judgment.
2. Do not use a sale price unless it is the only price posted and write "sale price" in comments.
3. Do not use club card/loyalty card prices unless specifically noted. If used, record both prices if possible

Preparation

At the top of each page, fill in the following:

- Rater ID
- Store ID
- Type of store (Grocery, Convenience or Other)
  "Other" would be specialty stores such as meat markets, green grocers, health stores, etc.
- Date

Cover Page

On the cover page, fill in the following:

- Start time (when you enter the store)
- End time (when you have finished the measures and reviewed them for completeness)
- Number of cash registers in the store (including any at the pharmacy or customer service). Each checkout register should be counted, even if a clerk is not there at the time of your visit. For stores that have a self checkout area, include only the cash register(s) serving the self checkout stations.

General Completion Tips

Remember to follow the tips below to decrease the data cleaning time later.

1. Write legibly.
2. Check your work.
3. Use the correct line/bubble.

Measure #1: MILK

Milk Definitions

a. Low-fat milk – skim/fat-free and 1%
b. Reduced fat milk – 2%
c. Whole milk – full fat (3.25%)

Measurement Procedures

1. Find the milk aisle in the store.

2. Look for the store brand as it is the preferred brand. If **available**, mark "yes".

Store brand (preferred)	○ Yes	○ No

3. If there is no store brand, mark "no" and look for the brand with the most shelf space. If there is equal shelf space for different brands, select the one that has a brand name closest to the beginning of the alphabet (e.g., Foremost instead of Parmalat). Write the name of the brand in the space provided. This brand is now the reference brand for this measure since the store brand was not available.

Alternate Brand Name:	☐☐☐☐☐☐☐☐☐☐☐☐

4. Using the reference brand, look for low-fat milk (skim or 1%). If **available**, mark "yes" and then mark "N/A" for the 2% available question.

5. If low-fat milk is not available, mark "no" and look for 2%. Mark whether or not it is available.

6. **Shelf space:** Complete **only** if low-fat milk is available. Count and record the **number** of columns of each requested milk item (pint of skim, quart of skim, etc.) for the reference brand. Count only columns that have (any) milk there, but not empty slots where it may need to be restocked. If there are none of a particular item, write "0" in the box.

Shelf space:

Type	**Pint**	**Quart**	**Half gallon**	**Gallon**
a. Skim	☐☐	☐☐	☐☐	☐☐
b. 1%	☐☐	☐☐	☐☐	☐☐
c. Whole	☐☐	☐☐	☐☐	☐☐

7. Record the **price** of a quart and a half-gallon of whole milk of the reference brand.
   - ❖ If the reference brand does not have milk available in the quart or half-gallon size, select another brand similar in price and write its name in comments.

8. Continuing to use the reference brand, record the price of a quart and a half-gallon of the lowest fat milk available (meaning choose skim milk first; if not available, choose 1%). Mark "N/A" for the alternate items.

9. If there is no low-fat milk available, record the price of a quart and a half-gallon of 2% of the

Measure #2: FRUIT

Measurement Procedures

Produce Item		Available Yes	Available No	Price	#	Unit pc	Unit kg	Quality A	Quality UA	Comments
1. Bananas		O	O	$☐.☐☐	☐	O	O	O	O	________ ________
2. Apples	O Red delicious O ________	O	O	$☐.☐☐	☐	O	O	O	O	________ ________

1. Find the produce department in the store.
2. Look for the fruit listed. If it is **available**, mark the bubble next to it.
3. If it is not available and there is a line below it for an alternate item, look for the cheapest similar alternate. Write it down and mark the bubble next to it. For example, if there are no Red delicious apples and Gala apples are the cheapest alternate, write "Gala" on the line below "Red delicious".
4. If the fruit or alternate is available, mark "yes". If it is not available, mark "no". If the item is sold out, write "sold out" in comments and record the available information.
   - If the fruit is only available as pre-sliced and in a container, still mark "yes" for available and write "pre-cut in container" and any size information in comments.
   - If the fruit is available but mixed with other fruit in a container, mark "no" for available but note the fruit cup contents, price and size in comments.
5. Record the regular **price** of the fruit. If it is on sale and the regular price is not posted, see if it can be calculated based on the sale price label (i.e., add the sales price and the "you save" price) and record it. If the regular price cannot to be calculated based on the sale price label, just record the sale price.
   - Always choose the price per kilogram if there is an option.
6. Write the **quantity (#)** of the fruit that is listed **for the price.** For example, if the sign says 2 for $1.00, write "2" for the quantity. If the sign says 3 lbs for 99¢, write "3" for the quantity.
   - If the fruit is not loose but packaged (e.g., pint or container), count the quantity as "1" and write the quantity of the package in comments.
7. Indicate if the price of the fruit is calculated by the piece or Kilogram by marking "pc" or "kg". For example, if the sign says 2 for $1.00, mark "pc" for piece. If the sign says $1.00/kg mark "kg" for kilogram
   - If packaging is other than pc/kg (e.g., per pint or bunch), mark "pc" and note under comments.
8. Record the **quality** of the item by marking "A" for acceptable or "UA" for unacceptable.
   - Acceptable = peak condition, top quality, good color, fresh, firm and clean
   - Unacceptable = bruised, old looking, mushy, dry, overripe, dark sunken spots in irregular patches or cracked or broken surfaces, signs of shriveling, mold or excessive softening
   - The rating is based on the majority (>50%) of fruits. If it seems difficult to decide whether to mark "A" or "UA", mark "UA" and describe in comments.
9. After completing the information for the 10 fruit items, count the number that are marked "yes" under available and record the total.

11. Total Types:	(Count # of yes	☐

Measure #3: FROZEN FRUIT

Measurement Procedures

	Package Size (grams)	Available Yes No	Price	Comments
1. Blueberries O Europe's Best	☐☐☐☐ g	O O	$☐.☐☐	
O Other________	☐☐☐☐ g		$☐.☐☐	

1. Find the frozen section of the store.

2. Look for the products listed

3. If the listed product is not available look for an alternate brand of the same fruit. Look for the cheapest alternate brand. Mark the "other bubble" and write down the brand name. For example, if Europe's Best frozen blueberries are not available but Lucerne brand are, write Lucerne on the line beside other.

4. If the listed frozen fruit or alternate is available, mark "yes". If not available mark "no". If the item is sold out, write "sold out" in comments and record the available information.

5. Record the regular price of the frozen fruit. If it is on sale and the regular price is not posted, see if it can be calculated based on the sale price label (i.e., add the sale price and the "you save" price) and record it. If the regular price cannot be calculated based on the sale price label just record the sale price, and note it in the comment section.

Measure #4: CANNED FRUIT

Measurement Procedures

Item		Can Size (mL)	Available Yes No	Price	Comments
1. Peaches	O Del Monte	398 mL	O O	$ ☐.☐☐	________
(In Juice)	O Other ______	☐☐☐ mL			

1. Find the canned fruit section of the store.

2. Look for the products listed.

3. If the listed product is not available look for an alternate brand of the same fruit. Look for the cheapest alternate brand. Look for the cheapest alternate brand. Mark the "other" bubble and write down the brand name. For example, if Del Monte peaches packed in juice are not available but Dole brand peaches packed in juice are, write Dole down on the line beside other and fill in the can size. **DO NOT USE FRUIT PACKED IN SYRUP AS AN ALTERNATE.**

4. If the listed canned fruit or alternate is available , mark "yes". If not available mark "no". If the item is sold out, write "sold out" in comments and record the available information.

5. Record the regular price of the canned fruit. If it is on sale and the regular price is not posted, see if it can be calculated based on the sale price label (i.e., add the sale price and the "you save" price) and record it. If the regular price cannot be calculated based on the sale price just record the sale price and note it in the comment section.

Measure #5: VEGETABLES

Measurement Procedures

Produce Item		Available Yes No	Price	#	Unit pc kg	Quality A UA	Comments
1. Carrots	O 2 lb bag	O O	$☐.☐☐	☐	O O	O O	________
	O ______						________

1. Find the produce department in the store.
2. Look for the vegetables listed. If it is **available**, mark the bubble next to it.
3. If it is not available and there is a line below it for an alternate item, look for a similar alternate. Write it down and mark the bubble next to it. For example, if there are no 2 lb bags of whole carrots but there are 1 lb bags, write "1 lb bag" on the line below "2 lb bag".
   - For carrots, look for whole carrots. Only select baby or precut carrots as a last resort and make a note in comments.
   - For tomatoes, look for the loose field tomatoes (regular size) first. If not available, look for alternate loose tomatoes. Choose tomatoes on the vine or cherry tomatoes as a last resort and make a note in comments.
4. If the vegetable or alternate is available, mark "yes". If it is not available, mark "no". If the item is sold out, write "sold out" in comments and record the available information.
5. Record the regular **price** of the vegetable. If it is on sale and the regular price is not posted, see if it can be calculated based on the sale price label (i.e., add the sales price and the "you save" price) and record it. If the regular price cannot to be calculated based on the sale price label, just record the sale price.
   - If the vegetable is not specifically listed as packaged (e.g., corn or celery) but is sold as packaged or loose, record the price of the one that is cheapest.
6. Write the **quantity (#)** of the item that is listed **for the price.** For example, if the sign says 2 for $1.00, write "2" for the quantity. If the sign says $1.00/kg write "1" for the quantity.
   - If the item is sold by the package (e.g., corn), count the quantity as "1" and write the number of the item included in the package in comments (e.g., 3 in package).
   - Always choose the price per kilogram if there is an option.
7. Indicate if the price of the item is by the piece or kilogram by marking "pc" or "kg". For example, if the sign says 2 for $1.00, mark "pc" for piece. If the sign says $1.00/kg, mark "kg" for kilogram.
   - If packaging is other than pc/kg (e.g., per pint or bunch), mark "pc" and note in comments.
   - If an item is packaged and its size is listed in kg or equal to a pound, mark "kg" for kilogram.
8. Record the **quality** of the item by marking "A" for acceptable or "UA" for unacceptable.
   - Acceptable = peak condition, top quality, good color, fresh, firm and clean

- Unacceptable = bruised, old looking, mushy, dry, overripe, dark sunken spots in irregular patches or cracked or broken surfaces, signs of shriveling, mold or excessive softening
- The rating is based on the majority (>50%) of fruits. If it seems difficult to decide whether to mark "A" or "UA", mark "UA" and describe in comments.

9. After completing the information for the 10 vegetable items, count the number that are marked "yes" under available and record the total.

11. Total Types: (Count # of yes responses) ☐☐

Measure #6: FROZEN VEGETABLES

Measurement Procedures

		Package Size (grams)	Available Yes No	Price	Comments
1. Peas	O Green Giantt	1000 g	O O	$ ☐.☐☐	
	O Other ______	☐☐☐☐ g		$ ☐.☐☐	______

1. Find the frozen section of the store.

2. Look for the products listed

3. If the listed product is not available look for an alternate brand of the same vegetable. Look for the cheapest alternate brand. Mark the "other bubble" and write down the brand name. For example, if Green Giant frozen peas are not available but Lucerne brand are, write Lucerne on the line beside other.

4. If the listed frozen vegetable or alternate is available, mark "yes". If not available mark "no". If the item is sold out, write "sold out" in comments and record the available information.

5. Record the regular price of the frozen vegetable. If it is on sale and the regular price is not posted, see if it can be calculated based on the sale price label (i.e., add the sale price and the "you save" price) and record it. If the regular price cannot be calculated based on the sale price label just record the sale price, and note it in the comment section.

Measure #7: CANNED VEGETABLES

Measurement Procedures

Item		Can Size (mL)	Available Yes No	Price	Comments
1. Tomatoes (Stewed)	O Hunts	398 mL	O O	$ ☐.☐☐	______
	O Other ______	☐☐☐ mL			

1. Find the canned vegetables section of the store.

2. Look for the products listed.

3. If the listed product is not available look for an alternate brand of the same vegetable. Look for the cheapest alternate brand. Mark the "other" bubble and write down the brand name. For example, if Hunts stewed tomatoes packed are not available but Aylmer brand tomatoes are, write Aylmer down on the line beside other and fill in the can size.

4. If the listed canned vegetable or alternate is available, mark "yes". If not available mark "no". If the item is sold out, write "sold out" in comments and record the available information.

5. Record the regular price of the vegetable. If it is on sale and the regular price is not posted, see if it can be calculated based on the sale price label (i.e., add the sale price and the "you save" price) and record it. If the re
co

Measure #4: GROUND BEEF

Ground Beef Definitions:

a. Lean ground beef: ≥83% lean, ≤17% fat
b. Regular ground beef: 77% lean, 23% fat

Measurement Procedures

Item	Available Yes No N/A	Price/kg.	Comments
Healthier option: 1. Lean ground beef, ≥ 83%lean, **≤17% fat** (Ground Sirloin)	○ ○	$☐.☐☐	____________ ____________

1. Find the fresh meat case in the store.

2. Most stores sell only their own ground beef. If there is ground beef with a brand name, choose the store brand first.

3. For the healthier option, locate the lean ground beef with ≤ 17 % fat, it should be labelled **Lean**. If **available**, mark yes. Choose the package of lean ground beef closest to 500 grams. Record the **price per kg** listed and **not** the actual price of the package of meat (i.e., the label should have a price/kg and price. Record the price/kg.). Mark "N/A" for the alternate items.
   - ❖ In general, if only organic ground beef is available, look for an alternate. However, if alternates are not labeled and staff doesn't know % fat, go with the organic and write "organic" in comments.

4. If no lean ground beef with ≤ 17% fat is available, mark "no" and look for lean ground beef with ≤ 10% fat usually marked extra-lean. If available, write in the % fat (e.g., 7), mark "yes" and record the price per kg listed. Mark "N/A" for the remaining alternate item.

5. If no lean or extra-lean ground beef is available, look for ground turkey (≤ 17% fat). If available, write in the % fat, mark "yes" and record the price per kg listed.

6. Count and record the **number of varieties** of lean ground beef available, which includes both different brands and variety of % fat (e.g., 10%, 7%, 3%, etc.). Include any organic varieties as well.

# of varieties of lean ground beef (≤17% fat)	○ 0	○ 1-2	○ 3-4	○ 4-5	○ 6+

7. For the regular option, locate the standard ground beef with ≤ 20% fat. Repeat steps 3-4.

Measure #5: HOT DOGS

Hot Dog Definitions

Measurement Procedures

Item	Available Yes No N/A	Price/pkg	Comments
Healthier option:			
1. Schneiders Low Fat Wieners (mixed meat source) <1g fat	○ ○	$☐.☐☐	________

1. Find the hot dogs in the prepared meats section in the store.
2. For the healthier option, locate Schneiders low fat wieners regular size. If **available**, mark "yes" and record the **price**. Mark "N/A" for the alternate items.
   - ❖ If only BBQ size is available, go to the first alternate item and look for regular size. BBQ should be selected only if no other alternate in regular size is available. If BBQ is selected, complete information under "Other" and write "BBQ" in comments.
3. If Schneiders low fat wieners are not available, mark "no" and look for an alternate brand of low fat (<1g). Write down the brand name. If available, mark "yes" and record the price. Mark "N/A" for the remaining alternate items.
4. If no alternate low fat (<1g) variety is available, mark "no" and continue down the alternate list until an item is available or the list is exhausted.
   - ❖ Note that an alternate "Other" item does **not** include soy-based hotdogs, bratwurst or other hotdog-like products.
5. For the regular option, look for Schneiders regular wieners (turkey/pork/chicken). If available, mark "yes", record the price, and mark "NA" for the alternates.
6. If Schneiders regular wieners are not available, mark "no" and continue down the alternate list until an item is available or the list is exhausted.

Measure #6: FROZEN DINNER

Frozen Dinner Definitions:

a. Reduced-fat frozen dinner = ≤ 9 g fat/serving (160-300 g package)
b. Regular frozen dinner = ≥ 10 g fat/serving (160-300 g package)

Measurement Procedures

1. Find the frozen dinners in the frozen food case.
2. Look for Stouffer's® brand of frozen meals as the reference brand. If **available**, mark "yes".
3. If not available, mark "no" and choose another brand that has both regular and reduced-fat entrees. Write the name of the brand in the space provided.

Alternate brand (with reduced-fat dinners available)	Brand Name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

4. Indicate whether reduced-fat frozen dinners (Stouffer's Lean Cuisine® or other) are available by marking "yes" or "no".

5. Estimate the **proportion** of the reduced-fat compared to regular frozen dinners <u>only</u> for Stouffer's® or the alternate brand selected and mark either ≤ 10%, 11-33%, 34-50%, or 51%+. If there is only a reduced-fat option of a particular brand and not a regular version (e.g., Healthy Choice), estimate the proportion of the reduced-fat dinners compared to the regular across all brands.

Reduced-fat dinners/regular dinners: Proportion	○ ≤ 10% ○ 11-33% ○ 34-50% ○

6. Look for Lean Cuisine® and Stouffer's® Lasagna, Chicken Panini and one other set of comparable dinners (e.g. turkey dinner). If a pair is **available**, write the **price**, **grams**, total **calories** (Kcal) and grams of **fat** (g fat). If grams of fat is not a whole number, round up or down accordingly (e.g., if 9 ⅝ oz, write "10").

Reduced Fat Dinner	Price/Pkg	Regular Dinner	Price/Pkg
Lean Cuisine Lasagna ☐☐g. ☐☐☐Kcal. ☐☐g fat	$☐.☐☐	Stouffer's Lasagna ☐☐g. ☐☐☐Kcal. ☐☐g fat	$☐.☐☐

7. If only one of the regular or reduced-fat entrées is available or neither is available, look for an alternate pair of similar entrees to rate. Write the main item of the entrée on the line provided (e.g., chicken or meatballs) and record the price, ounces, total calories and grams of fat.
   - ❖ If there is no brand of reduced-fat frozen dinners, look at the nutritional information to see if any frozen dinners qualify as reduced fat (≤ 9 g fat). Pizza does not count.

Reduced Fat Alternate (≤ 9 g fat)		**Regular Alternate** (≥ 10 g fat)	
Other__________ ☐☐g. ☐☐☐Kcal. ☐☐g fat	$☐.☐☐	Other__________ ☐☐g. ☐☐☐Kcal. ☐☐g fat	$☐.☐☐

8. If there is a limited selection and no alternate pairs available, just record the information on what is available.

Measure #7: BAKED GOODS

Baked Goods Definitions

a. Healthier items
   i. Fat-free = 0 g fat/serving
   ii. Low-fat = ≤3 g fat/serving
b. Regular item: energy dense = >400 kcal/portion or >3 g fat/portion

Measurement Procedures

Item	Available Yes No	Amt. per package	g fat/ per item	kcal/ per item	Price	Comments
Healthier option:						
Bagel						
Single	○ ○		☐☐	☐☐☐	$☐.☐☐	________

1. Find the baked goods/pastries section in the store.
2. For the healthier option, locate the individually sold bagels. Choose a plain bagel to rate if possible. If **available**, mark "yes" and record the grams of **fat** and **calories** listed per bagel and the **price.** If grams of fat is not a whole number, round up or down accordingly (e.g., if 3.5 grams, write "4"). Mark "N/A" for the alternate items.
   - ❖ If an item does not have nutritional information, just record the price.
3. If individual bagels are not available, mark "no" and look for the smallest package of bagels. If available, mark "yes" and record the amount of bagels in the package, the grams of fat and calories listed per bagel, and the price.
   - ❖ For all of the baked goods, if more than one brand is available, use the brand that has the most shelf space of that item. If there are brands with equal shelf space, choose the brand with the name closest to the beginning of the alphabet.
4. If a package of bagels is not available, mark "no and continue down the list of alternates until an item is available or the list is exhausted.
   - ❖ If the alternate item is low-fat muffin:
     - **For grocery stores**, look for a pack of 4 low-fat muffins. If no 4 pack of low-fat muffins is available, choose the 6 pack. If no 6 pack is available, choose a smaller package. If regular and jumbo size muffins are available, choose the regular size. If only jumbo size muffins are available, write "jumbo" in comments.
     - **For convenience stores**, look for individually sold items (muffin and danish) first before packaged items. However, if the single muffins do not have nutritional information and a packaged one does, choose the packaged muffins.
   - ❖ Recording the nutritional information can be tricky as the serving size may not be equal to the entire item (e.g., the serving size may be only ½ of the muffin). Be sure to calculate the nutritional information for the entire item.
5. If the low-fat muffin is the available item for the healthier option of the Baked Goods, count and record the **number of varieties** of low-fat muffins which includes both different brands and flavors (blueberry, banana nut, etc.).
6. For the regular option, look for a regular muffin. Follow the same procedures as for low-fat muffins. If available, mark "yes" and record the amount in a package, grams of fat per muffin, total calories per muffin and price. Mark "NA" for the alternate items.
7. If a regular muffin is unavailable, mark "no" and continue down the list of alternates.

Measure # 8-CS: BEVERAGE

Beverage Definitions

a. Diet soda - 0 kcal
b. Sugared soda – Regular
c. 100% juice – Natural fruit juice with no added sugars. Container must say 100% fruit juice on label.
d. Juice drink/beverage – Fruit juice with added sugar and water

Measurement Procedures

Soda		Available Yes	Available No	Price	Comments
Healthier option:					
Diet Coke	355 mL	○	○	$☐.☐☐	________
	591 mL	○	○	$☐.☐☐	________

For the Soda:

1. Find the chilled beverage section in the store.
2. For the healthier option, locate the 355 mL can and 591 mL bottle of Diet Coca Cola (Diet Coke). If **available**, mark "yes" and record the **price**. Then mark "N/A" for the alternate item.
3. If the 355 mL can or 591 mL bottle is not available, mark "no" and look for an alternate brand of diet soda. Choose the brand with the most shelf space. If there are brands with equal shelf space, choose the brand with the name closest to the beginning of the alphabet. Write in the brand name, mark "yes" and record the price.
4. For the regular option, look for same brand and size of sugared soda to compare.

For Chilled Juice:

1. For the healthier option, look for a 1.89 L bottle of Minute Maid 100% juice first, then Tropicana, then Other. If **available**, mark the brand and "yes" for available, and record the **price**. Mark "NA" for the alternate items.

Juice	Available Yes	Available No	Price	Comments
100% juice, 1.89 L ○ Minute Maid ○ Tropicana ○ Other	○	○	$☐.☐☐	________

2. If no 1.89 L bottle of 100% juice is available, mark "no" and determine if a 1 L bottle of Minute Maid 100% juice is available, then Tropicana and then Other. If available, mark the brand and "yes" for available and record the price. Mark "NA" for the alternate item.
3. If no 1 L bottle of 100% juice is available, mark "no" and locate an alternate size of 100% juice. Look for the Minute Maid brand of 100% juice first, then Tropicana, then Other. If available, mark record the size of the bottle in mL. Then, mark the brand and "yes" for available and record the price.

4. For the regular option, look for the same brand and size of a juice drink to compare. If not available, choose a comparable option in size and price.

Measure # 8-GS: BEVERAGE cont.

For Shelf Stable Juice:

1. Find the beverage section of the store

2. For the healthier option locate 100% orange, apple and grape juice of comparable size. Look for SunRype brand first then the store brand then Other.

3. If available mark Yes for available and record the amount in mL and the price.

4. If one of the types of juice is not available choose an alternative type of 100% juice. Look for SunRype brand first then the store brand then Other. If available mark Yes for available and record the amount in mL and the price.

5. For the regular option locate orange, apple and grape beverage/drink of comparable size to each other and 100% juice choices. If possible choose the same brand. If available mark Yes for available and record the amount in mL and the price.

6. If one of the types of fruit beverage/drink is not available choose an alternative. If available mark Yes for available and record the amount in mL and the price.

Measure #9: BREAD

Bread Definitions

a. Healthier: 100% whole wheat and 100% whole grain bread
b. Regular: Bread made with refined flour

Measurement Procedures

Item	Available Yes No N/A	Loaf size (grams)	Price/loaf	Comments
Healthier option: Store Bakery ________	○ ○	☐☐	$☐.☐☐	

1. Find the bread aisle in the store.

2. For the <u>healthier</u> option, locate the Store Bakeries/Brand 100% whole wheat bread.

3. If the Store Brand 100% whole wheat bread is available marks "yes".

4. Record the **loaf size** in grams and **price** of the loaf.

5. If the Store Brand is not available, mark "no" and look for Dempsters 100% Whole Wheat Bread. If that is available, mark "yes" and record the size and price.

6. If Dempsters is not available, mark "no and choose the brand with the most shelf space. If there is equal shelf space for different brands, select the one that has a brand name closest to the beginning of the alphabet (e.g., Colonial instead of Sunbeam).

7. Write its name, size and price.

8. Count and record the **number of varieties** of 100% whole wheat bread and whole grain bread, which includes both different brands and types (100% whole wheat, 100% honey whole wheat, etc.) but does **not** include different sizes of the same bread.

# of varieties of 100% whole wheat bread and whole grain (all brands)	○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6+

9. Repeat steps 2-6 for the comparable regular option, looking for the same brand that was available for the healthier option if possible. If the same brand is not available for the regular option, choose a comparable option.

Measure #10: BAKED CHIPS

Baked Chips Definitions

a. Healthier items:
   i. Fat-free = 0 g fat/serving
   ii. Low-fat = ≤3 g fat/ per 28 g serving
b. Regular items: > 3 g fat/ per 28 g serving

Measurement Procedures

Item	Available Yes No N/A	Price	Comments
Healthier option: Baked Lays Potato Chips ○ 180 g ○ Other _____ g	○ ○	$☐.☐☐	_________

1. For **grocery stores**, go to the MAIN chips/snacks aisle. For **convenience stores**, find where the smallest size packages of chips are located.

2. For the healthier option, locate Baked Lays® Potato Chips and mark the 180 g size if **available.** (Do not choose chips that come in multi-packs). If the 180 g size is not available, mark "other" and write the size that is available.

3. If Baked Lays® are not available, mark "no" and look for an alternate chips item that has **≤3 g fat per one ounce serving.** Write the name and mark "yes" under available. Some low fat or baked chips may be found in the health food or natural food section of the store.

4. Record the **price** of the Baked Lays® or the alternate item.

5. Count and record the **number of varieties** of low-fat chips (**≤3 g fat per one ounce serving)**, which includes different brands (Lays, Ruffles, etc.) and flavors (Plain, Ranch, BBQ, etc.) and type of chip (corn, potato, etc). It does **not** include different sizes of the same chip. Be sure to check the health food or natural food section of the store.

# of varieties of low-fat chips (any brand)	○ 0	○ 1	○ 2	○ 3	○ 4	○ 5	○	

6. Repeat steps 2-4 for the comparable regular option, looking for the same brand and size that was available for the healthier option.

Measure #11: CEREAL

Cereal Definition
Healthier: < 7g sugar per serving

Measurement Procedures

Item	Available Yes	Available No	Size (ounces)	Price	Comments
Healthier Option: Cheerios (Plain)	○	○	☐☐	$☐.☐☐	________ ________

1. Look for plain Cheerios.
2. If plain Cheerios is **available**, mark "yes" under available.
3. Record the **smallest size** box of Cheerios available in ounces listed on the bottom front of the box.
4. Record the **price**.
5. If plain Cheerios is not available, look for an alternate that qualifies as healthier (<7 g sugar per serving). Write its name, marking "yes" under available and follow steps 3-4 for size and price. Examples of other cereals that have <7 g of sugar per serving include Multigrain Cheerios, Special K, Total Whole Wheat, Rice Krispies, and Corn Flakes.
6. Count and record the **number of varieties** of healthier cereal (<7 g sugar per serving).

# of varieties of healthier cereal	○ 0	○ 1	○ 2	○ 3+

Item	Available Yes	Available No	Size (ounces)	Price	Comments
Regular Option: Cheerios (Honey Nut) ________	○	○	☐☐	$☐.☐☐	________ ________

7. Look for a flavored Honey Nut Cheerios cereal. If available, mark "yes" under available. If plain Cheerios is not available for the healthier option and an alternate healthier cereal is available, look for the sugared version as the regular option (e.g., Corn Flakes and Frosted Corn Flakes).
8. Record the **size** in ounces. If multiple sizes are available, record the smallest.
9. Record the **price**.
10. If Honey Nut Cheerios are not available, look for an alternate that qualifies (≥7 g sugar per serving). Write its name, marking "yes" under available and follow steps 8-9 for size and price.

Appendix A: Nutrition Environment Measures Survey - Stores Tool Adapted For Canada

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #1: MILK

Rater ID: ☐☐

Store ID: ☐☐-☐-☐☐-☐☐☐

Date: ☐☐/☐☐/☐☐☐
Month Day Year

O Grocery Store O Convenience Store O Other

Marking Insv\\\tructions

Please use a pencil or blue or black ink Correct ● Incorrect ✓ ⊗ ⊖ ⊙

A. Reference Brand

1. Store brand (preferred) O yes O no

2. Alternate Brand Name ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Comments: ____________________

____

B. **Availability** Comments:

1. a. Is low-fat (skim or 1%) available? O Yes O No ____________

   b. If not, is 2% available? O Yes O No O NA ____________

2. **Shelf Space:** (measure only if low fat milk is available)

Type	**1 L**	**2 L**	**4 L**
a. Skim	☐☐	☐☐	☐☐
b. 1%	☐☐	☐☐	☐☐
c. Whole	☐☐	☐☐	☐☐

C. Pricing: All items should be same brand (reference brand preferred) Comments:

1. Whole milk, 1 L	$☐.☐☐	____________
2. Whole milk, 2 L	$☐.☐☐	____________
3. Skim or 1% milk, 1 L (Lowest available)	$☐.☐☐	____________
4. Skim or 1% milk, 2 L (Lowest available)	$☐.☐☐	____________

Alternate Items:

5. 2%, 1 L	$☐.☐☐	O N/A	____________

6. 2%, 2 L	$ ☐.☐☐	O N/A	______________

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #2: FRUIT

Rater ID: ☐☐ Store ID: ☐☐-☐-☐☐-☐☐☐

Date: ☐☐/☐☐/☐☐☐
Month Day Year

O Grocery Store O Convenience Store O Other

Availability and Price

Produce Item		Available Yes	Available No	Price	Unit #	Unit pc	Unit lb	Quality A	Quality UA	Comments
1. Bananas		O	O	$ ☐.☐☐	☐	O	O	O	O	______________
2. Apples	O Red delicious O______	O	O	$ ☐.☐☐	☐	O	O	O	O	______________
3. Oranges	O Navel O______	O	O	$ ☐.☐☐	☐	O	O	O	O	______________
4. Grapes	O Red Seedless O______	O	O	$ ☐.☐☐	☐	O	O	O	O	______________
5. Cantaloupe		O	O	$ ☐.☐☐	☐	O	O	O	O	______________
6. Peaches		O	O	$ ☐.☐☐	☐	O	O	O	O	______________
7. Strawberries		O	O	$ ☐.☐☐	☐	O	O	O	O	______________
8. Honeydew Melon		O	O	$ ☐.☐☐	☐	O	O	O	O	______________
9. Watermelon	O Seedless	O	O	$ ☐.☐☐	☐	O	O	O	O	______________

	O______					
10. Pears	O Anjou (Red or Yellow)	O O	$☐.☐☐	☐ O O	O O	______________
	O______					

Produce Item		Available Yes No	Price	Unit # pc lb	Quality A UA	Comments
11. Pineapple		O O	$☐.☐☐	☐ O O	O O	______________
12. Kiwis		O O	$☐.☐☐	☐ O O	O O	______________
13. Plums	O______	O O	$☐.☐☐	☐ O O	O O	______________

14. Total Types: (count # of yes responses) ☐☐

Measure Complete ☐

Nutrition Environment Measures Survey (NEMS)
Measure #3: FROZEN FRUIT

Rater ID: ☐☐ Store ID: ☐☐-☐-☐☐-☐☐☐

Date: ☐☐/☐☐/☐☐
Month Day Year

O Grocery Store O Convenience Store O Other

Availability and Price

Item		Package Size (grams)	Available Yes No	Price	Comments
1. Blueberries	O Europe's Best	☐☐☐☐ g	O O	$☐.☐☐	______________
	O Other________	☐☐☐☐ g		$☐.☐☐	
2. Strawberries	O Europe's Best	☐☐☐☐ g	O O	$☐.☐☐	______________
	O Other________	☐☐☐☐ g		$☐.☐☐	
3. Raspberries	O Europe's Best	☐☐☐☐ g	O O	$☐.☐☐	______________
	O Other________	☐☐☐☐ g		$☐.☐☐	

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #4: CANNED FRUIT

Rater ID: Store ID:

Date: Month Day Year   O Grocery Store   O Convenience Store O Other

Availability and Price

Item		Can Size (mL)	Available Yes	Available No	Price	Comments
1. Peaches	**O Del Monte**	**398 mL**	O	O	$.	
(In juice)	O Other________	mL			$.	
Available packed in water with no added sugar?			O	O		
2. Pineapple	**O Dole**	**398 mL**	O	O	$.	____________
(In Juice)	O Other________	mL			$.	
Available packed in water with no added sugar?			O	O		
1. Applesauce	**O SunRype**	**625 mL**	O	O	$.	
	O Other________	mL			$.	
2. Pears	**O Del Monte**	**398 mL**	O	O	$.	____________
(In Juice)	O Other________	mL			$.	
Available packed in water with no added sugar?			O	O		

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #5: VEGETABLES

Rater ID: Store ID:

Date: Month / Day / Year

O Grocery Store O Convenience Store O Other

Availability and Price

Produce Item		Available Yes	No	Price	Unit #	pc	lb	Quality A	UA	Comments
1. Carrots	O 2 lb bag / O______	O	O	$.		O	O	O	O	______________
2. Tomatoes (Field)	O Loose / O______	O	O	$.		O	O	O	O	______________
3. Sweet Peppers	O Green bell / O______	O	O	$.		O	O	O	O	______________
4. Broccoli	O Bunch / O______	O	O	$.		O	O	O	O	______________
5. Lettuce	O Green leaf / O______	O	O	$.		O	O	O	O	______________
6. Corn		O	O	$.		O	O	O	O	______________
7. Celery		O	O	$.		O	O	O	O	______________
8. Cucumbers	O Long English / O______	O	O	$.		O	O	O	O	______________
9. Green Cabbage	O Head / O______	O	O	$.		O	O	O	O	______________
10. Cauliflower		O	O	$.		O	O	O	O	______________

Produce Item		Available Yes	No	Price	Unit #	pc	lb	Quality A	UA	Comments
11. Potatoes	(White) O 5 lb bag / O______	O	O	$.		O	O	O	O	______________
				$.		pc O	kg O			______________
12. Yams		O	O	$.		O	O	O	O	______________
				$.		pc O	kg O			______________

13. Total Types: (count # of yes responses)

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #6: FROZEN VEGETABLES

Rater ID: 　　　　Store ID:

Date: 　　/　　/　　
Month Day Year

O Grocery Store 　O Convenience Store O Other

Availability and Price

Item		Package Size (grams)	Available Yes	Available No	Price	Comments
1. Peas	O Green Giant	**1 kg**	O	O	$.	________
	O Other______	g				
2. Corn	O Green Giant	**1 kg**	O	O	$.	________
	O Other______	g				
3. Mixed Vegetables	O Green Giant	**1 kg**	O	O	$.	________
	O Other______	g				
4. Carrots	O Green Giant	**1 kg**	O	O	$.	________
(Straight Cut)	O Other______	g				

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #7: CANNED VEGETABLES

Rater ID: 　　　　Store ID:

Date: 　　/　　/　　
Month Day Year

O Grocery Store 　O Convenience Store O Other

Availability and Price

Item		Can Size (mL)	Available Yes	Available No	Price	Comments
1. Tomatoes	O Hunts	**398 mL**	O	O	$.	________
(Stewed)	O Other______	mL			$.	
Available canned without added salt?			O	O		
2. Corn	O Green Giant	**398 mL**	O	O	$.	________
	O Other______	mL			$.	
Available canned without added salt?			O	O		
3. Peas	O Green Giant	**398 mL**	O	O	$.	________
	O Other______	mL			$.	
Available canned without added salt?			O	O		
4. Beets	O Aylmer	**398 mL**	O	O	$.	________
	O Other______	mL			$.	
Available canned without added salt?			O	O		

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #8: GROUND BEEF

Rater ID: Store ID:

Date: Month / Day / Year

O Grocery Store O Convenience Store O Other

Availability and Price

Item	Available Yes No N/A	Price/kg	Comments
Healthier Option:			
1. Lean ground beef, (Use Smallest Package)	O O	$.	
Alternate Items:	**Yes No N/A**		
2. Extra Lean ground beef (<10% fat)	O O O	$.	
% fat			
3. Ground Turkey (≤ 10% fat)	O O O	$.	
% fat			
Regular option:			
5. Regular ground beef, (Use Smallest Package)	O O	$.	
Alternate Item:	**Yes No N/A**		
6. Standard alternate ground beef, if above is not available	O O O	$.	
% fat			

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #9: HOT DOG

Rater ID:

Store ID:

Date: Month Day Year

O Grocery Store O Convenience Store O Other

Availability and Price

Item	Available Yes No N/A	Price/pkg.	Comments
Healthier Option:			
1. Schneiders low fat weiners (turkey/beef) < 1g fat	O O	$.	
Alternate Items: (≤ 9 g Fat)	Yes No N/A		
2. Fat-free other brand 0g fat Brand name	O O O	$. Kcal/svg	
3. Light Wieners (turkey/pork)	O O O	$.	
4. Light beef Franks, (about 1/3 less calories 50% less fat)	O O O	$.	
5. Turkey Wieners (about 1/3 less fat)	O O O	$.	
6. Other	O O O	$. g pkg Hot dogs/pkg g fat kcal/svg	
Regular option:			
7. Schneiders regular weiners	O O	$.	
Alternate Items: (≥ 10g fat)			
8. Beef Franks (regular) 13 g fat	O O O	$.	
9. Other			

O O O $. g pkg Hot dogs/pkg

g fat kcal/svg

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #10: FROZEN DINNERS

Rater ID: Store ID: - - -

Date: / /
Month Day Year

O Grocery Store O Convenience Store O Other

A. Reference Brand

1. Stouffer's brand (preferred) O Yes O No

2. Alternate brand (with reduced-fat dinners available) Brand Name:

Comments: ____

B. Availability

1. Are reduced-fat frozen dinners available? (≤ 9 g fat/8-11 oz.)

Shelf Space: (measure only if reduced-fat frozen dinners are available)

2. Reduced-fat dinners/regular dinners: Proportion O<=10% O 11-33% O 34-50% O 51%+

C. Pricing (All items must be same brand)

Reduced-Fat Dinner	**Price/Pkg**	**Comments**	**Regular Dinner**	**Price/Pkg**
1. Lean Cuisine **Lasagna**	$.		g K cal. g fat	
g K cal.			5. Other ______	$.
2.Lean Cusine **Tuscan Chicken Panini**	$.		g K cal. g fat	
g K cal.			6. Other ______	$.
3. ______	$.		g K cal. g fat	
g K cal. g fat				
Reduced-Fat Alternate (≤9 g fat)	**Price/Pkg**		Stouffer's **Lasagna**	$. ______
4. Other ______	$.			

g K cal. g fat

Stouffer's Bistro Panini $.
Grilled Chicken Italian Style

g K cal. g fat

$.

g K cal.

Regular Alternate (≥10g fat) Price/Pkg C

Other $.

g K cal. g fat

Other $.

g K cal. g fat

Other $.

g K cal. g fat

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #11: BAKED GOODS

Rater ID: Store ID:

Date: / /
Month Day Year

O Grocery Store O Convenience Store O Other

Availability & Price
Low-fat baked goods ≤3g fat/serving

Item	Available Yes No	Amt. per package	g fat/ per item	kcal/ per item	Price	Comments
Healthier option:						
1. Bagel						
Single	O O				$	
	Yes No N/A					
Package	O O O				$	
Alternate Items:	Yes No N/A					
2. English muffin	O O O				$	
3. a. Low-fat muffin	O O O				$	

b. # varieties of low fat muffins O 0 O 1 O 2 O 3+

Regular option (≥4g fat/serving or 400 Kcal/serving):

4. Regular muffin O O $

Alternate Items **Yes** **No** **N/A**

5. Regular Danish O O O $

6. Other O O O $

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #12-CS-BEVERAGE

Rater ID: Store ID:

Date: / / O Grocery Store O Convenience Store O Other

Month Day Year

Availability & Price

Healthier option:		**Available**	**Price**	**Comments**
		Yes No		
1. Diet Coke	355 mL	O O	$	
	591 mL	O O	$	
2. Alternate brand of diet soda		**Yes No N/A**	$	
	355 mL	O O O	$	
	591 mL	O O O	$	

Regular option:		**Yes No**		
3. Coke	355 mL	O O	$	
	591 mL	O O	$	
4. Alternate brand of sugared soda		**Yes No N/A**		
	355 mL	O O O	$	
	591 mL	O O O	$	

Healthier option:

5. **100% juice, 1.89 L** **Yes No**
O Minute Maid O Tropicana O Other O O $ ________

Alternate Items: **Yes No N/A**
6. **100% juice, 1.89 L**
O Minute Maid O Tropicana O Other O O O $ ________
7. **100% juice,** ___ mL
O Minute Maid O Tropicana O Other O O O $ ________

Regular option: **Yes No**
8. **Juice Drink, 1.89 L**
O Five Alive O Tropicana O Other O O $ ________

Alternate Items: **Yes No N/A**
9. **Juice Drink, 1.89 L**
O Minute Maid O Tropicana O Other O O O $ ________

10. **Juice Drink,** ___ mL.
O Minute Maid O Tropicana O Other O O O $ ________

Healthier option:
11. **100% Orange Juice, ___ mL** **Yes No**
O SunRype O Store Brand O Other O O $ ________

12. **100% Apple Juice, ___ mL** **Yes No**
O SunRype O Store Brand O Other O O $ ________

13. **100% Grape Juice, ___ mL** **Yes No**
O SunRype O Store Brand O Other O O $ ________

Alternate Items: **Yes No N/A**
14. **100% Juice ___mL**
O SunRype O Store brand O Other O O O $ ________

Regular option: **Yes No**
15. **Orange Drink, ___mL**
O Brand ________ O Store Brand O O $ ________

16. **Apple Drink, ___mL**
O Brand ________ O Store Brand O O $ ________

17. **Grape Drink, mL**

O Brand ________ O Store Brand O O $ ________

Alternate Items: **Yes No N/A**
18. **Juice Drink, ____mL**
O Brand ________ O Store Brand O O O $ ________

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #13: BREAD

Rater ID: 　　　　Store ID:

Date: ___/___/___ (Month Day Year)　　O Grocery Store　　O Convenience Store O Other

Availability & Price

Item	Available Yes No N/A	Loaf size (grams)	Price/loaf	Comments
Healthier Option: Whole grain bread (100% whole wheat bread and whole grain bread)				
1. Store Bakery	O O		$	
Alternate Items:				
2. Dempsters 100% Whole Wheat Bread	O O O		$	
3. Other:	Yes No N/A O O O		$	
4. # of varieties of 100% whole wheat bread and whole grain (all brands)	O 0　O 1　O 2　O 3　O 4　O 5　O 6+			

Item	Available Yes No N/A	Loaf size (grams)	Price/loaf	Comments
Regular Option: White bread (bread made with refined flour)				
5. Store Bakery	O O		$	
Alternate Items:	Yes No N/A			
6. Dempsters White Bread	O O O		$	
7. Other:	O O O		$	

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #14: BAKED CHIPS

Rater ID: Store ID:

Date: / / O Grocery Store O Convenience Store O Other
Month Day Year

Availability & Price
Low-fat chips ≤3g fat per 28 g serving

Item	Available	Price	Comments
Healthier Option :	**Yes No**		
1. Baked Lays Potato Chips O 180 g O Other ____________ g.	O O	$	________________
Alternate Item:	**Yes No N/A**		
2. O 180 g. O Other ____________ g.	O O O	$	________________
3. # of varieties of low-fat chips (any brand)	O 0 O 1 O 2 O 3 O 4 O 5 O 6+		

Regular Option (select most comparable size to healthier option available):

Item	Available	Price	Comments
	Yes No		
4. Lays Potato Chips Classic O 235 g O Other ____________ g.	O O	$	________________
Alternate Item:	**Yes No N/A**		
5. O 235 g. O Other ____________ g.	O O O	$	________________

Measure Complete

Nutrition Environment Measures Survey (NEMS)
Measure #15: CEREAL

Rater ID: ______ Store ID: ______

Date: ___/___/___ (Month Day Year) O Grocery Store O Convenience Store O Other

Availability & Price
Healthier cereals < 7 g sugar per serving

Item	Available Yes No N/A	Size (grams)	Price	Comments
Healthier Option:				
1. Cheerios (Plain)	O O		$	______
Alternate Item:	Yes No N/A			
2. Other ______	O O O		$	______
3. # of varieties of healthier cereals	O 0 O 1 O 2 O 3+			
Regular Options (≥7g of sugar per serving):				
4. Cheerios (Honey Nut)	O O		$	______
Alternate Item:	Yes No N/A			
5. Other ______	O O O		$	______

Appendix C: Nutrition Environment Measures Survey – Restaurants Protocol

Nutrition Environment Measures Survey (NEMS)
Restaurant Measures Survey Instructions

These measures are designed to rate the nutrition environments of restaurants serving either lunch or dinner. They are not designed to rate specialty shops such as coffee or ice cream shops, unless these shops serve lunch or dinner items (e.g., sandwiches). In addition, there are other establishments that may serve food that fall into an exclusions category (see below) and would not be rated. However, based on your survey purposes, you may decide to set different exclusion criteria.

Exclusions

Establishments that are not open to the general public, or those where you have to pay a charge just to enter. Also, establishments where food is not the primary product (e.g., food counters at drugstores).

Examples:

- schools
- churches
- convalescent homes
- bars, clubs, or places excluding children 18 and under
- movie theatres
- hospitals
- stores not preparing food to order or consume immediately (bakery, dairy store, store that sells coffee beans, etc.)
- food counters within discount/superstores (e.g., Wal-Mart)
- workplace cafeterias

In these protocol instructions, each section of the survey is shown, followed by instructions for completing that section. Refer to the *Restaurant Data Collection Flowchart*, which explains the suggested order for completing the survey components, if you have any questions on the data collection process.

General Completion Tips

Remember to follow the tips below to decrease the data cleaning time later.

4. Write legibly.
5. Check your work.
6. Use the correct line/bubble.

For Those Whose Forms will be Scanned

The surveys will be scanned on a machine that is very picky, so please remember to do the following:

1. **Darken** your circles once you are sure of the answer.
2. Press down when writing letters or numbers so they are legible and dark.

3. Write your comments and notes on the lines provided.
4. Do not cross through any individual items or sections.
5. Erase any stray marks you make.

Cover Page

- Record your Rater ID at the top of the page.
- Confirm that the category assigned to the restaurant (sit down-SD, fast casual-FC, fast food-FF, specialty, or other) during the enumeration process is correct and mark the appropriate bubble. See instructions below on restaurant classification.
    - If it is incorrect, explain in the "Comments" section of the cover page and alert project coordinator when submitting the form.
    - Continue with the assessment, unless it is not a restaurant.
- Record the date and start/end times for each data source as you complete the data collection.

Classifying Restaurants:

1. **Sit-down Restaurants category (SD)**

This category includes traditional sit-down restaurants, and bars and pubs with full menus that are open to all ages.

a. **Sit-down Restaurant**-Restaurant that offers full table service by wait staff, who take your order at the table.

Examples:

- Applebee's
- Benihana - http://www.benihana.com/
- Cheesecake Factory - http://www.cheesecakefactory.com/
- Chili's Grill & Bar - http://www.chilis.com/
- Denny's- http://www.dennys.com/
- Don Pablo's
- Golden Corral
- Hard Rock Cafe
- International House of Pancakes or IHOP
- Olive Garden
- Outback Steakhouse- http://www.outback.com/
- P.F. Chang's China Bistro - http://www.pfchangs.com/
- Planet Hollywood - http://www.planethollywood.com/
- Qdoba Mexican Grill - http://www.qdoba.com/
- Ruby Tuesday
- Sizzler - http://www.sizzler.com/home/home.html
- TGI Friday's - http://www.tgifridays.com/
- Thaicoon
- Todai Seafood Buffet - http://www.todai.com/
- Top Spice
- Touch of India
- Z' Tejas Southwestern Grill - http://www.ztejas.com/

b. **Bars/Pubs** – A restaurant that sells a full range of alcoholic beverages, has a full menu and is open to all ages. These are to be listed under the **Sit-down Restaurants** heading.

Examples:

- Brick Store Pub
- Famous Pub and Sports Palace
- Maggie's Neighbourhood Bar & Grill
- Taco Mac

2. **Fast Casual Restaurant (FC)**

A restaurant that is similar to fast-food in that it does not offer table service, but promises somewhat higher quality of food and atmosphere. (http://en.wikipedia.org/wiki/List_of_fast_casual_dining_restaurants) You may order and pay at a counter. Often food is brought to your table.

Examples:

- Atlanta Bread Company
- Baja Fresh
- Boston Market
- Café Express
- Chipotle Mexican Grill
- Fresh City
- Fuddruckers
- Mama Fu's
- Moe's Southwest Grill
- Panera Bread Company
- Pita Palace
- Wingstop

3. **Fast Food Restaurants category (FF)**

This category includes fast food restaurants only. Fast food restaurants are characterized by minimal service and by food that is supplied quickly after ordering. Food purchased may or may not be eaten quickly as well. Food is commonly cooked in bulk in advance and kept hot, or reheated to order.

Fast Food restaurants usually meet at least one of the following criteria:

A. A restaurant that is **part of a fast food chain or franchise** (see list) that ships standardized foodstuffs to the individual restaurants from central locations.
B. A restaurant that is **located in a food court.**
C. A restaurant that is limited to **take-out only.**
D. **Lunch trucks, trailers, wagons, etc.**

More on Fast Food:

Fast food is often highly processed and prepared in an industrial fashion, i.e., with standard ingredients and methodical cooking and production methods. It is served usually in cartons or bags in a rapid manner in order to minimize costs. Fast food outlets often provide take-away or take-out food in addition to tables for eating-in. A drive-through allows food to be ordered and delivered without leaving the car to further speed service.

Fast food is often finger food that can be eaten quickly and without cutlery. Fast food often consists of fish and chips, sandwiches, pitas, hamburgers, breaded chicken, French fries, chicken nuggets, pizza or ice cream, although many fast food restaurants offer some other less easily consumed choices like chili, mashed potatoes, or salads. *Chinese cuisine, although often served as take-away, is not always considered fast food.* (http://encyclopedia.thefreedictionary.com/Fast-food%20restaurant)

Examples:

- Arby's http://www.arbys.com
- Blimpie
- Burger King
- Carl's Jr. http://www.carlsjr.com/
- Chick-fil-A http://www.chickfila.com
- Dairy Queen (Brazier)
- El Pollo Loco http://www.elpolloloco.com/
- Jack in the Box
- KFC
- Krystal http://www.krystalco.com/
- Little Caesar's
- Long John Silver's
- McDonald's
- Panda Express http://www.pandaexpress.com/
- Pizza Hut
- Popeye's Fried Chicken http://www.popeyes.com/
- Quizno's
- Sbarro
- Schlotzsky's http://www.cooldeli.com/
- Sonic Drive-In http://www.sonicdrivein.com/
- Steak and Shake
- Subway Sandwich
- Taco Bell
- Tastee Freeze
- Wendy's
- Whataburger

4. **Specialty Shops category**
   a. **Coffee/Pastry** - This category includes restaurants where coffee and/or pastries are the main items sold.

   Examples:
   - Caribou Coffee
   - Dunkin' Donuts
   - Krispy Kreme
   - Seattle's Best Coffee
   - Starbucks

   b. **Ice Cream** -This category contains restaurants where ice cream or similar types of food such as smoothies, yogurt, etc.

are the main items sold. The food is a single serving that is prepared for immediate consumption.

Examples:
- Baskin Robbins
- Cold Stone Creamery
- Planet Smoothie
- Smoothie King
- TCBY

5. **Other category** – All other restaurants; we think that we captured all restaurant establishments, but in case we overlooked one, please use this category!

All Pages

Restaurant ID: □□-□-□□-□□□ Date: □□/□□/□□

Rater ID: □□

Record the following at the top of all pages of the form:

- Restaurant ID
- Today's date
- Rater ID

PAGE 1

TYPE OF RESTAURANT:

)1) **Type of Restaurant:** Code # □□

1. Record code from **Restaurant Code List** for type of restaurant, basing it on the main category of cuisine served (e.g., if it is a Chinese vegetarian restaurant, code it as Chinese, not Vegetarian).

NEMS Restaurant Code List		
Code #	Type of Restaurant	Examples
01	General / Mixed / American	Applebees, Chili's, TGI Friday, IHOP, Waffle House
02	Burgers	McDonald's, Wendy's, Hardees
03	Chicken	KFC, Mrs. Winner's, Chick-Fil-A
04	Sub Sandwiches	Subway, Blimpie, Quiznos
05	Pizza	Pizza Inn, Pizza Hut, Mellow Mushroom
06	Bagel / Deli	Einstein's, Bagel Palace Deli
07	Seafood	Pappadeaux, Red Lobster
08	BBQ	Dusty's, Sonny's BBQ
09	Steakhouse	Outback Steakhouse, Ruth Chris' Steakhouse, Longhorn
10	Coffee Shops	Starbuck's, Seattle's Best Coffee, Caribou Coffee
11	Ice Cream/Frozen Yogurt Shops	Baskin Robbins, TCBY, Cold Stone Creamery, Baskin-Robbins
12	Donut Shops	Krispy Kreme, Dunkin' Donuts
13	Bakery/Pastry Shops	Mrs. Fields' Cookies, Cinnabon
14	Bars/Pubs	Taco Mac, ESPN Zone
15	Asian (mixed, other)	Mama Fu's, Chopsticks, Top Spice
16	Chinese	Red Pepper, The Golden Buddha, Panda Chinese
17	Thai	Thai Chili, Thaicoon
18	Japanese	Edo Steak House, Shogun, Fuji Japanese
19	Mexican	Chipotle, Pappasitos, Don Pablos
20	Italian	Sbarro, Olive Garden, Romano's Macaroni Grill
21	French	Petite Auberge, Le Madeleine
22	Indian	Touch of India, Himalayas Indian, Haveli
23	Greek, Middle Eastern	Athens Restaurant, Kyma, Basil's Mediterranean
24	Vegetarian	
25	Other	

Data Sources:

2) Data sources:	Site visit/Observation	Take-Away Menu	Internet	Interview
	O yes	O yes O no	O yes O no	O yes O no

2. Record all the data sources that you use in completing the data collection form for this restaurant.
If you fill in "no" for any of the data sources, leave the corresponding data source in Items #3-6 blank and note the reason in comments. For example, if you are not able to complete the site visit for whatever reason, leave Item #3 (Site Visit) blank and note the reason (e.g., manager refused).

Site Features and Information:

3) Site Visit Information:			4) Take-Away Menu Features:			5) Internet Site Features:			6) Interview Information:		
Take-away Menu	O yes	O no	Nutrition Information	O yes	O no	Menu	O yes	O no	Menu options	O yes	O no
Nutrition Information	O yes	O no	Identification of healthier menu items	O yes	O no	Nutrition Information	O yes	O no	Pricing	O yes	O no
Other:	O yes	O no	Other:	O yes	O no	Identification of healthier menu items	O yes	O no	Other:	O yes	O no
Other:	O yes	O no	Other:	O yes	O no	Other:	O yes	O no	Comments (describe items above):		
Comments:_______________			Comments:_______________			Web site URL:_______________			______________________		
______________________			______________________			Comments:_______________			______________________		
									______________________		

3. **Site Visit Information:** Record whether you were able to obtain a take-away menu and/or nutrition information during your site visit. If the site visit includes other nutrition-environment relevant information (e.g., a healthy eating brochure), mark "yes" next to "Other" and describe in comments.

4. **Take-Away Menu Features:** Record whether the take-away menu includes nutrition information or identification of healthier menu items. If the menu includes other nutrition-environment relevant information (e.g., a statement encouraging healthy eating), mark "yes" next to "Other" and describe in comments.

5. **Internet Site Features:** Record what type of information you found on the Internet about this restaurant. Also record the Web address (URL) or addresses where you found the information. If the website includes other nutrition-environment relevant information (e.g., a nutrition calculator), mark "yes" next to "Other" and describe in comments.

6. **Interview Information:** Record whether you used a formal sit-down interview to obtain menu options, pricing, or other informatior that you could not get from the other data sources. Asking wait staff a few questions is not considered an interview.

Hours of Operation:

7) Hours of Operation:			Data Source(s): ○ Site ○ Menu ○ Web
Sunday ○ Open ○ Closed	**Thursda y** ○ Open ○ Closed	**Frida y** ○ Open ○ Closed	**Saturda y** ○ Open ○ Closed
○ B: 6:00 – 11:00 am	○ B: 6:00 – 11:00 am	○ B: 6:00 – 11:00 am	○ B: 6:00 – 11:00 am
○ L: 11:00 am – 3:00 pm	○ L: 11:00 am – 3:00 pm	○ L: 11:00 am – 3:00 pm	○ L: 11:00 am – 3:00 pm
○ D: 5:00 pm to Close	○ D: 5:00 pm to Close	○ D: 5:00 pm to Close	○ D: 5:00 pm to Close
☐☐:☐☐ ○ AM ○ PM	☐☐:☐☐ ○ AM ○ PM	☐☐:☐☐ ○ AM ○ PM	☐☐:☐☐ ○ AM ○ PM
○ Open 24 Hours (If 24-hr, leave *Hours of Operation* section blank)			

7. **Hours of Operation**
   - **Note:** The hours listed beside breakfast (B), lunch (L), and dinner (D) are approximate times. For example, for a restaurant that is open 10:30 am – 10:00 pm, mark *L* (Lunch) and *D* (Dinner), or even if the restaurant opens at 7:00 am instead of 6:00, mark *B* (Breakfast).

   During the site visit (or from another data source), record the following:
   - Data source(s)
   - Is the restaurant open or closed on the days indicated?
   - If so, record whether it is open for breakfast (B), lunch (L), and/or dinner (D). If it serves brunch, mark as breakfast and lunch.
   - Record the latest hour open, and mark *am* or *pm*.
   - If the restaurant is open 24 hours, leave the rest of Section 7 blank.

Access:

8) Access: Drive-thru window	Parking onsite
○ yes ○ no	○ yes ○ no
Comments:____________________	

8. **Access**

- Record whether there is a drive-thru window. If the restaurant offers the option of sitting in your car and a server comes out to take your order or bring you your food (e.g., such as Ruby Tuesday's), this is NOT considered a drive-thru. Just note this in comments.

- Parking onsite
    - Mark YES, if parking is available in a parking lot or structure/parking deck associated with the restaurant.
    - It does not matter if the parking is paid, free, valet, or self-park.
    - If there is only street parking (free or metered), answer NO to parking, as that is not associated with the restaurant.

SIZE OF RESTAURANT:

9) Size of Restaurant:

○ Seating capacity = ______ OR○ Number of tables = ______

Comments:________________________________

9. **Size of Restaurant**

- Record the seating capacity (from the fire department sign on the wall), or count the number of tables of any size, if you do not see the sign. Count both exterior and interior tables. Count the counter seating as one table and note the number of counter seats in comments.
    - Note: If you use the seating capacity from the fire department sign, you will still need to count any exterior tables and note it in comments.
- If the restaurant is in a food court and has no tables, fill in seating capacity = 0 and note in comments that the restaurant is in a food court. If the restaurant has its own tables, list the seating capacity, or count the tables and note in comments that there are also tables in the food court.

10. Salad bar

10) Restaurant has a salad bar	O yes O no	

- Record whether the restaurant has a salad bar.

11. Signage/Promotions

11) Signage/Promotions		
a. Is nutrition information posted near point-of-purchase, or available in a brochure?	O yes O no	
b. Do signs/table tents/displays highlight healthy menu options?	O yes O no	
c. Do signs/table tents/displays encourage **healthy** eating?	O yes O no	
d. Do signs/table tents/displays encourage **unhealthy** eating?	O yes O no	
e. Do signs/table tents/displays encourage overeating (all-you-can-eat, super-size, jumbo, grande, supreme, king size, feast descriptors on menu or signage)?	O yes O no	
f. Does this restaurant have a low-carb promotion?	O yes O no	
g. Other? ____________________	O yes O no	

Record the following and describe the signage in comments. Please note that signage can be **inside** or **outside** the restaurant.

a. Nutrition information near point of purchase

- Is nutrition information posted near point-of-purchase, or available in a brochure that is prominently displayed?

b. Signs/table tents/displays highlight healthy menu options

- Signage may relate to nutritional value/type of food (grilled food, salads)
  - Example: "Try a low-fat option—We feature salads made with fat-free dressing"
  - Example: "Eat healthy: Try our Brown Rice"

c. Signs/table tents/displays encourage healthy eating

- Signage that encourages making healthy choices
  - Example: "Here's to Eating Well"
  - Example: "Fruits and Vegetables—the Smart Choice!"

d. Signs/table tents/displays encourage unhealthy eating

- It can be related to nutritional value/type of food (promoting rich desserts and fried foods) or price (combo discounts)
  - Example: "Try our cheesecake: Rich & creamy"
  - Example: Posters featuring pictures of high-fat foods
  - Example: Promotional signs or posters pushing combo discounts

e. Signs/table tents/displays encourage overeating

- Related to quantity
  - Examples: All-you-can-eat, super-size, jumbo, grande, supreme, king size, feast descriptors

f. Low-carb promotion

- Is restaurant promoting low-carb menu items?
  - Example: "The Low Carb Option"
  - Example: Low-Carb Chopped Steak

g. Other

- Note any other signage or displays that would influence food purchasing.

MENU REVIEW/SITE VISIT ITEMS 12-15

Items 12-15 are under the header Menu Review/Site Visit, because sometimes they are not listed on the menu and you may need to ask wait staff if they are available.

12. Chips

12) a. Chips b. Baked chips	O yes O no O yes O no	

- Record whether chips (fried) and baked chips are available (yes/no).
- Note: Baked chips must have ≤ 3 grams fat/serving. Baked Lays® and Baked Tostitos® meet this criterion; however, Baked Doritos® do not.

13. Whole Grain Bread

13) a. Bread b. 100% Whole wheat or whole grain bread	O yes O no O yes O no	

- Record whether regular (enriched flour) and 100% whole wheat or whole grain bread are available (yes/no).

14. 100% Fruit Juice

14. 100% fruit juice	O yes O no	

- Record whether 100% fruit juice is available (yes/no).

15. 1% Low-fat, Skim or Non-fat milk

15. 1% low-fat, skim, or non-fat milk	O yes O no	

- Record whether low-fat (1% or ½ %), skim or non-fat milk is available (yes/no).

Menu Review (#16-21)

16. Main Dishes/Entrees:

16) Main Dishes/Entrees: a. Total # Main Dishes/Entrees.	○ yes # ☐☐☐ ○ no	
b. Healthy options	○ yes # ☐☐ ○ no	

16a. Total number of main dishes/entrees

- Count the total number of main dishes and entrees on the menu. Include any entrees that are listed as specials that do not appear on the menu. If there are both lunch and dinner menu items listed on the same menu, do **not** count the entrees listed as "Lunch" items. Do not include main dish salads.

Use the following guidelines:

- General rule of thumb: If an item is listed as a separate entrée, count it. Do not think too hard about it.

- **Definition of an entrée--**
  It must be distinctly different, either in ingredients, proportion of ingredients, or preparation method
  and
  Differ in ways OTHER THAN JUST SIZE/QUANTITY

- An example of different proportion of ingredients: A cheeseburger and a double cheeseburger have proportionately different ingredients, making one higher in percent fat than the other. Proportionally, a double cheeseburger is higher in percent fat than a cheeseburger, because it has a smaller percentage of bread, lettuce and tomato (lower fat ingredients) than meat and cheese (higher fat and saturated fat ingredients). Thus, these would be two separate entrees.

- Count each type of entrée only once. If the entrée is offered in different sizes or in combination with another food, count it only once.
  - Example: Baby Back Ribs *(Count as one entrée)*
    ½ Rack Baby Back Ribs
  - Example: FAJITAS *(Count as 2 entrees, not 4)*
    Steak: Seasoned Steak Grilled to Perfection
    Chicken: Grill and Marinated Chicken Breast
    ~~Combo: Grilled and Marinated Chicken Breast with Seasoned Steak~~

~~Double: Your Choice of Chicken, Steak, or as a Combo~~

- If the entrée is listed with an option of "chicken or beef" or similar choices, count each item as a separate entree.
  - Example: Curries: Choice of Chicken, Beef, or Pork *(Count as 12 entrees, not 4)*
    - Panang
    - Massaman
    - Red Curry
    - Pineapple Curry

- If entrees are listed together in a section, but are distinctly different, count each one as an entrée.
  - Example: *(Count as 5 entrees, not 1)*

    Blimpies Hot Subs—Grilled

    6 In: $3.99 6 In: Stacker: $5.19 12 In: $6.29
    - Buffalo Chicken
    - Ultimate Club
    - Beef, Turkey & Cheddar
    - Pastrami Special
    - Reuben

- If various preparation options, e.g., broiled, fried, or grilled, are available, count each preparation option as an entrée.
  - Example: Farm-raised Catfish, grilled or breaded and pan-fried *(Count as 2 entrées, not 1)*

- If the same entrée is prepared with different sauces, count them as different entrées.
  - Example: A dozen hot wings offered in BBQ, Honey Mustard or Lemon Pepper *(count as 3 entrées, not 1)*
  - Example: Spaghetti with marinara sauce, meat sauce or Alfredo sauce *(count as 3 entrées, not 1)*

- If an entrée is listed twice in separate sections of the menu, count it twice.

- Soup is counted as an entrée if it is priced similar to other entrees.

- **Do not** count the following as main dishes:
  - Sushi
  - Dim Sum
  - Tapas

- If a restaurant serves brunch items and there is no separate dinner menu, or if breakfast items are offered all day, count them as entrees.

- Count "build your own" as one item.
  - Example: Build your own omelet (with choice of ingredients) *(Count as 1 entrée)*
  - Example: Build your own pizza *(Count as 1 entrée)*

- If the restaurant features a buffet or smorgasbord for one price, count as one entrée. Note this in comments.

16b. Healthy options
If calorie and fat information or a healthy symbol or notation (e.g., ***light fare, light, heart healthy, healthy***) are provided, mark "yes". If not, mark "no". Then follow the steps below to count whether the options meet the NEMS definition of "healthy".

<u>If nutrition information is available:</u>

1. Count the number of **entrees (except burgers and sandwiches)** that meet **all three** of the following criteria:
   a) ≤ 800 calories
   b) ≤ 30% of calories from fat (see % Fat Chart)
   c) If saturated fat data are available, then check to see if the items that meet the total fat criterion also have ≤ 10% of calories from saturated fat (see % Fat Chart).

2. Count the number of a la carte **burgers and sandwiches** that meet **all three** of the following criteria:
   a) ≤ 650 calories
   b) ≤ 30% of calories from fat (see % Fat Chart)
   c) If saturated fat data are available, then check to see if the items that meet the total fat criterion also have ≤ 10% of calories from saturated fat (see % Fat Chart).

3. Add the numbers of entrees, burgers, sandwiches meeting the criteria and record in **#16b** on data collection form.

4. If a menu does not have any healthy options, write "0" in the # box.

<u>If nutrition information is **not** available:</u>
Record the number of entrees identified as ***"light fare," "light," "heart healthy," "healthy,"*** sometimes designated with a small heart symbol. If a menu does not have any healthy options, write "0" in the # box.

% Fat Chart

Count entrees and main dish salads with the following maximum amounts of calories and total fat (30% calories from fat) as healthful choices. Look at the nutritional information listed by each entrée. Find where each entrée falls in the calorie range listed. Then, see if the grams of fat given for that range are equal to or less than the fat content of the entrée. If the fat grams in the entrée are greater than the chart, it is not counted as a healthy option.

Calories	≤ grams of fat
≤ 179	5 grams
180 - 209	6 grams
210 - 239	7 grams
240 - 269	8 grams
270 - 299	9 grams
300 - 329	10 grams
330 - 359	11 grams
360 - 389	12 grams
390 - 419	13 grams
420 - 449	14 grams
450 – 479	15 grams
480 - 509	16 grams
510 – 539	17 grams
540 - 569	18 grams
570 - 599	19 grams
600 – 629	20 grams
630 – 659	21 grams
660 – 689	22 grams
690 – 719	23 grams
720 – 749	24 grams
750 – 779	25 grams
780 – 800	26 grams

If saturated fat data are available, then items must also have no more than 10% saturated fat calories to count as healthful. See chart below:

Calories	≤ grams of saturated fat
≤ 149	1 gram
150 – 239	2 grams
240 – 319	3 grams
320 – 419	4 grams
420 – 499	5 grams
500 – 589	6 grams
Remember, burgers and sandwiches ≤ 650 calories	
590 – 689	7 grams
690 –769	8 grams
770 – 800	9 grams

17. Main Dish Salads

17) Main dish salads: a. Total # Main dish salads	○ yes # ☐☐ ○ no	
b. Healthy options	○ yes # ☐☐ ○ no	
c. Low-fat or fat free salad dressings	○ yes # ☐☐ ○ no	

17a. Total #Main dish salads

Record the total number of main dish salads of any kind listed on the menu and mark "yes." See definition of main dish salad below. If there are no main dish salads on the menu, mark "no" and write "0" in the # box.

- **Definition of a Main Dish Salad:**

A main dish salad is of sufficient size to be the central part of a meal (or a meal in itself) and typically contains at least one protein source as an integral ingredient (see list for examples).

- Do not count salads that are listed under the following sections of the menu or that are clearly smaller in size than the main dish salads (e.g., their price is half of the average main dish salad price):
  - Appetizers
  - Side items, side orders, or sides
  - Extras
- Do not count salads that are indicated for sharing, as is typical in an Italian restaurant.
- Greek or Mediterranean salads should be counted as a main dish salad, if they meet the size/price criterion.
- If in doubt about the ingredients, and the price is similar to other main dishes on the menu, count it as a main dish salad.
- Do not count the following salads as a main dish, unless they have a high-protein ingredient (see *Protein Sources* below).
  - Pasta salad
  - Caesar salad
  - House salad

Protein Sources
▪ Tofu ▪ Chicken or turkey (poultry) ▪ Fish or seafood ▪ Beef or pork (do **not** count bacon as a protein source) ▪ Vegetarian chili ▪ Pinto beans, soybeans, chickpeas (or hummus) or other legumes ▪ Egg (unless used only as a garnish)

17b. Main dish salads: Healthy options
If calorie and fat information or a healthy symbol or notation (e.g., ***light fare, light, heart healthy, healthy***) are provided, mark "yes". If not, mark "no". Follow the steps below to count whether the main dish salads meet the NEMS definition of "healthy" based on whether nutrition information is or isn't available.

<u>If nutrition information is available:</u>

1. Record the number of **main dish salads** that meet **all three** of the following criteria:
    a) ≤ 800 calories
    b) ≤ 30% of calories from fat (see % Fat Chart)
    c) If saturated fat data are available, then check to see if the items that meet the total fat criterion also have ≤ 10% of calories from saturated fat (see % Fat Chart).
2. If there are none that meet the criteria, write a "0" in the # box

<u>If nutrition information is **not** available:</u>

1. Record the number of main dish salads with ≤ two high-fat ingredients (see **Supplementary Information** below for list).
2. If there is no low-fat or fat-free dressing available, then the salads cannot be counted as healthy options.
3. If there are none that meet the criteria, or if the salad ingredients are not listed, write a "0" in the # box.

Supplementary Information: Main Dish Salads	
Note: If a salad comes dressed, it cannot be counted as healthful, unless low-fat or fat-free dressing is an option on the menu (included in separate list of dressings).	
Yes	**No**
▪ Grilled, chargrilled or charbroiled chicken breast salad ▪ Grilled fish or seafood salad ▪ Turkey breast or ham as ingredients ▪ Vegetable salad	▪ Salads with three or more of the following: • Avocado or guacamole • Bacon • Cheese • Croutons • Egg (if already have a protein source) • Fried (crispy) noodles, tortilla strips (or similar fried garnishes) • Nuts • Olives • Pesto • Sausage or pepperoni • Salami, bologna, pastrami, corned beef or other high-fat lunch meat (roast beef, okay) • Sour cream ▪ Mayonnaise-based salads such as tuna salad, chicken salad ▪ Caesar salad ▪ Salad topped with fried chicken or other fried meat ▪ Salad in a fried shell (e.g., taco salad)

17c. Main dish salads: Low-fat or fat free salad dressings

Record whether the restaurant has low-fat or fat free salad dressings. If yes, record how many there are. If none, mark "no" and write "0" in the # box. If nutrition information is available, check to see if any dressings qualify using the fat chart. Some do but may not be labeled as low-fat or fat free.

18. Fruit

18) Fruit (w/out added sugar)	○ yes # ☐☐ ○ no	

- Record the number of fruit side dishes without added sugar (see **Supplementary Information** for guidance) and mark "yes".
  - If the menu lists a fruit cup, ask if it is fresh.
- If there are no fruit side dishes without added sugar, mark "no" and write "0" in the # box.
- Again, if there is nutrition information, check to make sure that fruit qualifies as sometimes there may be added sugar not noted on the menu.

Supplementary Information: Fruits Without Added Sugar	
Yes	**No**
▪ Fresh fruit or canned fruit (in fruit juice) ▪ Fresh fruit compote ▪ Fresh fruit salad without dressing or on the side ▪ Fresh fruit with yogurt ▪ Fresh fruit plate with cottage cheese ▪ Fresh fruit on the salad bar	▪ Cinnamon apples ▪ Fruit canned in syrup ▪ Fruit salad with dressing ▪ Applesauce

19. Non-fried Vegetables (without added sauce)

Menu Review	Choices (#)	Comments
19) Non-fried vegetables (w/out added sauce)	○ yes # ☐☐ ○ no	

- Look for any vegetables separately listed as "sides" or "extras" and see if they meet the NEMS criteria of non-fried vegetables without added sauce. If there is any indication of a sauce (e.g., steamed broccoli with a buttery sauce), it does **not** count. Also, if vegetables are listed "**separately**" and not as part of an entrée (i.e., you have a choice of vegetables that are grouped below or above the entrée), these can be counted, if they are healthy. Salad listed as a side when the restaurant has low-fat or fat free dressings counts. Again, if there is nutrition information available for the sides, make sure that the vegetable qualifies. For example, it might say "Steamed broccoli" but the nutrition information states 80 calories with 6 grams of fat which would mean that this item would not qualify as a non-fried vegetable.

- Record the number of non-fried vegetables (also without sauce or breading) and mark "yes". (See **Supplementary Information** for guidance.)

- If there are no vegetables that meet the criteria, mark "no" and write "0" in the # box.

Supplementary Information: Non-fried Vegetables Without Added Sauce	
Note: Do not count vegetables that are a part of a main dish, such as those found in stew or spinach lasagna. Do not count vegetables on the salad bar.	
Yes	**No**
▪ Raw (e.g., sliced tomato) ▪ Steamed ▪ Grilled or chargrilled ▪ Baked ▪ Pickled	▪ Mixed dishes, such as lasagna, pot pie, stew, spinach calzone, or shepherd's pie ▪ Fried, stir-fried ▪ Breaded ▪ Au gratin ▪ Casserole ▪ Creamed ▪ Scalloped ▪ With sauce ▪ Glazed ▪ Sauteed ▪ Potatoes ▪ Pinto beans or other dried beans or peas

20. Diet Soda

20) Diet Soda	○ yes ○ no	

- Record whether the restaurant offers diet soda (<5 calories per serving is considered calorie free).

21. Other Healthy or Low Calorie Beverage

21) Other healthy or low calorie beverage?____	○ yes ○ no	

- Record whether the restaurant offers any additional healthy or low calorie beverage. A low calorie beverage is considered any beverage with ≤ 40 calories per stated serving.
    - Examples: a low calorie drink that is not a soft drink like lemonade sweetened with splenda or nutrasweet, diet Snapple,
    low-cal Sobe, unsweetened iced tea, bottled/flavored water, Perrier.

22. Facilitators and Supports

(Note: Always assess the following on the menu, if available, even if you have reviewed the Web site.)

22) Facilitators & Supports			
a. Nutrition information on menu (paper or posted menu)	○ yes	○ no	
b. Healthy entrees identified on menu	○ yes	○ no	
c. Reduced-size portions offered on menu	○ yes	○ no	
	○standard		
d. Menu notations that encourage healthy requests	○ yes	○ no	
e. Other? ___________	○ yes	○ no	

a. Nutrition information

- Nutrition information must be listed for more than one item and also include as a minimum: **Calories and total fat**

b. Healthy entrees identified

- Entrees must be in a separate section identified as healthier choices or have a symbol with a footnote describing them as a healthier choice.
- **Do not** include low-carb or vegetarian notations.

c. Reduced-size portions

- Does the menu offer reduced-size portions, e.g., half-order vs. full-order?
    - Example: Taco Heap................$6.79/$4.25 half

- If multiple-size options are a **standard** part of the menu, mark "standard".
    - Example: Small vs. large pizza, 6" vs. 12" sub, 6 pc vs. 12 pc fried chicken, regular vs. large burger
- If 22c is "No", OR "Standard" then mark 24d "N/A".

d. Encourage healthy requests

- Do menu notations encourage healthy requests and indicate that it would make the selection a healthier choice?
    - Example: Under the "Low-Fat Meals" section, the menu says, "Ask your server for Light Ranch Dressing for salads."
    - Example: Menu says, "A lighter quantity of rice or beans is no problem—just ask!"
    - Example: Menu says, "Our sandwiches are topped with lettuce, tomato and cheese. For a low-fat option, ask for lettuce and tomato only."

e. Other

- Note any other facilitators and supports on the menu

23. Barriers

23) Barriers	Select One	Comments
a. Large portion sizes encouraged? Super-sized items on menu	O yes O no	
b. Menu notations that discourage special requests (e.g., *No substitutions* or charge for substitutions)	O yes O no	
c. All-you-can-eat or "unlimited trips"	O yes O no	
d. Other? __________	O yes O no	

a. Large portion size encouraged?

- Does the restaurant promote large portion sizes on the menu?
    - Example: Super-sized items
    - Example: Giant spuds
    - Example: Colossal burger
    - Example: The Heap ("A heap of...")

b. Discourage special requests

- Do menu notations discourage special requests
    - Example: "No substitutions"

- Example: "Extra charge for substitutions"

c. All-You-Can-Eat or Unlimited Trips

- Example: All-you-can-eat buffet
- Example: "We keep bringing the food until you stay 'stop'"
- Does **not** include beverages, unless it is a milkshake or ice-cream drink

d. Other barriers

- Record other barriers not previously noted and describe in comments.
  - Example: free refills on bread or French fries

24. Pricing

24) Pricing	Select One	Comments
a. Sum of individual items compared to combo meal	○ more ○ less ○same ○ NA	
b. Healthy entrées compared to regular ones	○ more ○ less ○same ○ NA	
c. Charge for shared entrée?	○ yes ○ no	
d. Smaller portion compared to regular portion	○ more ○ less ○same ○ NA	
e. Other? ____________________	○ more ○ less ○same ○ NA	

a. Combo meals

- Identify if combo meals are more, the same, or less than purchasing individual items.
- **Definition of Combo Meal**
  - A combo meal combines several menu items that would otherwise be sold separately.
  - It is not an entrée with side dish(es), but separate items with separate prices, put together as a "combo".
  - It may include a drink but not necessarily.
  - It does not matter if they offer diet drinks (since all McDonald's, Burger King, etc., do this also).
- Example: Burger + fries + soda as a combo, vs. burger + fries + soda separately

b. Healthy entrees compared to regular

- Identify if healthy meal options are more expensive, the same, or less than regular meal options.

- Based on the healthy meal options you identified in Items #16b and #17b, are similar menu items more expensive, the same, or less expensive?
- If there are no healthy items, mark NA.
- If you will need to return to the office to figure out which items are healthy options based on the fat chart and nutrition information, note the prices for the items you think might be the healthy options and their comparisons. An example would be if there was a grilled chicken sandwich and a fried chicken sandwich on the menu. Answer 24b once you have determined if it is a healthy option.

c. Extra charge for shared entrée

- Example: Notation on menu-- "$1.50 plate charge for shared entrée"

d. Smaller portion pricing

- Is a smaller portion more, the same price, or less than a regular portion?

e. Other

- Note any additional pricing incentives that encourage overeating or healthy eating and describe in comments.

25. Kid's Menu

In general, stick to the kid's menu as the source of information for answering questions about the kid's menu. However, if not specifically stated on the kid's menu or if referred by the kid's menu to the full menu (e.g., can substitute any other side, but no sides are listed on the kid's menu), look on the full menu for:

1) 1% lowfat, skim or non-fat milk and 100% juice availability,
2) whether refills are free on unhealthy drinks, and
3) if there are healthy sides.

If any information is obtained from the full menu to answer a kid's menu question, please note "from full menu" in comments.

Menu Options	Select One	Comments
25) **Kid's menu?**	O yes O no	
a. Age limit	O 10 and under O 12 and under O Other O NA	
b. Any healthy entrees?	O yes O no O NA	

25. Kid's menu

- Determine whether there is a kid's menu and record the information in **25.** If there is not a kid's menu, mark "NA" for item a-m.

a. Age limit

- Record in **25a** the age limit listed on the menu by marking 10 and under, 12 and under, or other. If other is marked, write the age limit on the line provided. If an age limit is not stated on the menu, mark other and write "not stated" or whatever is listed on the menu (e.g., "kids of all ages").

b. Healthy entrees

- Record in **25b** whether the kid's menu contains healthy entrees for lunch or dinner (e.g., grilled chicken sandwich or pasta with tomato sauce). Do **not** consider breakfast items. The burden of proof must be on the kid's menu to identify that an entrée is healthy or prepared in a healthy way.

Use the following guidelines:

- Healthy preparations such as "grilled", "baked" or "broiled" generally are considered a healthy choice (e.g., grilled chicken
- Preparations such as "fried" are **not** considered healthy. Unless otherwise noted, fish and chicken entrees should be considered fried (e.g., chicken fingers or chicken wings).
- Anything with "cheese", "butter" or a cream sauce as a significant ingredient (e.g., mac 'n cheese, cheese ravioli, pasta with butter) is **not** considered healthy.
- Anything with red meat is **not** considered healthy (e.g., hamburger, taco, hotdog).
- Green salads are considered a healthy entrée regardless of dressing, unless the protein source does not follow the guidelines above. For example, a salad with fried chicken as the protein source is not a healthy entrée.
- **Only** rate a peanut butter and jelly sandwich as healthy, if it is "modified" to be made with whole wheat bread or all fruit preserves (lower sugar).
- Pizza is not considered healthy.
- Do **not** automatically consider an item as healthy if it is labeled as "healthy".

- Do **not** consider items promoted as low carbohydrates as "healthy" options.

c. 100% fruit juice	O yes O no O NA	
d. 1% low-fat, skim or non-fat milk	O yes O no O NA	
e. Are there free refills on unhealthy drinks?	O yes O no O NA	

c-d. 100% juice and milk

- Record in **25c** and **25d** whether the restaurant serves 100% fruit juice and low-fat (1% or ½ %), skim or non-fat milk.

e. Unhealthy drinks

- Record in **25e** whether there are free refills on unhealthy drinks (e.g., sugared sodas).

f. Are there any healthy side items (either assigned or to choose)?	O yes O no O NA	
g. Can you substitute a healthy side for an assigned unhealthy one?	O yes O no O NA	
h. Do any entrees that have assigned sides include an assigned healthy side?	O yes O no O NA	

f. Healthy sides

- Record in **25f** whether there are healthy side dishes (e.g., rice, salad, low-fat yogurt, cottage cheese, applesauce, etc.).

<u>Use the following guidelines</u>:

- Fruit or vegetables are considered healthy unless things are added to them to make them unhealthy such as added sugar or butter (see Supplemental information: Fruits without added sugar pg. 21 and Non-Fried Vegetables without added sauce pg. 22). Note that although applesauce does **not** count as fruit without added sugar for the full menu review, it does count as a healthy side for kids.

- Green salads are considered a healthy side regardless of the dressing.

- Raw vegetables served with dipping sauces or dressing (e.g., carrot sticks with ranch dressing) are considered healthy sides.

- Baked chips is considered healthy.

- Mayonnaise or oil-based sides (e.g., coleslaw, potato salad, etc.) are **not** considered healthy.
- Other sides where oil or butter is typically added to the preparation are not considered healthy (e.g., garlic bread, mashed potatoes, stuffing or dressing, etc.)
- Sides with cheese as a primary ingredient are not considered healthy (e.g., macaroni casserole).

g. Healthy side substitutions

- Record in **25g** whether a healthy side item can be substituted for an unhealthy side item (e.g., french fries). An assigned side is one that is designated for a specific entrée on the menu (e.g., hamburger with french fries).
- Mark "**NA**" when no entrees are assigned a specific side.
- Mark "yes" if two or more side options are assigned to a given entrée and at least one is healthy.

h. Assigned sides

- Record in **25h** whether any entrees that have assigned sides include an assigned healthy side (e.g., steamed veggies). An assigned side is one that is designated for a specific entrée on the menu (e.g., hamburger with french fries).
- Mark "**NA**" when no entrees are assigned a specific side.

i. **Is an unhealthy dessert automatically included in a kid's meal?**	O yes O no O NA	
j. **Are there any healthy desserts (either free or at additional cost)?**	O yes O no O NA	

i-j. Desserts

- Record in **25i** whether unhealthy desserts are automatically included in a kid's meal. Unhealthy desserts include ice cream-based desserts (e.g., sundaes, ice cream smoothies, milkshakes) and other sugar-based desserts (e.g., slushees). If a dessert is not specifically listed (e.g., labelled generically as a "special treat"), consider it an unhealthy dessert.
- Record in **25j** whether there are healthy desserts available, either free or at additional cost. Healthy desserts are fruit without added sugar or unhealthy topping, fruit with a healthy topping added (e.g., low-fat yogurt), or lowfat frozen yogurt.

k. Is nutrition information (e.g., calories or fat) provided on the kid's menu?	O yes O no O NA		
l. Other unhealthful eating promotion?	O yes O no O NA		
m. Other healthful eating promotion?	O yes O no O NA		

k. Nutrition information

- Record in **25k** whether nutrition information, which includes either **calories or fat**, is listed on the kid's menu.

l. Other unhealthful eating promotion

- Record in 25l whether there are other unhealthy eating promotions on the kid's menu other than what you have already noted (e.g., free dessert) and describe in comments.

Use the following guidelines:

- Cheaper price indicated for adding more food than if the additional food was purchased separately (e.g., Chillin' Fruit Freezers are 99¢ with the purchase of a Pepper Pal meal; $2.29 if purchased separately).
- Specific encouragement to add an unhealthy dessert at an inexpensive price (<$1.50) to the existing meal even when the full price of the dessert is not specified (e.g., Sundae 99¢ with kid's meal purchase).
- Inexpensive desserts that are not specifically encouraged do **not** count as an unhealthy promotion (e.g., $1.49 sundae is listed under dessert).
- Additional costs for healthy additions to meal combinations (e.g., extra juice box for 79¢) would **not** be considered as an unhealthy promotion.
- Kid's eat free or get a free kid's meal with an adult meal purchased is **not** considered an unhealthy promotion.

m. Other healthful eating promotion

- Record in **25m** whether there are any healthy eating promotions on the kid's menu and describe in comments (e.g., substitute whole wheat pasta or order the steamed broccoli!).

Appendix D: Nutrition Environment Measures Survey – Restaurants Tool

Nutrition Environment Measures Survey (NEMS)
RESTAURANT MEASURES—DATA COLLECTION

Restaurant ID: ___-___-___-___ Date: ___/___/___
Rater ID: ___ Month / Day / Year

1) Type of Restaurant: Code #: ___

2) Data Sources: Site Visit/Observation O yes O no | Take-Away Menu O yes O no | Internet O yes O no | Interview O yes O no

3) Site Visit Information:
Take–away menu O yes O no
Nutrition Information O yes O no
Other: O yes O no
Other: O yes O no
Comments:____________________
____
____

4) Take-Away Menu Features:
Nutrition Information O yes O no
Identification of Healthier menu items O yes O no
Other: O yes O no
Other: O yes O no
Comments: ___________
____

5) Internet Site Features:
Menu O yes O no
Nutrition Information O yes O no
Identification of Healthier menu items O yes O no
Other: O yes O no
Web Site URL: ___________
Comments:________________
____

6) Interview Information:
Menu Options O yes O no
Pricing O yes O no
Other: O yes O no
Comments (describe items above)
____
____

7) Hours of operation: Data Source(s): O Site O Menu O Web

Sunday O open O closed
O B: 6:00-11:00 am
O L: 11:00 am-3:00 pm
O D: 5:00 pm to Close
___ : ___ O AM O PM

Thursday O open O closed
O B: 6:00-11:00 am
O L: 11:00 am-3:00 pm
O D: 5:00 pm to Close
___ : ___ O AM O PM

Friday O open O closed
O B: 6:00-11:00 am
O L: 11:00 am-3:00 pm
O D: 5:00 pm to Close
___ : ___ O AM O PM

Saturday O open O closed
O B: 6:00-11:00 am
O L: 11:00 am-3:00 pm
O D: 5:00 pm to Close
___ : ___ O AM O PM

O open 24 Hours (If 24 hour, leave *Hours of Operations section* blank)

8) Access: Drive-thru window O yes O no | Parking onsite O yes O no

9) Size of Restaurant: O Seating capacity = ___ OR O Number of tables = ___

Nutrition Environment Measures Survey (NEMS)
RESTAURANT MEASURES—DATA COLLECTION

Restaurant ID: ___ - ___ - ___ - ___ Date: ___ / ___ / ___
Month / Day / Year

Rater ID: ___

Site Visit (Observation)	Select One	Comments
10) Restaurant has a salad bar	O yes O no	____________
11) Signage/Promotions	O yes O no	____________
a. Is nutrition information posted near point-of-purchase, or available in a brochure?		
b. Do signs/table tents/displays highlight healthy menu options?	O yes O no	____________
c. Do signs/table tents/displays encourage healthy eating?	O yes O no	____________
d. Do signs/table tents/displays encourage unhealthy eating?	O yes O no	____________
e. Do signs/table tents/displays encourage overeating (all-you-can-eat, super-size, jumbo, grande, supreme, king size, feast descriptors on menu or signage)?	O yes O no	____________
f. Does this restaurant have a low-carb promotion?	O yes O no	____________
g. Other? ____________	O yes O no	____________
Menu Review/Site visit		
12) a. Chips	O yes O no	____________
b. Baked chips	O yes O no	____________
13) a. Bread	O yes O no	____________
b.100% wheat or whole grain bread	O yes O no	____________
14) 100% fruit juice	O yes O no	____________
15) 1% Low-fat, skim, or non-fat milk	O yes O no	____________

Nutrition Environment Measures Survey (NEMS)
RESTAURANT MEASURES—DATA COLLECTION

Restaurant ID: __ __ - __ - __ __ - __ __ __

Date: __ __ / __ __ / __ __ (Month / Day / Year)

Rater ID: __ __

Menu Review	Select One	Choices (#)	Comments
16) Main Dishes/Entrees:	O yes	#	
a. Total # Main Dishes/Entrees	O no		________
b. Healthy Options	O yes O no		________
17) Main dish salads:			
a. Total # Main dish salads	O yes O no		________
b. Healthy Options	O yes O no		________
c. Low-fat or fat free salad dressings	O yes O no		________
18) Fruit (w/out sugar)	O yes O no		________
19) Non-fried vegetables (w/out sauce)	O yes O no		________
20) Diet soda	O yes O no		________
21) Other healthy or low calorie beverage?	O yes		

	O no	

Nutrition Environment Measures Survey (NEMS)
RESTAURANT MEASURES—DATA COLLECTION

Restaurant ID: [|]-[ ]-[|]-[| |]   Date: [|]/[|]/[|] Month / Day / Year

Rater ID: [|]

Menu Review/Site Visit	Select One	Comments
22) a. Nutrition information on menu (paper or posted menu)	O yes O no	
b. Healthy entrees identified on menu	O yes O no	
c. Reduced-size portions offered on menu	O yes O no O standard	
d. Menu notations that encourage healthy requests	O yes O no	
e. Other? ____________	O yes O no	
23) Barriers		
a. Large portion sizes encouraged? Super-size items on menu	O yes O no	
b. Menu notations that discourage special requests (e.g *No substitutions* or charge for substitutions)	O yes O no	

Restaurant ID: [|]-[ ]-[|]-[| |]   Date: [|]/[|]/[| |]
Month / Day / Year

Rater ID: [| |]

23) Barriers (Cont.)	Select One	Comments
c. All-you-can-eat or "Unlimited trips"	O yes	______________________
	O no	______________________
d. Other? _______________	O yes	______________________
	O no	______________________
24) Pricing		
a. Sum of individual items compared to combo meal	O more O less	______________________
	O same O NA	______________________
b. Healthy entrees compared to regular ones	O more O less	______________________
	O same O NA	______________________
c. Charged for shared entrée?	O yes	______________________
	O no	______________________
d. Smaller portion compared to regular portion	O yes O NA	______________________
(If 22c is No or Standard then mark N/A.)	O no	______________________
e. Other? _______________	O more O less	______________________
	O same O NA	______________________

Nutrition Environment Measures Survey (NEMS)
RESTAURANT MEASURES—DATA COLLECTION

Restaurant ID: ☐☐-☐-☐☐-☐☐☐   Date: ☐☐/☐☐/☐☐ Month / Day / Year

Rater ID: ☐☐

Menu Review	Select One	Comments
25) **Kid's menu?**	O yes O no	______
a. Age limit	O 10 & Under O 12 & Under O Other O NA	______
b. Any healthy entrees?	O yes O no O NA	______
c. 100% fruit juice	O yes O no O NA	______
d. 1% low-fat, skim or non-fat milk	O yes O no O NA	______
e. Are there any free refills on unhealthy drinks?	O yes O no O NA	______
f. Are there any healthy side items (either assigned or to choose)?	O yes O no O NA	______
g. Can you substitute a healthy side for an assigned unhealthy one?	O yes O no O NA	______
h. Do any entrees that have assigned sides include an assigned healthy side?	O yes O no O NA	______
i. Is an unhealthy dessert automatically included in a kid's meal?	O yes O no O NA	______
j. Are there any healthy desserts (either free or at additional cost)?	O yes O no O NA	______
k. Is nutrition information (e.g. calories or fat) provided on the kid's menu?	O yes O no O NA	______
l. Other unhealthful eating promotion?	O yes O no O NA	______
m. Other healthful eating promotion?	O yes O no O NA	______

Appendix E: Region of Waterloo Shelf Space Measure Protocol

Number of Displays, Shelf Space and Location of Food Items

- Record the number of separate display stands or aisles for particular foods that exist in store.

- Measure linear floor space in feet and inches and record for each separate display. Do not measure depth or number of shelves in an aisle. Measure the consumer accessible circumference of all display stands. If display stand or aisle is partially empty, measure only portion of display that includes food.

- Circle yes or no on whether display is within one meter of a cash register (approximately the length of the rola-tape measurement device fully extended).

- For FRESH FRUITS, raw fruits in salad bars are eligible for measurement.

- For FRESH VEGETABLES, raw vegetables found in salad bars, tomatoes, avocadoes, fresh herbs, fresh garlic are eligible for measurement.

- For CANNED FRUITS, mixed fruit, fruit cups, dried bagged fruit, and applesauce eligible for measurement. Do not include cranberry sauce.

- For CANNED VEGETABLES, chopped tomatoes, tomato paste, and beans that are green are eligible for measurement. Do not include salsa, pasta sauce, beans that are not green, chili, pork and beans, soups, pickles, olives, other pickled foods, or other mixed dishes.

- For FROZEN FRUIT, do not include fruit with added sugar, popsicles made with fruit or other fruit-flavored frozen desserts.

- For FROZEN VEGETABLES, do not include mixed dishes, frozen dinners, or frozen fried potatoes.

- For SALTY SNACK FOODS, chips, nuts, pretzels, cheetos, rice cakes, soy crisps and other salty snacks are eligible for measurement. Do not include beef jerky or other salted dried meats. Do not include salty snacks found in vending machines

- For COOKIES & CRACKERS, count pre-packaged cookies and crackers as well as cookies found in the bakery section. Do not include unprepared cookie mixes or cookies or crackers found in vending machines.

- For DOUGHNUTS & PASTERIES, doughnuts, pastries, baked sweets, pies, cakes, etc. are eligible for measurement. Include seasonal or holiday related items. Do not include unprepared baking mixes, pop tarts, granola bars, or energy bars. Do not include doughnuts & pastries found in vending machines

- For CANDY, hard candy, candy bars, gum, bagged candy etc. are eligible for measurement. Include seasonal or holiday related items. Do not include candy found in vending machines.

- For CARBONATED BEVERAGES, all carbonate beverages including diet sodas, tonic water, club soda, and other carbonated alcohol mixers are eligible for measurement. Do not include sparkling juice or energy drinks. Do not include carbonated beverages found in vending machines.

<u>Q12. Total Floor Space</u>

- Measure entire interior length and width of store. When taking the width measurement, measure the width at the back of the store. When measuring the length, measure the length down the middle of the store.

- When shape of store is complex, sketch the shape of the store and measure all dimensions.

Appendix F: NEWPATH data collection tools

Part 4: Neighbourhood Food Environment

In this next set of questions, we are asking you about the availability, cost and quality of food **in your neighbourhood.** This includes the stores or markets where you shop for food. Please think of your neighbourhood as only the area within about a 10-15 minute walk (1 to 1.5 kilometres) from your home.

Please circle the answer that best applies to you and your neighbourhood.

	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
1. There are no food outlets in my neighbourhood.	1	2	3	4
2. I shop elsewhere because the prices in my neighbourhood are too high.	1	2	3	4
3. It is easy to purchase fresh fruits and vegetables in my neighbourhood.	1	2	3	4
4. There is a large selection of fresh fruits and vegetables available in my neighbourhood.	1	2	3	4
5. The fresh produce in my neighbourhood is of high quality.	1	2	3	4
6. The produce in my neighbourhood is more expensive than that in other areas.	1	2	3	4
7. It is easy to purchase low-fat products (such as low-fat milk or lean meats) in my neighbourhood.	1	2	3	4
8. There is a large selection of low-fat products available in my neighbourhood.	1	2	3	4
9. The low-fat products in my neighbourhood are of high quality.	1	2	3	4
10. The low-fat products in my neighbourhood are more expensive than those in other areas.	1	2	3	4
11. There are a lot of fast food restaurants in my neighbourhood	1	2	3	4
12. It is easy to eat healthily at the restaurants in my neighbourhood.	1	2	3	4

Please record your height, weight and waist measurement here.

Height: How tall are you without shoes on?

____feet ____inches **OR** ________cm

Weight: How much do you weigh without shoes?

_______ pounds **OR** _______kilograms

Do you consider yourself (choose only one):

- ☐ Overweight
- ☐ Underweight
- ☐ Just about right

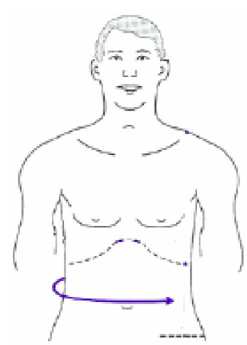
To measure your waist circumference:
Measure your waist circumference to the nearest 0.5 cm using the tape measure that was sent to you with this diary.

1. Measure your waist on bare skin.
2. Locate your waist at the midpoint between the lower part of your ribs and the upper part of your pelvis (hip bones). See diagram below.
3. We recommend you mark where you will measure on the skin with a pen. Select two points to mark (one above your right hip, and one above your left hip). This will ensure that the tape measure remains horizontal.
4. Stand with your feet 25-30 cm (or 1 foot) apart.
5. Circle the tape measure around you, holding one end in front
6. Hold the measuring tape in a horizontal position while measuring
7. Breathe out (exhale)
8. Record your waist circumference.

Repeat steps 5 through 8 for 2nd measure.

What is your waist circumference?

1st measure ___________cm
2nd measure ___________cm



Day One PLACE 2

A **WHAT is this PLACE?**

☐ My Home ☐ My School
☐ My Primary Workplace ☐ Another PLACE

Please provide as much of the address as possible:

Place name: ____________________
#_____Street:__________________City:______________PC:______
Cross Streets: ____________________
Landmark Building: ____________________

Please circle a.m. OR p.m.

B **What TIME did you ARRIVE?** (Please be as exact as possible) : a.m./p.m.

C **How did you get to this PLACE?** (Write codes from TRAVEL MODES LIST on flap)

	Code	
First Mode		Other mode specify:
SecondMode		Other mode specify:
Third Mode		Other mode specify:

D **If you got there by:**

Auto/Truck/Van Modes: 1 - 2	GRT/MobilityPlus Modes: 3 - 4	Bicycle/Walk Modes: 7 - 8
⇩ Total number (including yourself) traveling with you?	⇩ Stop # where boarding:	⇩ How many kilometres did you travel?
Number of household members traveling with you?	Route number:	

E **What ACTIVITIES did you do?** (Write codes from ACTIVITY LIST on flap)

	Code	Other specify	Time Spent
Main Activity:			____hrs:____mins
Other Activity:			____hrs:____mins
Other Activity:			____hrs:____mins
Other Activity:			____hrs:____mins
Other Activity:			____hrs:____mins
Other Activity:			____hrs:____mins

F **Did you eat or drink while traveling from Place 1 to Place 2?**

☐ YES (Specify in chart below) or ☐ NO (Go to **G**)

Description of food or drink	#	Size code	Other Specify	Cost

G **Did you purchase food at Place 2?**

☐ YES or ☐ NO (skip to **I**)

Food to take home/delivery ☐ **Yes** ☐ **No**
Food/drink to consume immediately ☐ **Yes** ☐ **No**

H **Indicate what type of food place this is by choosing the code from the FOOD SUPPLY LIST on flap**

Code	Other specify

I **Did you eat or drink at Place 2?**

☐ YES or ☐ NO (Go to **J**)

Description of food or drink	#	Size code	Other Specify	Cost

J **Was this your LAST PLACE for the day?**

☐ NO → **Go to K**
☐ YES → **Begin Day 2 at 3am in Diary Two**

K **What TIME did you LEAVE this PLACE?** (Be as exact as possible)