**University of Alberta**

# **Exploring Obesogenic Food Environments in Urban Edmonton**

by

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# ABSTRACT

The purpose of this thesis was to explore the fast-food environment in urban Edmonton using a combination of concepts from geography and health promotion, and to investigate whether having residence in a relatively deprived area was predictive of higher fast-food access. This thesis is comprised of two papers, the first focused directly on the purpose above. The second paper examines the process of calculating accessibility from a health promotion perspective, and uses a comparison of two common calculation methods to illustrate some of the theoretical and practical issues commonly encountered in such studies. Results from the first paper indicated that living in a relatively deprived area is predictive of higher access to fast-food, especially for neighbourhoods high in housing renters and low-income people. The second paper concluded that a combination of relatively simple geographical techniques and traditional research methods might be an effective balance for health promotion-focused accessibility research.

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# 1. INTRODUCTION

## 1.1 Theoretical Overview

Obesity, or the condition of having a Body Mass Index (BMI) of 30 kg/m$^2$ or higher, has long been associated with a large number of health risks. These include coronary heart disease and stroke, Type 2 diabetes, a variety of cancers, and respiratory conditions (World Health Organization, 2000). Other related health outcomes include mental health issues, social prejudice, disability, decreased quality of life, and premature death. Because of the enormous direct and indirect costs to the health care system, which have been estimated at $4.3 billion yearly (Katzmarzyk & Janssen, 2004), obesity has received a considerable amount of attention as a major public health concern.

While these health risks are a cause for concern in themselves, so too is the fact that rates of obesity have been rapidly rising in Canada over the past 20 years. A review of self-reported National health surveys revealed that the prevalence of obesity increased from 5.6% in 1985 to 14.8% in 1998 (Katzmarzyk, 2002a). Subsequent surveys have resulted in similar figures, including 14.9% from the 2003 Canadian Community Health Survey (Statistics Canada, 2004). Further, these self-reported studies tend to underestimate obesity rates relative to measured data, as individuals who respond to telephone surveys have been shown to underreport their weight (Katzmarzyk, 2002b). Regardless of the source or method used to obtain these statistics, however, Canadian obesity rates have never been higher, nearly tripling since the mid-1980's.

Many perspectives have been put forth in an effort to both explain this new public health epidemic, as well as to reverse it. The simplest explanation is physiological, and involves what is called a positive energy balance; i.e. the intake of energy from food consumption is greater than the amount of energy that is expended through physical activity. The excess energy that results from this imbalance is stored by the body, which leads to an increase in body mass over time. This biological process is the foundation for weight gain, and requires a very small shift in caloric intake or expenditure to make a difference at the population level (Raine, 2004).

This process, however, does not act in isolation. From all sides, people are inundated with a wide variety of personal, social and environmental circumstances that influence this energy balance in a positive or negative manner. The multifaceted, multi-level nature of causality associated with obesity lends itself very well to ecological theory, first proposed by Bronfenbrenner (1989) and since revised into a health promotion context (Stokols, 1996; Green & Kreuter, 1999). By examining each of the ecological levels, from the personal or "micro" orientation to the broader social and cultural mores surrounding a particular society ("macro"), it becomes possible for the complex interactions affecting obesity to be organized and qualified. Other variations of this theory, such as the ANGELO (Analysis Grid for Environments Linked to Obesity; Swinburn, Egger & Raza, 1999) framework and the International Obesity Task Force (IOTF; Kumanyika, Jeffery, Morabia, Ritenbaugh & Antipatis, 2002) Causal Web (see Figure 1.1), have applied ecological concepts specifically to obesity. Much work has since been undertaken to flesh out not only what these levels are, but what processes are operating there and how they might link together and influence each other.

It has long been understood that individuals living in low-income situations are at a higher risk for a wide range of health conditions, including obesity, relative to their higher-income counterparts (Sobal & Stunkard, 1989; Acheson, 1998; Lin, Huang & French, 2004; Raphael, 2001). When examined more closely, the circumstances that underlie this relationship begin to emerge. For example,

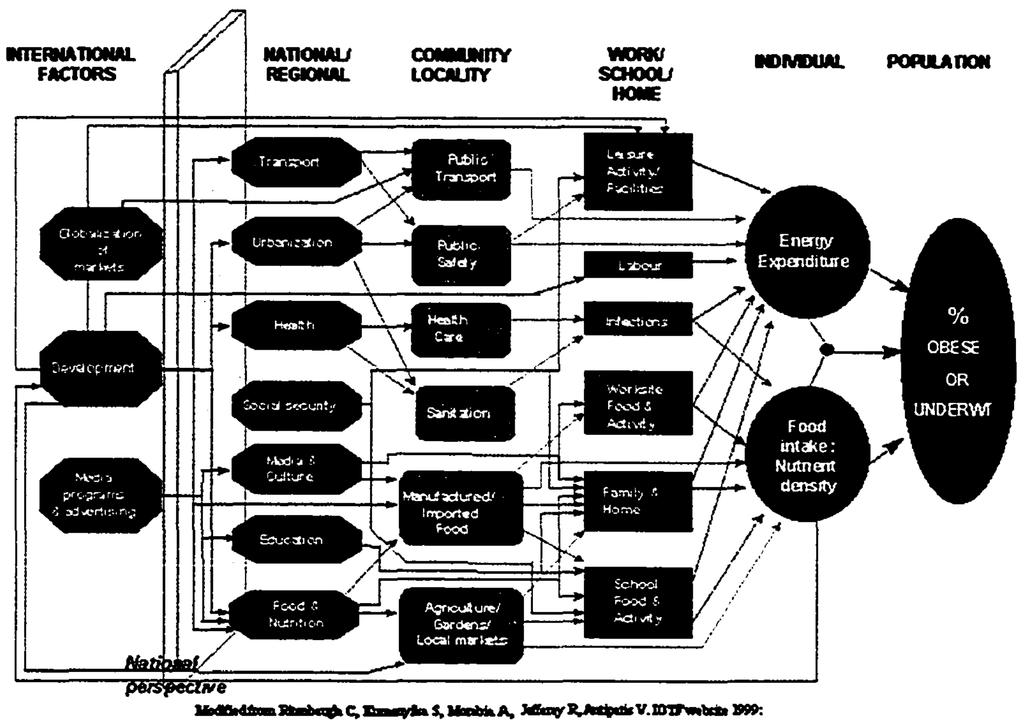


Figure 1.1 IOTF Causal Web

a single parent working more than one job may have less leisure time to engage in some form of physical activity, and their lower income may restrict the food choices that they are able to make. The children in such families may not be as likely to participate in organized sports, since the cost of such activities and the required equipment for many sports has increased dramatically in recent years (Canadian Fitness and Lifestyle Research Institute, 2000). Although many more such examples could be given for this one specific population group, they all serve as influences that exacerbate the negative energy balance described above.

A common theme throughout these examples is that there are many extraneous circumstances that make healthy choices very difficult to incorporate into the lifestyles of individuals and families. Even for populations not classified as "vulnerable", or "at-risk", there are many far-reaching influences that create a toxic, obesogenic (obesity-promoting) environment. One specific feature of this obesogenic environment that has garnered an increasing amount of attention over the past decade is the physical or built urban environment. Researchers are attempting to discover if there are any characteristics of the urban built environment that may have a role in the increasing incidence of obesity, and other associated health conditions; to do this, a major focus of this area has been on the spatial distribution of various urban amenities that can impact the obesogenicity of an environment.

Although there are relatively few published studies on this topic in the health or geographical literature, early results suggest that the urban physical environment may indeed have a role in the obesity epidemic. It has been demonstrated that the farther a person is away from a physical activity facility, the less likely they are to exercise (Sallis, Hovell, Hofstetter, Elder, Hackley, Caspersen & Powell, 1990; Troped, Saunders, Pate, Reininger, Ureda & Thompson, 2001). Other features of the physical environment, including aesthetics (e.g. tree cover, lighting, cleanliness), terrain (e.g. presence of sidewalks, hills), and physical barriers (e.g. major transportation routes, rivers) have all been linked to the likelihood of engaging in physical activity (Ball, Bauman, Leslie & Owen, 2001; Giles-Corti & Donovan, 2002). Urban sprawl, or the widespread growth of urban centres from the city core, produces a reliance on vehicular modes of transportation rather than those that are more physically engaging; only 28% of Canadians living within 8 kilometers of their workplace choose to commute by bicycle, citing the dangers of heavy traffic and the lack of bicycle lanes (Go For Green, 1998). Finally, the level of access to different types of opportunities for physical activity has been shown to vary by neighbourhood-level socioeconomic status (SES), with a US study showing that higher-status neighbourhoods had greater access to free-for-use services than those of lower status (Estabrooks, Lee & Gyurscik, 2003). Although these examples encompass a wide variety of the influences of the built environment on physical activity, the surface is only being scratched.

The same can be said about the relationship between the physical environment and healthy eating/food consumption. Here, however, greater attention has been given to spatial associations with measures of relative deprivation, such as socioeconomic status. "Food deserts", or areas that have little to no representation by fresh food retailers, were first described by researchers in the UK as a potential barrier to healthy eating for residents of those areas (Cummins & McIntyre, 2002; Whelan, Wrigley, Warm & Cannings, 2002). Since food deserts tend to be situated in areas that are already relatively materially deprived, with a lower level of car ownership for example, their decreased mobility further exacerbates the issue of access to healthy foods. One of the reasons why food deserts are being created is because larger food retailers, who generally have the widest variety and best prices relative to other food sources, are moving out of inner-city areas in favor of the wealthier outlying suburbs (Travers, 1996). The food sources that remain are often of poorer quality and more expensive than stores in outlying urban areas, even within the same retail chain (Travers, 1997).

These inequities in food services and costs extend beyond traditional grocery-type food sources. Less healthy opportunities for purchasing food may become more frequently used as food sources following the departure of a larger market. An analysis of food opportunities in several different American urban centres found that while neighbourhood income decreased, the number of grocery stores decreased while the number of fast-food restaurants and bars increased (Morland, Wing, Diez Roux & Poole, 2002). These findings supported an Australian study, which found two-and-a-half times more fast-food outlets in lower-status areas relative to higher-status ones (Reidpath, Burns, Garrard, Mahoney & Townsend, 2002). The combination of low accessibility to fresh foods, the poorer variety and value of those fresh foods that remain, and the increased exposure to unhealthy food sources make healthy food choices in lower-status urban areas very difficult. In turn, this obesogenic context is capable of increasing its inhabitants' risk for a number of adverse health conditions, including obesity.

1.2 Overall Rationale for the Study

This study examines the micro-level physical built environment of a Canadian urban centre, and attempts to uncover whether there is any relationship between the placement of fast-food outlets and neighbourhood-level sociodemographic characteristics. Previous research has noted that access to obesity-promoting and protecting urban amenities, including fast-food, grocery stores and opportunities for physical activity, may be different depending on the demographic characteristics of the neighbourhoods in which they are situated. Since these other studies were done in Australia and the United States, this will be the first known such analysis of fast-food in a Canadian urban context.

The enormous complexity associated with the root causes of obesity, in reference to the determinants of health, necessitates an innovative approach to their description and analysis within the above-described ecological context. This work is also intended to provide a basis and direction for a more specific qualitative examination of these relationships (e.g. higher fast-food access in low-income neighbourhoods) as they emerge. The ultimate goal of this research is then to inform public policies that will reduce the impact of obesogenic environmental factors, such as access to fast-food, which in turn may help to reduce the prevalence of obesity in Canadian urban centres.

1.3 Research Aim 1

The initial aim of this study is to describe and categorize neighbourhoods within the city of Edmonton as having a high, medium or low level or access to fast-food outlets, and to compare sociodemographic data for these neighbourhoods to determine if there are any relationships between them and areas of fast-food concentration or deprivation. This aim addresses the following research questions:

*Research Question 1:* Where are the areas of high and low fast-food concentration within the City of Edmonton?

*Research Question 2:* What are the neighbourhood-level sociodemographic characteristics that are most accurately predictive of a neighbourhood having high access to fast-food?

## 1.4 Research Aim 2

The second research aim of this study is more theoretical, and focuses on the application of geographical concepts and technology to health promotion research. These two fields can learn a tremendous amount from one another, and together have a great potential for addressing major issues of public health such as obesity. However, differences in values and approaches, across both the broader fields and within specific projects, are in need of illumination if the partnership is to be a successful one. Thus, the second research aim will discuss the following research questions:

*Research Question 3:* How can geographically-based research methods be most effectively translated into a format usable by and applicable to health promotion researchers / practitioners?

*Research Question 4:* What are some of the practical and conceptual differences between various methods of measuring accessibility to an urban amenity?

*Research Question 5:* How can the practical and conceptual differences between the fields of geography and health promotion be balanced, in terms of validity, reliability and complexity/practicality?

## 1.5 Plan of the Thesis

According to the guidelines set forth by the Faculty of Graduate Studies and Research at the University of Alberta, this thesis is classified as a *mixed format*,. The use of this format, as opposed to the traditional thesis style, places specific emphasis on the production of at least two independent manuscripts of publishable quality. Given that the topic matter of this thesis is of high interest to health promotion researchers and others, it was agreed that a format that would expedite the publication process would be most appropriate – in keeping, of course, with the content and quality associated with a proper traditional thesis.

This thesis begins with a brief introductory chapter, which describes the theoretical basis for the course of study as well as the research aims and questions it purports to answer. The following two chapters are presented as independent manuscripts, each including their own literature review, methods, results, discussion, conclusion, figures, tables, and bibliography. The topic of these papers corresponds to each of the research aims and associated questions presented above: the first paper, or Chapter 2, addresses Research Aim 1, while the second paper (Chapter 3) examines Research Aim 2. As each of these three chapters are based on a similar conceptual foundation, overlap and repetition of several key facts and theories should be expected.

Chapter 4 is included as a summary of the findings of both papers, and draws on each to provide a series of conclusions and recommendations for further work Following this short synopsis will be several Appendices, including an expanded literature review (Appendix I) and an expanded methods section (Appendix II). Appendix III will be included as a compilation of all references and other documents used to support this thesis, while Appendix IV will include tables and figures from all prior sections of the thesis.

Because this research only involves secondary analysis of publicly-available data, ethical approval was deemed as not necessary by the Health Research Ethics Board Panel B, University of Alberta, in March 2004. A letter to this regard is attached as Appendix III.

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# CHAPTER TWO – PAPER ONE

## Exploring Obesogenic Food Environments in Urban Edmonton: Is Socioeconomic Status Predictive of Fast-Food Access?

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## Abstract

In Canada and other developed countries, obesity has reached the point of epidemic and remains a risk factor for many chronic diseases. Obesogenic environments, i.e. those that may promote or contribute to the development of obesity among their inhabitants, have received recent attention as a potentially significant determinant of this prominent health issue. Previous research has found differences in access to opportunities for healthy living (physical activity and food procurement) between urban areas with different socioeconomic characteristics, and has also linked fast-food consumption with increases in body weight. The purpose of this study was to explore the relationship between the placement of fast-food restaurants and neighbourhood-level socioeconomic variables within the city of Edmonton, by determining if indicators of relative deprivation were predictive of high exposure to fast-food. Neighbourhoods were classified as high, medium or low access based on the number of fast-food opportunities within them, and neighbourhood-level socio-economic data from the 2001 Statistics Canada federal census was obtained. A discriminant function analysis was employed to determine if there was any relationship between neighbourhood demographic characteristics and accessibility of fast-food. Significant differences were found between three levels of fast-food concentration across most of the census variables, and a high score on several of these variables was predictive of greater access to fast-food restaurants. Although a causal inference is not possible from this analysis, these results suggest that the distribution of fast-food requires further attention in the process of explaining the increased rates of obesity observed in relatively deprived populations.

**Exploring Obesogenic Food Environments in Urban Edmonton – Is Socioeconomic Status Predictive of Fast-Food Access?**

## Introduction

The prevalence of obesity in Canada has increased from 5.6% in 1985 to 14.9% in 2003 (Katzmarzyk, 2002; Statistics Canada, 2004). The health risks of obesity are numerous, including coronary heart disease and stroke, Type 2 Diabetes, several cancers, respiratory conditions and disability (WHO, 2000), all of which can lead to premature death and a decreased quality of life. Also significant is the burden obesity and related conditions place on the Canadian health system; the direct and indirect costs have been estimated at $4.3 billion annually (Katzmarzyk & Janssen, 2004).

The most basic explanation for the rise in obesity rates concerns a positive energy imbalance; the amount of energy taken into the body is greater than the amount expended through physical activity. Academic research and interventions designed to prevent obesity have focused the majority of their efforts on the lifestyle factors that contribute to this imbalance, namely the consumption of unhealthy foods and physical inactivity (Raine, 2004). Despite these efforts, the prevalence of obesity in Canada has continued to rise, especially among vulnerable groups such as low income and Aboriginal populations.

These trends have spurred researchers to begin looking outside the realm of lifestyle factors, and to more closely examine the role of a variety of social and environmental determinants of obesity. Although a wide variety of influences have been explored, particularly strong relationships have been uncovered between low income, related social factors (e.g. substandard housing, food insecurity), poor nutrition and limited physical activity – all of which contribute to the risk of becoming obese (Raine, 2004; Olson, 1999; Macdonald, Reeder, Chen & Despres, 1997). Increases in the number of meals eaten outside of the home (Statistics Canada, 2003), along with a corresponding rise in per capita soft drink consumption (Nielsen & Popkin, 2002), have mirrored obesity increases over the past 20 years (Young & Nestle, 2002). As the body of literature builds, many other influences are being explored.

In an interesting conception of these influences, Swinburn and others have termed factors that promote obesity to be "obesogenic", and have proposed an ecological framework as a method of organizing the vast range of such factors (Swinburn, Egger & Raza, 1999). One area of this framework that has received considerable attention as a mitigating factor to increasingly unhealthy lifestyle choices is the built or physical environment. Progressively sprawling urban planning designs have been implicated in both reducing rates of physical activity as well as limiting access to healthy or fresh foods (Frank, Andresen & Schmid, 2004). A longer distance necessary to access opportunities for physical exercise has been linked with a decrease in overall levels of physical activity (Sallis, Hovell, Hofstetter, Elder, Hackley, Caspersen & Powell, 1990). Further, a US study found disparities in the level of access to opportunities for physical activity according to neighbourhood socioeconomic status (SES), with lower SES neighbourhoods seeing fewer free-for-use amenities than other neighbourhoods (Estabrooks, Lee & Gyurcsik, 2003). Although generalizability of these findings would be limited due to differences in city sizes, city planning priorities and the like, these examples do show that access to amenities for physical activity can vary depending on the setting within which they are examined.

A similar pattern exists for access to food: larger grocery stores have been moving away from poorer, urban cores into wealthier, suburban outlying areas (Cummins & McIntyre, 2002). A different analysis, based on ethnicity and income levels, found over three times more supermarkets in high-income areas compared to those of low-income, and that areas with higher concentrations of Caucasians were four times more likely to have a supermarket near them than an area populated predominantly by African-Americans (Morland, Wing, Diez Roux & Poole, 2002). This further constrains the already limited choices faced by inner-city residents, often leaving more unhealthy food sources such as fast-food and pubs (Morland et al., 2002). In fact, an Australian study found 2.5 times more fast-food in low-income areas than in high-income area (Reidpath, Burns, Garrard, Mahoney & Townsend, 2002). In the United States, another recent paper found positive correlations between state-level obesity rates and the overall number of fast-food restaurants, as well as the number of square miles per fast-food restaurant within the state (Maddock, 2004).

The lack of readily accessible, good quality fresh food in an area then leaves a distinct opportunity for retailers of fast-food. Fast-food restaurants provide a source of food that is relatively low-cost, is very energy-dense, and in many areas is easily accessible (Drewnowski & Specter, 2004). These types of calorically-dense foods have been shown to be a desirable choice for individuals with limited food budgets, as they tend to feel more “filling” than a similar amount of other, less dense foods (e.g. fruits and vegetables). Drewnowski and colleagues have provided empirical support for this hypothesis by calculating the cost per energy unit for a variety of foods. Their analysis revealed that energy-dense processed foods are actually a more efficient choice for those with limited food budgets, as they provide much more energy for the amount of money spent (Drewnowski & Specter, 2004). This again makes fast-food a rational and desirable food choice for individuals of lower SES.

Several other studies have associated fast-food consumption with increases in overweight, obesity and other health conditions (Jeffery & French, 1998; French, Harnack & Jeffery, 2000; Pereira, Kartashov, Ebbeling et al., 2005). In the United States, a major representative sample found that 26.5% of adults consumed fast-food on at least one of two survey days (Bowman & Vinyard, 2004); another paper estimated that 75% of American adolescents consume fast-food at least once per week (French, Story, Neumark-Sztainer, French, Fulkerson & Hannan, 2001). Finally, it was found that over 30% of American children consume fast-food on any given day (Bowman, Gortmaker, Ebbeling, Pereira & Ludwig, 2004). Although Canadian data on fast food consumption are unavailable, it is reasonable to assume that American trends are similar to those found in Canada, and thus, a significant proportion of the population are consuming fast food on a regular basis. Together, these studies suggest that differences in access to obesogenic food sources in low and high-income areas may have a role in explaining a portion of the variance in obesity rates between these two population groups.

## Purpose

The existence and influence of obesogenic physical environments are largely unexplored in Canada. The purpose of this study was to explore the relationship between neighbourhood-level socioeconomic variables and the placement of fast-food restaurants within the city of Edmonton, to determine if any indicators of relative deprivation were predictive of high exposure to fast-food. Although the method of this study is slightly different than others cited above, it serves as an attempt to replicate the associations found within these papers in terms of the availability of fast-food to different groups of urban dwellers. The findings from this work will be used to inform future research into the environmental risk factors for obesity and related chronic disease, including the impact of these risk factors on obesity rates and public health.

## Methods

### *Design*

This study is a descriptive survey of neighbourhood-level fast-food distribution in a Canadian urban centre. The data sources and analysis techniques used in this work will now be introduced in detail.

### *Data Sources and Characteristics*

#### Neighbourhoods

Information concerning standard neighbourhoods in Edmonton was solicited from the City of Edmonton Department of City Planning. A standard neighbourhood is a municipally-defined unit of area similar in size to a federal census tract used in other studies of urban environments (e.g. Gilliland & Ross, 2004). Standard neighbourhoods average approximately 6 by 6 city blocks in area, and approximately 3000 in population. Of approximately 300 located within the city limits of Edmonton, 204 were included in this analysis. Neighbourhoods were excluded if they were not primarily residentially zoned (i.e. industrial or commercial), or if no demographic data was available for that area.

Fast-Food Outlets

Location information for all fast-food outlets within Edmonton city limits, including street addresses and postal codes, was obtained from the Capital Health Region Department of Environmental Health, Health Inspection Division; a total of 762 fast-food establishments were included. Restaurants were classified as fast food if they provided walk-up counter service, and served foods that were predominantly pre-processed and prepared to order in a highly standardized, mechanized fashion. Concession stands, sit-down restaurants, school cafeterias and cafes/coffee shops (besides those that also served full meals, e.g. Tim Horton's) were excluded from the analysis. This study differs from other similar analyses in that it includes *all* sources of fast-food in the study area, rather than a select group (i.e. popular chain restaurants; see Block, Scribner & DeSalvo, 2004; Maddock, 2004).

Demographic Data

Socio-demographic information was compiled from Statistics Canada's 2001 federal census figures. Since Statistics Canada does not aggregate census data to the municipal neighbourhood level, a special run was requested for these data by a local social policy organization , the Edmonton Social Planning Council (ESPC). Permission to use these data was given by ESPC and Statistics Canada. As they have been utilized in prior studies as indicators of relative SES (Acheson, 1998), neighbourhood-level proportions of low-income individuals, individuals without a high-school diploma, unemployment, housing renters and recent immigrants were used in this analysis.

*Accessibility Calculations*

The relative accessibility of each neighbourhood to fast-food outlets was then calculated based on the *coverage* method. The coverage method uses the principle of concentration to determine accessibility: in general, the number of opportunities located within a predefined "buffer" area is that area's relative level of access to that type of opportunity (Talen & Anselin, 1998). For this analysis, the buffer zone for a specific neighbourhood was defined as the area covered by that neighbourhood *plus* the area of the neighbourhoods that immediately surround it. For example, the neighbourhood of Garneau is immediately surrounded by five other neighbourhoods – based on the coverage method of accessibility, the raw accessibility score for Garneau would be the sum of the number of fast-food outlets within it plus the number of outlets within these five adjacent neighbourhoods. Although simple compared to other available methods of accessibility calculation, the coverage method is useful for identifying areas of relative concentration or diffusion in a user-friendly manner.

To calculate the accessibility value for each neighbourhood, all fast-food outlets were first geocoded (i.e. their locations were digitized and marked onto a city base map), checked for accuracy of location, and adjusted as necessary using Geopinpoint 3 (DMTI, 2004) and ArcGIS 8.3 (ESRI, 2004) software. The number of fast-food outlets in each neighbourhood was then tallied and compiled. Finally, the number of fast-food outlets in each neighbourhood was added to the numbers of outlets in the surrounding neighbourhoods, which resulted in that neighbourhood's raw accessibility score. These neighbourhoods were divided into three access categories based on a tertile split (low, medium and high access).

*Analysis*

For this study, the dependent variable (DV) was the level of access to fast-food while the independent variables (IV)s were the five socioeconomic indicators described above. A discriminant function analysis (DFA) was used to analyze these data, using SPSS v.12. The DFA took place in two stages: First, a basic ANOVA was conducted to test for differences between the means of each IV across each level of the DV; second, the DFA created a model based on the predictive power of each IV relative to the levels of the DV (i.e. which IV is the best predictor of having high access to fast-food?). Output from this analysis then included F and p-values for the ANOVA, an analysis of covariance between IVs (assessed by Box's Test of Equality of Covariance Matrices, as the function analysis assumes low covariance between IVs), r-values of correlation between each IV and the DV, and a classification table for each level of the DV. Here, the DFA used the model to try and predict, based on the IV, into which level of the DV each case fell.

## Results

In total, 204 neighbourhoods, with a mean population of 3128 persons (SD=1774) were included in this analysis. An examination of the histogram and frequencies for the number of fast-food outlets revealed tertile breaks at values of 10 and 19, creating three ranges of values for relative accessibility: low from 0-10 outlets, medium from 11-19 outlets, and high from 20 and above. A summary of the descriptive characteristics of these groups is displayed as Table 1. Overall, the mean number of restaurants available to each neighbourhood was 22.36 (SD=27.15). The low group included 70 neighbourhoods, while the medium and high groups had 67 each. A map of the neighbourhood-level areas of concentration of fast-food outlets within Edmonton is included as Figure 1. Finally, as mentioned above, five variables were chosen to represent the SES of each of the 204 neighbourhoods. All of these variables were normally distributed; low income and housing renters had a slight positive skew.

Table 1. Fast-Food Access Categories and Descriptive Statistics

| | | Number of Fast-Food Restaurants | | | |
|---|---|---|---|---|---|
| Group | N | Minimum | Maximum | Mean (SD) | Median |
| Low | 70 | 0 | 10 | 5.16 (3.16) | 5 |
| Medium | 67 | 11 | 19 | 14.55 (2.61) | 15 |
| High | 67 | 20 | 156 | 48.13 (34.65) | 34 |
| Total | 204 | 0 | 156 | 22.36 (27.15) | 14.5 |

The results of the MANOVA are also included in Table 2. Between the three levels of fast-food access, all five variables (unemployment [F=8.923]; low income [F=16.992]; no high school [F=7.476]; housing renters [F=27.086]); new Canadian immigrants (F=3.725, p=.028) were significant at $p<.05$. Post-hoc tests revealed that these differences were occurring in a positive direction: lower rates of low income, unemployed, and renters were associated with low fast-food access, while higher rates of these variables were more closely associated with high fast-food access. Excepted were the New Canadian immigrant and No High School variables, which

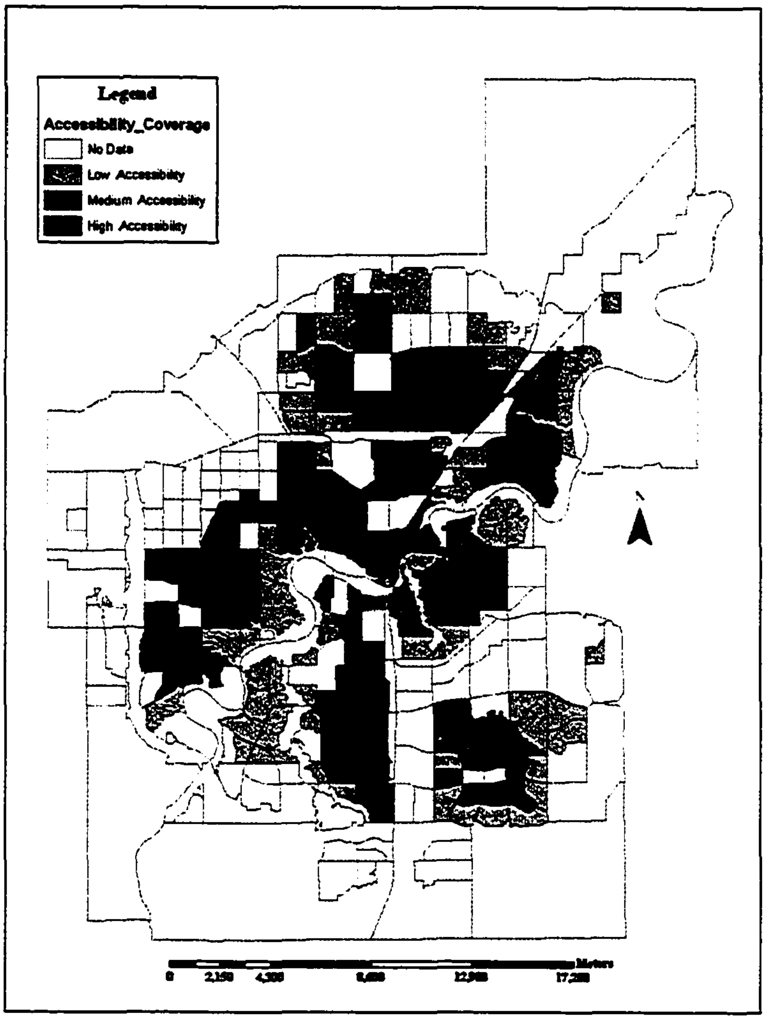


Figure 1. The Neighbourhood-Level Distribution of Fast-Food Outlets in Edmonton

had significant differences between all levels except the low and medium fast-food access groups (New Canadians) and the medium and high groups (No High School).

An examination of covariance between the five variables was done through a covariance matrix as well as Box's Test of Equality of Covariance Matrices. The matrix revealed a fairly high level of covariance between several variables, including low income/unemployment (r=.636), low income/renters (r=.630), low income/no high school (r=.412) and unemployment/housing renters (r=.443). According to

Table 2. Neighbourhood-Level Sociodemographics by Fast-Food Access Level

| | Mean Proportion (SD) by Access Group | | | | |
|---|---|---|---|---|---|
| Variable | Low | Medium | High | Wilks' Lambda | F |
| Employment | 4.69 (1.99) | 5.83 (2.29) | 6.30 (2.56) | .918 | .000 |
| Low Income | 9.69 (7.21) | 14.86 (9.49) | 18.32 (9.36) | .855 | .000 |
| Education | 15.87 (7.21) | 19.84 (6.77) | 19.75 (6.61) | .931 | .001 |
| Renters | 18.58 (17.51) | 34.15 (21.72) | 44.86 (23.55) | .788 | .000 |
| New Canadians | 20.57 (7.43) | 19.74 (7.48) | 23.00 (6.62) | .964 | .028 |

Box's M test, the covariance matrix was unequal (Box's M=51.546; F=1.657, p=.013). This is of note because one of the assumptions for DFA is that population covariances are equal. However, DFA has been shown to be robust even in such circumstances (Garson, 2004).

The results of DFA revealed two functions, the first of which explained 91.1% of the variance and the second the remaining 8.9%. However, only the first function demonstrated a significant relationship between the independent and predictor variables ($\chi^2_1(10)=67.737$, p=.000), while the second did not ($\chi^2_2(4)=6.826$, p=.145). The canonical correlations of individual predictor variables with the two discriminant functions are presented in Table 3. The variables Housing Renters ($r_c$=.867), Low Income ($r_c$=.686) and Unemployment ($r_c$=.491) were most highly associated with the first discriminant function, meaning that neighbourhoods with higher percentages of residents in these situations are also more likely to have a high level of access to fast-food restaurants. The remaining two predictor variables were most closely associated with the second discriminant function, but since this function did not explain a significant portion of the overall variance these results will not be reported.

Table 3. Structure Matrix – Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions

| Predictor Variable | Function | |
|---|---|---|
| | 1 | 2 |
| Renters | .867 | -.110 |
| Low Income | .686 | -.104 |
| Unemployment | .491 | -.261 |
| New Canadians | .215 | .765 |
| No High School | .406 | -.663 |

In total, the DFA correctly classified 110 out of 204 total neighbourhoods, or 53.9%. This is higher than would be expected by chance (n[largest group]/# of groups = 47.5 cases, or 23.3%). Fifty-one out of 70 neighbourhoods (72.9%) were correctly classified for the Low Access group, with 19/67 (28.4%) being correct for the Medium Access group and 40/67 (59.7%) correctly classified for the High Access group. The classification matrix summarizing this information is presented in Table 4.

Table 4. Classification Matrix

| | | Predicted Group Memberships | | | Total |
|---|---|---|---|---|---|
| | | Low Access | Medium Access | High Access | |
| Count (%) | Low Access | 51 (72.9) | 10 (14.3) | 9 (12.9) | 70 (100) |
| | Medium Access | 28 (41.8) | 19 (28.4) | 20 (29.9) | 67 (100) |
| | High Access | 13 (19.4) | 14 (20.9) | 40 (59.7) | 67 (100) |
| 53.9% of cases correctly classified (Chance = 23.3%) | | | | | |

## Discussion

All five of the SES variables were significant discriminators between the low, medium and high fast-food access levels. The variable Housing Renters, showed a difference of 250% between the low and high access groups; Low Income was close behind, nearly doubling between the same access levels, while the others demonstrated less drastic differences. The two variables of Housing Renters and Low Income are also most closely associated with the overall discriminant function, suggesting that areas with a high concentration of renting and/or poor individuals are more predictive of a high level of access to fast-food restaurants. Neighbourhoods with high rates of unemployment are also likely to be exposed to high numbers of fast-food restaurants.

Given that this field of research is relatively young, this work has produced some results that may provide a foundation for further exploration in the area of obesogenic physical environments. The results of this analysis support previous research suggesting that individuals who reside in relatively deprived urban areas have a higher level of access to fast-food than those who live in more affluent areas. This study is one of the first to investigate the relationship between multiple sociodemographic variables, beyond traditionally-used income and ethnicity data, and urban access to fast-food restaurants.

It is well established that individuals of lower SES are less mobile than other population groups (Travers, 1996; Acheson, 1998). Economic constraints can make vehicle ownership difficult or unreliable, while the time necessary to use public transit is often out of reach for parents with children or those with multiple places of employment. As a result, individuals in such situations may be more reliant on food sources located nearer to home for sustenance.

Over the past several years, a trend has emerged that has seen many large chain grocery stores leave poorer, inner-city areas for wealthier, suburban areas

(Cotterill & Franklin, 1995; Travers, 1996). Although this trend has reversed somewhat in recent years, it has still resulted in a higher concentration of less healthy food sources in these areas, including smaller independent food stores, convenience stores, liquor stores and fast-food outlets (Morland et al., 2002). Because smaller food stores do not have the overhead and turnover of product of larger grocery chains, the variety and quality of fresh foods available at these shops is often questionable. The same can be said of convenience stores, which predominantly sell calorie-dense, processed foods. Both of these sources also sell foods at a substantially higher cost than larger stores, and have been suggested to be taking advantage of the lack of mobility characteristic of inner-city residents; in particular, it has been shown that food prices are often higher in inner-city areas, even within the same chain of stores (Travers, 1996). These features of the food environment in relatively deprived, inner-city areas make it far more difficult for a resident to access healthy, fresh foods.

The literature on motives for food choices provides additional insight into why fast-food outlets may be concentrated in low-SES areas. Differences have been found in the type and strength of factors influencing food choices; specifically, low income respondents allocated more weight to the "low price" and "familiarity" dimensions of a Food Choice Questionnaire than those of higher income levels (Steptoe, Pollard & Wardle, 1995). This is especially important in relation to the likelihood of purchasing fast-food, since it is a relatively cheap source of dense, filling food. The familiarity aspect is perhaps more interesting, as fast-food corporations spend billions of dollars every year in advertising in an attempt to make their brand more recognizable (Nestle, 2002). Much of this advertising is also focused on highlighting fast-food as a less time-consuming alternative to preparing and consuming food in the home, something that may resonate particularly well in low-income populations given that their time for these activities may be relatively scarce.

**Limitations and Future Directions**

Although this study is supportive of previous research, several limitations require attention if the results are to be interpreted properly. Since it uses readily available data and fairly straightforward statistical techniques, one of the major strengths of this analysis lies in its simplicity. However, simple is certainly not an appropriate way to characterize the social determinants of overweight and obesity. An attempt was made in this study to extend the empirical analysis beyond the traditionally used "income and race" variables, to include other common yet underutilized population characteristics such as employment and family status. Although the addition of these variables is useful in broadening the topic area, many other sociodemographic characteristics were not included that may further describe the obesogenic environment. Thus, rather than a stand-alone explanation, these results should be seen as a first step in exploring the relationship between the physical environment and obesity.

The issue of causality is another point deserving attention. The work presented explores the relationship between demographic characteristics and fast-food accessibility; identifying demographic characteristics that may predispose a neighbourhood to be potentially more or less concentrated with fast-food. Because this was an exploratory study, and because actual data concerning rates of obesity at the neighbourhood level were not included, no conclusions concerning the actual impact of higher fast-food access on obesity can be outlined. Similarly, no conclusions concerning behaviours (e.g. whether different populations with higher access actually eat more fast-food) can be given.

Although this study is limited in terms of its explanatory capacity, it is quite useful for illuminating further paths for discussion and research. As mentioned above, only variables that were readily available were included in the analysis – many others, such as vehicle ownership or specific ethnicity, may have an impact and should be included in future replication of this work. The inclusion of a wide variety of variables in future work will eventually allow for those of minimal impact to be factored out in favour of those having a greater influence. As such, the variables of greater influence can then be examined in greater detail.

Similarly, this work has identified neighbourhoods that are either rich or poor in fast-food availability. To address the concerns of causality mentioned above, different methodologies should be employed to examine the behaviours of individuals in those neighbourhoods, and how these behaviours interact with their personal health and population health outcomes. For example, individual or group interviews can be used to determine how a particular neighbourhood or population group reacts to living in an area of high fast-food accessibility, or document analysis techniques can be employed to explore how government or planning processes resulted in some areas being concentrated with fast-food while others were not. Results from these types of studies would provide a context within which the quantitative, epidemiological aspects of the environment/health relationship reside and operate, and are critical if a full understanding of this important determinant of obesity is to be obtained.

In summary, this analysis matches well with other studies, finding that individuals and families residing in lower status neighbourhoods are exposed to more fast-food than those in higher-status neighbourhoods (Reidpath et al., 2002; Morland et al., 2002; Block et al., 2004). The relative importance of short-term-based needs such as proximity, time and value (i.e. more filling for a cheaper cost) for these populations may supersede the longer-term health risks of consuming fast-food. Combined with the accessibility calculations of this and other studies, a compelling line of evidence is mounting that may illuminate the discrepancy between low- and high-status populations and their respective rates of overweight and obesity.

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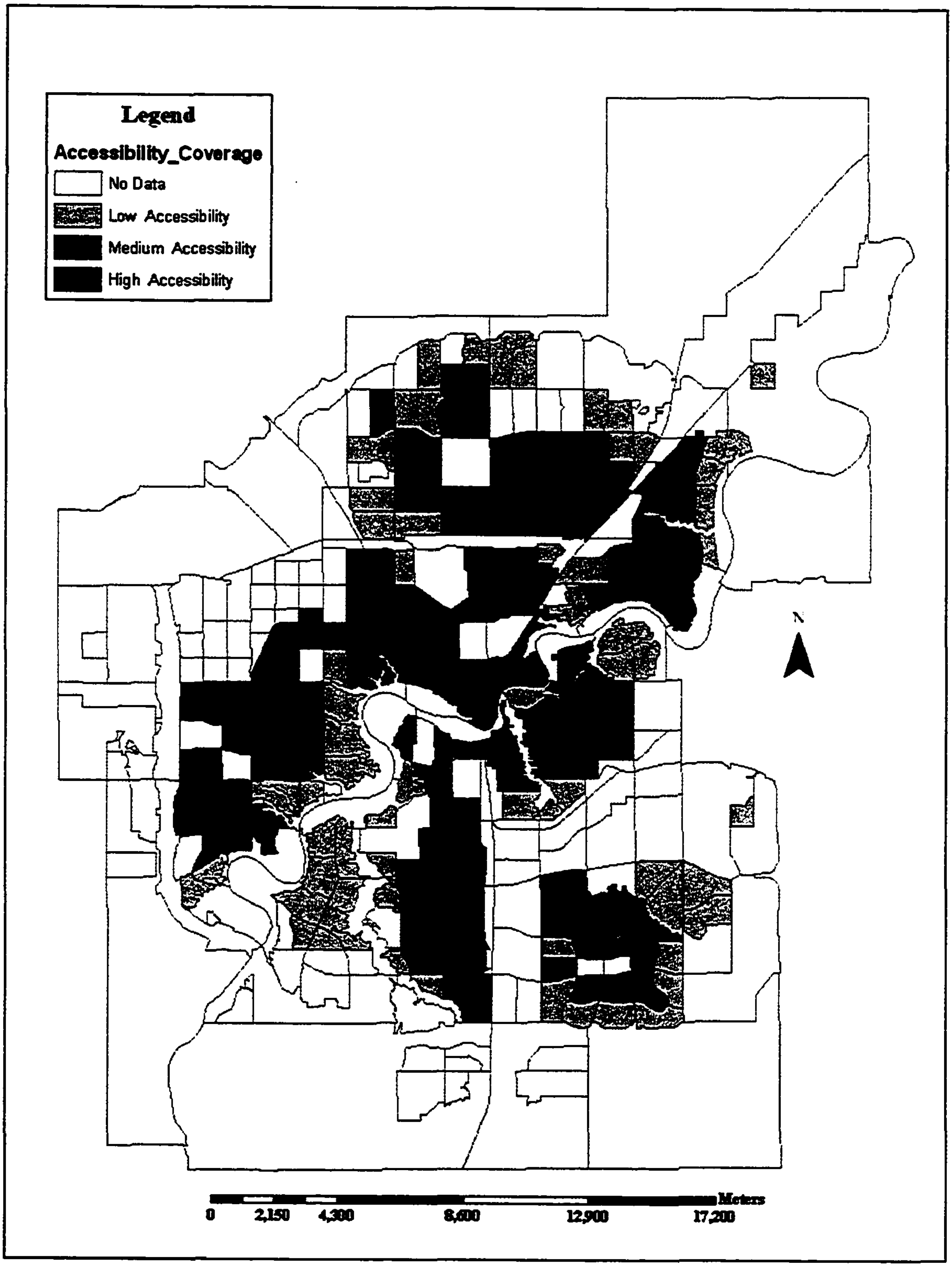
# Appendix A

Map of coverage model fast-food accessibility



RUNNING HEAD: GIS, ACCESSIBILITY AND HEALTH PROMOTION

# CHAPTER THREE – PAPER TWO

## GIS and Accessibility: Filling a Health Promotion Gap?

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**Abstract**

Background: Recently, much interest has been directed at "obesogenic" (obesity-promoting; Swinburn, Egger & Raza, 1998) built environments, and at Geographic Information Systems (GIS) as a tool for their exploration. A major geographical concept is accessibility, or the ease of moving from an origin to a destination point. There are several methods of calculating accessibility, each with its own strengths, drawbacks and level of precision that can be applied to various health promotion research issues.

Objectives: The purpose of this paper is to describe, compare and contrast four common methods of calculating accessibility to urban amenities in terms of their utility to obesity-related health promotion research. Practical and conceptual issues surrounding these methods are introduced and discussed with the intent of providing health promotion researchers with information useful for selecting the most appropriate accessibility method for their research goals.

Method: This paper describes methodological insights from two studies, both of which assessed the neighbourhood-level accessibility of fast-food establishments in Edmonton, Canada – one which used a relatively simple coverage method and one which used the more complex minimum cost method.

Discussion: A major drawback of both methods is that they assume the characteristics of the amenities and of the populations using them are all the same, and are static. The gravity potential model is introduced as an alternative, since it is capable of factoring in measures of quality and choice. A number of conceptual and practical issues, illustrated by the example of situational influences on food choice, make the

use of the gravity potential model unwieldy for health promotion research into socially-determined conditions such as obesity.

Conclusions: It recommended that geographical approaches be used in partnership with, or as a foundation for, traditional exploratory methodologies that are more inclusive and representative of the populations of interest.

**GIS and Accessibility: Filling a Health Promotion Gap?**

Recently, the obesity epidemic has been garnering worldwide publicity because of its startling increase in prevalence, especially in children. Research examining the relationship between income/social status and obesity has demonstrated a similar pattern as seen with other health concerns – those with lower social status are also the most obese, with the prevalence of obesity decreasing as personal or family wealth and education level increases. Gender and employment status have also been shown to interact with obesity rates (Sobal & Stunkard, 1989; Macdonald, Reeder, Chen & Despres, 1997; Lin, Huang & French, 2004; Sarlio-Lahteenkorva, Silventoinen & Lahelma, 2004). Interestingly, however, these relationships are not nearly as cut-and-dried as in other conditions. As the prevalence of lower-status obese persons is increasing faster than the population average, so too are rates of obesity in higher-status populations, specifically men (Raine, 2004).

One of the determinants of health that has generated an increased amount of attention, in the fields of nutrition and physical activity (and obesity, by association), is the physical or built environment. Specifically, researchers have tried to delineate whether there is anything in the physical environment that might increase the risk for obesity in different population groups. High-profile projects have examined several aspects of this relationship, including the effects of urban sprawl on health and obesity (Frumkin, 2002; Vandegrift & Yoked, 2003), the socioeconomic and population-based aspects of grocery store placement (i.e. "food deserts"; Cummins & McIntyre, 2002; Whelan, Wrigley, Warm & Cannings, 2002; Clarke, Eyre & Guy, 2002; Morland, Wing, Diez Roux & Poole, 2002), and the influence of urban form on physical activity behaviour (Handy, Boarnet, Ewing & Killingsworth, 2002; Pikora, Bull, Jamrozik, Knuiman, Giles-Corti & Donovan, 2002; Frank, Andresen & Schmid, 2004). The majority of these studies have found differences in built environments in terms of the distribution of amenities for food and physical activity, and in the populations who inhabit them. The results of most of these studies point in a negative direction (i.e. increasing health risks from urban sprawl, food deserts often situated in relatively impoverished areas; Jackson, 2003; Whelan et al., 2002). More importantly, the neighbourhood-level characteristics that may result in these negative health impacts are being uncovered and discussed.

The study of the urban influences on health is relatively young. One of the most promising techniques is to analyze these built environments through the use of Geographic Information Systems (GIS) technology (Talen, 1998). GIS allows researchers to examine, pinpoint and display a broad range of features of the built environment, from street networks and traffic density to the location of neighbourhood amenities. Further, the quantification of these environmental factors, which can be used in a broader analysis (e.g. correlation with socioeconomic status, or other variables), has become relatively simple.

One of the focuses made easier by GIS technology is an analysis of the concept of accessibility. In other words, GIS software allows researchers to visualize areas of high concentration of a specific amenity, 'desert' areas (of very low concentration), and other characteristics of the built environment that may influence how often an amenity is accessed. This is of obvious interest to the field of chronic disease prevention and health promotion, especially if it is shown that differences in these measures are associated with obesity or other conditions.

In light of these advances, health researchers have become understandably excited about the inclusion of GIS technology in their studies. Not surprisingly, papers using this technology are appearing rapidly, and across a variety of health fields (e.g. Gilliland & Ross, 2005; Estabrooks et al., 2003; Frank, Andresen & Schmid, 2004). With this increase in interest, however, health promotion researchers and professionals should also be fully aware of the limitations of this technology, as well as its strengths, if it is to be used to its full potential. This paper will therefore cover the following objectives:

1. To introduce several methods of calculating accessibility, taken from the fields of geography and spatial analysis, as they might pertain to the study of health promotion.

2. To present two examples of GIS applications and accessibility measures within a Canadian urban centre to illustrate what these geographic models can tell us, and what they cannot, in terms of health promotion research, outcomes and application.

3. To introduce practical and theoretical issues common to this work, and suggestions for maximally coordinating health promotion and geographical research concepts and techniques.

## The Geographical Concept of Accessibility

Simply defined, accessibility is a measure of the ease of which a person at a starting point (origin) can arrive at another point of interest (destination) (Hansen, 1959). There are several specific ways that accessibility can be operationalized, depending on the variables of interest and the data that are available. Four major methods for calculating accessibility, in order of their relative sophistication, are coverage, minimum cost, average cost and gravity potential. It is important to note that within each of these methods, there are variations in specificity for calculating several of the variables of interest. Therefore, more complex methods of calculating coverage (e.g. including a measured distance buffer area around a point of interest) and simpler methods of calculating average cost (e.g. using a unmodified geographical centroid for calculation as opposed to a population-weighted centroid), may be more similar than a clear-cut classification scheme may suggest. For the purpose of this paper, however, methods are presented in a manner that facilitates distinct comparisons by emphasizing variation between those methods chosen. Table 1 summarizes general characteristics of each of the four methods discussed. (Church & Marston, 2003; Talen & Anselin, 1998).

Table 1. Characteristics of Four Common Accessibility Methods

| Accessibility Method | Measure | Variables Requiring Definition |
|---|---|---|
| Coverage / Container | Number of destinations within buffer zone | • Nature of buffer zone (existing boundaries, distance from origin) |
| Minimum Distance | Distance to nearest destination | • Type of distance measure (Euclidian or street network)<br>• Centroid placement (geographical or population weighted) |
| Average Distance | Average distance to "x" nearest destinations | • Minimum distance variables plus...<br>• Number and characteristics of destinations |
| Gravity Potential | Average distance to "x" nearest dest. weighted by external variables | • Average distance variables plus...<br>• Attractiveness features of destinations. |

The *coverage* method is one of the simplest ways to determine accessibility. In this method, a buffer zone of either distance or time is created around the origin, which often corresponds to the population of interest (e.g. walking distance). Buffers created with Euclidian distance (linear, or "as the crow flies") result in a circular area; however, more sophisticated coverage methods utilize street network distances and travel times, which more accurately reflect "real-life" travel routes and barriers. Other types of limiters, such as natural features (e.g. rivers) or artificial boundaries (e.g. neighbourhoods, city limits), can also be employed depending on how the environment is structured. Following the definition of the buffer area, the number of amenities of interest that lie within the area are tallied. This raw score corresponds to the relative accessibility of a person at that origin, to the amenity of interest (Talen & Anselin, 1998).

The coverage method uses the concept of concentration to determine accessibility, i.e. the more amenities within the buffer, the greater chance a person at the origin has to access one of them. In contrast, the *minimum cost* model uses the shortest distance or travel time as its basis for relative accessibility. The distance to the nearest amenity, again calculated by either straight-line or street network distances (street network again being more realistic), results in the origin's accessibility score. In this case, the closer the origin is to the amenity, the higher its relative level of access. A more sophisticated version of this model, called *average cost*, averages the distance of a predefined number of the closest amenities to provide a value that reflects somewhat the concept of personal choice in its calculation. If the model is applied from a large number of origin points in an area, a substantive picture of minimum or average cost accessibility can be produced (Hewko, Smoyer-Tomic & Hodgson, 2002).

The final method to be described here is the *gravity potential* model. This model builds on the others by including a coefficient of amenity quality into the calculation; in other words, variables can be included in the accessibility calculations that make Amenity A a more attractive choice than Amenity B, even though Amenity B may be closer in distance or time. The clear strength of this quality coefficient is that, theoretically, it provides some objective context for making one choice more attractive than another. This allows researchers to integrate real-life factors into their accessibility calculations, making them more relevant to the populations living in the areas under study. For example, in an immigrant community, an Asian market might be labeled as a more attractive choice for a given household or individual than a Western-style grocery store, even though the market might be further away. This advantage speaks particularly to community health and health promotion researchers, and is an attractive choice for projects examining equity issues or other social determinants of health in an urban context. For more detailed information on these methods, readers should consult Hewko et al. (2002); Talen & Anselin (1998); Church & Marston (2003).

## Examples of Accessibility to Urban Fast-Food

As part of two larger studies, accessibility to fast-food restaurants in Edmonton, Alberta (population 650,000) was calculated using the coverage and minimum cost methods. These studies were undertaken when the author was a member of two distinct, collaborative research teams from the University of Alberta, one based in the Centre for Health Promotion Studies, and the other based in Department of Geography. As each of these studies are still in process, detailed descriptions of each project's methods will not be given here (K. Smoyer-Tomic, personal communication, December 2, 2004). However, a brief overview of the process and the results of each will be described. These projects are presented as concrete examples of the conceptual and practical differences between these two methods in terms of their conceptualization, process and the interpretation of results.

Both projects used the same data set, which included 762 fast-food outlets. Also for both, a fast-food restaurant was defined as an establishment with walk-up counter service, and where the majority of the served foods are pre-cooked and heated to order. Coffee shops that also served full meals (e.g. Tim Horton's) using the defined service style were included, as were Asian food restaurants in shopping centres. Stand-alone Asian establishments were excluded, as well as all restaurants with waited-table service, as well as cafes, and concessions stands. The location of each restaurant was obtained through a partnership with Capital Health, Department of Population and Public Health, Health Inspection division, including the city neighbourhood in which each was located. Data analysis was conducted in the summer of 2004 using Geopinpoint (DMTI, 2003) and ArcGIS 8.3 (ESRI, 2003) for geocoding (electronically locating each food establishment to a point on a map) and mapping, respectively. Each fast-food location was manually checked, by comparing the points plotted location to the actual location as it was listed in the project's food location database. This ensured it was in the correct position on the city base map, and reduced errors associated with the geocoding process. If the point was not where it should have been, it was manually moved to the correct position – approximately 50% of the 789 plotted points required some measure of correction, ranging from the opposite side of the street (most common) to a few that needed relocation to the other side of the city.

Following the mapping stage, two statistical analyses were applied to the data output from the two accessibility methods. The purpose of these tests were to determine the strength of the association between the two methods; in other words, whether a neighbourhood with high coverage accessibility to fast-food will also have a high level of accessibility in terms of the minimum distance method. The tests that were used included a simple Pearsonian correlation and a Pearson Chi-Square.

*Coverage Method*

For this model, fast-food restaurants were geocoded and mapped. A tally of the number of establishments within each neighbourhood was then compiled, and listed in descending order. The final total number of establishments accessible to each neighbourhood included both those inside it, as well as the restaurants located within the neighbourhoods immediately adjacent to it. For example, the neighbourhood of Garneau had five neighbourhoods that immediately surround it: therefore, the total number of fast-food restaurants accessible to a Garneau resident included those within the neighbourhood as well as those within the neighbourhoods beside it. Using tertile breaks in the raw numbers of fast-food outlets available to them, neighbourhoods were then categorized as having either a high ($n=67$; $\mu=5.16$ [sd=3.16]), medium ($n=67$; $\mu=14.55$ [sd=2.61]), or low ($n=70$; $\mu=48.13$ [sd=34.65]) level of access to fast-food (see Table 2).

Table 2. Characteristics of High, Medium and Low Fast-Food Access Neighbourhoods; Coverage Method

| | | Number of Fast-Food Restaurants | | | |
|---|---|---|---|---|---|
| Group | N | Minimum | Maximum | Mean (SD) | Median |
| Low | 70 | 0 | 10 | 5.16 (3.16) | 5 |
| Medium | 67 | 11 | 19 | 14.55 (2.61) | 15 |
| High | 67 | 20 | 156 | 48.13 (34.65) | 34 |
| Total | 204 | 0 | 156 | 22.36 (27.15) | 14.5 |

*Minimum Cost*

The procedure for calculating accessibility based on this model included some of the steps listed above, but also many others that account for the increase in sophistication and precision relative to the coverage model. Beginning with the same database of fast-food locations, each point was geocoded and checked in the same manner as the previous example. Then the origins were established within each neighbourhood from which the minimum cost calculations would be taking place, also known as the neighbourhood *centroid*. Generally, this method assumes that the centroid of a neighbourhood or other area is located in the centre of the area. However, placing the centroid in the middle of the neighbourhood assumes that the population distribution within the area is uniform, which is often not the case (Hewko et al., 2002). In order to more fully understand where the population in each neighbourhood actually lived, the neighbourhood base maps were linked to the set of available Statistics Canada census data with the finest resolution – in Canada, this is the level of dissemination area (DA), which is basically one or more city blocks with a population of approximately 400-700 people (Statistics Canada, 2001). Since the DAs had a smaller area than the city neighbourhoods, a number of them fell inside these larger neighbourhood boundaries, effectively dividing them into a number of smaller areas. From this, the distance to the nearest fast-food establishment was calculated from the centroid of each of these smaller dissemination areas. A mathematical algorithm was then written and applied to the data, which averaged the distance calculated from each DA centroid as well as placed a weighting function according to the number of people living there. In other words, greater weight was given to the centroid-to-outlet distances from more highly-populated DAs rather than those that were less dense. The averaged, weighted distances from all the DAs within each neighbourhood then became the accessibility score for that neighbourhood.

As in the previous calculation of coverage method accessibility, neighbourhoods were divided into three equal groups based on a tertile split of minimum distance accessibility. Each access category then included 68 neighbourhoods, the descriptive characteristics of which are summarized in Table 3.

Table 3. Characteristics of High, Medium and Low Fast-Food Access Neighbourhoods; Minimum Distance Method

| | | | Distance to Nearest FF Outlet (m) | |
|---|---|---|---|---|
| Group | N | % | Range | Mean (SD) |
| Low | 68 | 33.3 | 1032.75-5691.02 | 1632.48 (739.05) |
| Medium | 68 | 33.3 | 643.74-1032.25 | 822.57 (117.63) |
| High | 68 | 33.3 | 153.00-639.92 | 477.61 (125.58) |
| Total | 204 | 100.0 | 153.00-5691.02 | 977.55 (652.30) |

*Overall Results*

Although basic, the coverage method resulted in a map that clearly delineated areas of concentration in terms of fast-food restaurants throughout the city – see Figure 1. Specifically, the downtown core of the city and the neighbourhoods surrounding it were all classified as having high access to fast-food, along with several neighbourhoods in older suburban areas that contained large shopping centres.

Conversely, many newer suburban areas, which are generally located towards the outskirts of the city, had little to no fast-food representation.

The map representing accessibility to fast-food using the minimum cost method shows that areas of high accessibility are spread throughout the city, with the exception of outlying suburban neighbourhoods which have a higher representation of low access. Areas of concentration are notable around neighbourhoods that contain shopping centres or are bordered by major transportation routes, as well as near the downtown core of the city.

The results of the correlation and Chi-Square tests indicate that the two accessibility methods are overlapping significantly in their outputs. Specifically, the

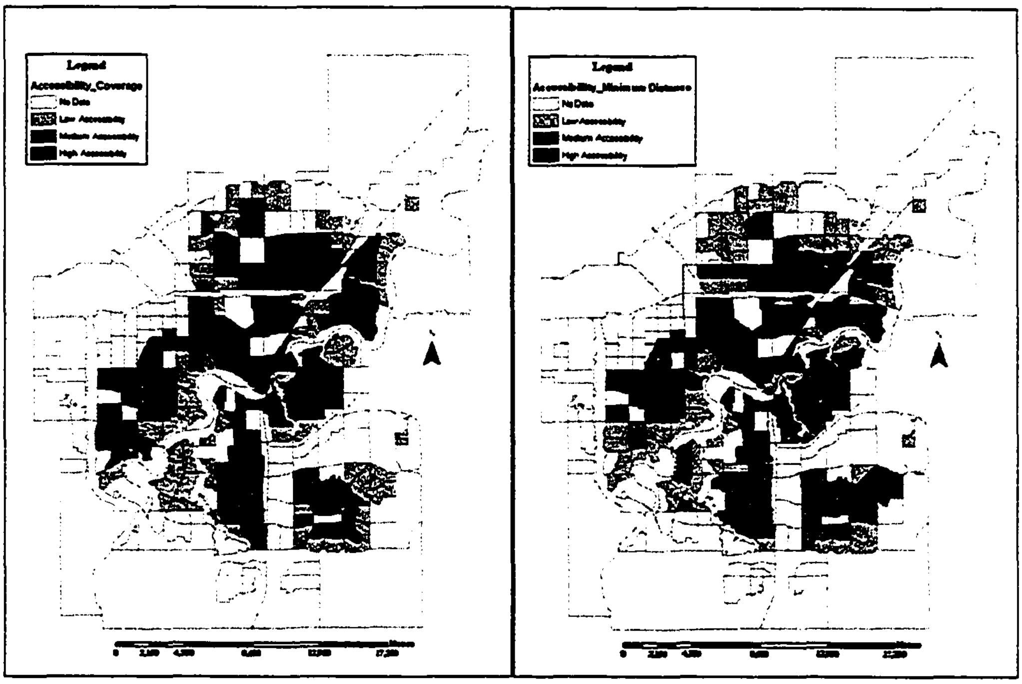

Figure 1. Coverage and Minimum Distance Accessibility Maps

Pearsonian correlation between the raw accessibility data from both methods resulted in $r = -.383$ ($p<.001$), which indicates that as the number of fast-food outlet available to a neighbourhood increases, the minimum distance from that neighbourhood to a fast-food outlet decreases (and vice-versa). Similarly, Pearson Chi-Square resulted in $\chi^2 = 56.78$ ($p<.001$), meaning that there is significant overlap between the accessibility methods in terms of their fast-food access level categorization (i.e. high coverage access is high minimum distance access, etc.).

**Discussion**

Despite their computational differences, the two accessibility models produced remarkably similar patterns when fast-food restaurants were the objects of interest. Each model confirmed that access is highest in the downtown core, near suburban shopping centres and, to a certain extent, along major arterial transportation routes. Similarly, areas on the outskirts of the city had the lowest accessibility. These results are supported by both correlational and chi-square analyses, which illustrate that the results of both accessibility methods are significantly related to one another. Given that both projects used the same data set and the same physical area, these results are not surprising.

At the broadest level, the two measures of accessibility purport to answer the same question: how easy is it for a resident in Neighbourhood X to access a fast-food restaurant? The two methods are different yet have a similar underlying purpose, to explain why residents of certain areas may have a higher or lower level of exposure to fast-food. However, a critical examination of logistical differences, what these models *do not* tell us, and the assumptions contained within them may be more informative to health promotion researchers who are interested in establishing which method might be the most appropriate to employ.

*Practical Differences*

Although the two research projects produced similar results in terms of measures of accessibility to fast-food, a number of logistical disparities emerged over the course of the studies that deserve mention. The relative complexity of each method, as well as the length of time, cost and human resources required by each, are key issues that should be discussed during the planning of any GIS-based research project (Porter, Kirtland, Neet, Williams & Ainsworth, 2004).

As is apparent from the project descriptions provided above, the coverage and minimum cost methods require many different inputs in order for them to be correctly calculated. Both models require the same basic information, including accurate address information for all fast-food restaurants, as well as base maps with the appropriate boundaries (in this case, city standard neighbourhood) that will allow the points to be plotted. Finally, both methods necessitate the use of both a GIS software package, as well as a geocoding program. The minimum cost method, however, also requires a street network map in order for distances to be calculated, along with specific GIS software extensions (i.e. program add-ons with specific functions). GIS software packages can be very costly, with or without these extra extensions; further, many of the computations necessary for this minimum cost method could only be run using a powerful computer system, which added to the overall cost.

Researchers not only need these resources, but they must also have the knowledge and skills to use them. Again, the skills necessary to run a coverage analysis are relatively simple – the raw accessibility scores of a particular area are the number of opportunities contained within it. In contrast, the minimum/average cost method requires that the distance from a representative point to the closest amenity be calculated for each area of interest, in this case from the neighbourhood centroid. When street network distances are used, as is the most appropriate, the analysis becomes more complex. In the minimum/average cost project, a further step was added – the population-based weighting of the neighbourhood centroid. This makes the calculations more accurate, but requires that a person with advanced mathematic or computing science skills be present on the research team in order for this step to be included.

Other aspects to consider are the capability and precision of the software used to geocode each point onto a digital map. Even the best geocoding software is not 100% accurate, and every geocoding program is susceptible to syntax errors such as misspelled place or street names, incomplete maps, or nonexistent postal codes which can cause points to be incorrectly plotted. This constitutes an advantage for the coverage method, because these calculations are based on concentration rather than specific distance, and there is slightly less of an emphasis on the precision of the plotted point. This is not to suggest that accuracy is unimportant; rather, the minimum cost method has more chance for error if the locations of the points are not mapped with extreme precision. For example, if a point is plotted 100 metres from where it should be, this error will be introduced into every calculation undertaken that uses this point for the cost models. In contrast, it is less likely that an error of this size will move the point outside of the defined coverage area used for those calculations. Again, regardless of the accessibility model chosen, precision should be of high priority. However, the minimum cost method demands that manual checks of every plotted point be conducted, which can consume a large amount of time if there are many points involved and many that require correction.

Several studies have used the information gathered from the coverage process to specify areas that can more closely examined – for example, researchers in the UK have begun describing specific characteristics of food deserts determined from previous research, and have begun to compare them to areas that are richer in these amenities to see what the differences might be (Cummins & Macintyre, 2002). In another study (Whelan, Wrigley, Warm & Cannings, 2002), a natural pre-post experimental situation was created when a major supermarket chain opened a store in an area previously classified as a food desert; important information about the purchasing and consumption habits of area residents were collected, effectively outlining the impact of the store's opening within an quasi-experimental context. Thus, it has been demonstrated that the coverage method of calculating accessibility is adequate in many cases for public health and health promotion purposes.

These examples serve to further solidify how the different levels of work involved are capable of producing results of varying sophistication. However, does this increase in precision counterbalance the amount of time, cost and expertise necessary to achieve it? The requirements necessary for each model's accessibility calculations should be weighed against the desired outcomes, and the future directions that the work will be taking.

*Conceptual Differences*

Balanced with these issues of time and skill are the conceptual issues and assumptions that underlie each of these models, which are closely tied to what they are capable of uncovering relative to health promotion research and practice. This discussion will illuminate some of the broader questions surrounding the use of these methods, in an attempt to spur discussion concerning where they might fit within a broader research agenda into the social determinants of health.

Simplicity, while one of the major strengths of the coverage method, is also its major weakness; there are certainly many questions that it cannot answer. Among these are the actual distances to access the chosen services, the specific qualities of the services, or how the population is actually affected by their specific physical environment. As well, there are questions about the definition of the buffer area to be examined. How big or small should this area be? Does it adequately represent the population living in that area? For example, an inner-city area with fewer car owners might have a smaller radius of distance that people can realistically travel (having a heavier reliance on walking or bus travel), whereas this buffer might be adjusted outwards if a car-heavy suburban area is the target of interest. Or, what if an amenity is situated just outside of the buffer area? A balance between empirical rigour and practical significance must be achieved if the research is to have meaning.

Several of the above questions and issues can be resolved through the use of the minimum distance model. As mentioned above, this technique removes the emphasis on concentration of amenities, instead focusing on the actual distance or time required to travel from the point of origin to the destination of interest. The strength of this model lies in its precision – with GIS software, it is possible to pinpoint these distances to within one meter or finer on a citywide scale. When the actual distance to the closest amenities is averaged, as in the case of the average cost model, a very accurate summary of these distances can be obtained. The intended use of the results of this method is fairly obvious, as there can be a wide variation of minimum distances to a certain target depending on where the origin point is located. As a hypothetical example, if the average distance to the 3 closest stores that sell fresh produce is 0.5km for Neighbourhood A, and 3.5km for Neighbourhood B, the implications are quite clear and can be very influential in terms of neighbourhood planning and its influences on health.

However, the process of determining minimum and average distances includes several assumptions and other methodological issues that deserve attention. The first assumption is that consumers will frequent the amenity that is closest to them, which has been demonstrated to be false (Hodgson, 1981; Handy & Neimeier, 1997). This assumption has less impact on the average distance model, as several choices are included, but is still applicable. The model also assumes that each opportunity is the same as any other, where in actuality an opportunity like "fast-food" can encompass a wide range of styles, prices, ethnicities, and many other features.

A basic assumption of these three models is that every amenity being included is the same, in terms of their individual characteristics and the impact they may have on the population of interest. Fast-food, as the object of choice in the above examples, is relatively consistent in terms of its negative impact on population health. Other types of amenities, such as grocery stores or community centres, may vary enough between cases to warrant a more specific examination or categorization. For example, a small neighbourhood market, a large chain supermarket and an Asian supermarket may all be classified as grocery stores. But do they all have the same impact on the community? In actuality, there is likely enough difference between the variety of products for sale at each store, the price at which they are being sold, and the clientele that frequent each store to conclude that each individual amenity is impacting the target population in a different way. This assumption is relatively minor, given that a closer examination of the amenities of interest (e.g. categorizing all small markets together, separate from the larger group) may reduce the issues associated with it.

Similarly, each accessibility model assumes that all people who consume fast-food are the same, and use the same criteria for choosing where, when and how they are accessed. Further, both models are measuring only objective aspects of the physical environment that may contribute to increased fast-food consumption. Not examined are the critically important subjective criteria that influence food choice, such as income levels, culture and other aspects of socioeconomic status (Connors, Bisogni, Sobal & Devine, 2001; Conner, 1994). As these external factors may exert a tremendous amount of influence over the process of accessibility, separating the objective and subjective aspects of access could be a very costly error.

*Gravity Potential and Food Choice – A Solution?*

The gravity potential technique is based on the same methodology as the minimum and average cost described above, only with an added coefficient of quality. The purpose of this quality indicator is to provide an empirical measure of the attractiveness of the amenity, in essence giving the "better" amenity more weight in terms of being a location of interest. Potentially, this technique allows researchers to factor in influences on the process of personal choice regarding the amenity of interest, which addresses many of the concerns and assumptions present with other accessibility models.

As above, specialized skills in high-level GIS and programming are required to complete this type of work, which may or not may not be available to health researchers. However, more of a conceptual issue with this model is what "quality" actually means, and whether it can be quantified. Depending on the amenity being examined, the quality coefficient can encompass a range of factors from simple objective classifications to more complex subjective influences. The process of determining quality needs to begin with the discussion of a number of questions, such as:

- What are the general indices of quality that are commonly used for this amenity?
- From whose perspective is the quality of this amenity being judged?
- Are there any broader influences (e.g. culture, income) that impact how quality is viewed by this population? If yes, can these be integrated into the coefficient?
- Once established, does the definition of quality accurately represent the perspective of the population defined above?

Other more specific questions may arise depending on the nature of the work being conducted. This process, although seemingly a simple part of the more complex model development, is capable of becoming an entire project unto itself. Again, defining and incorporating a measure of quality into accessibility calculations can be an arduous process; however, having results that realistically represent the perspectives of the people who may be affected by them is certainly worth the effort.

The body of research examining motivations for food choice suggests that proximity is only one of many factors that influence where people choose to buy their food, and is most often not the most important reason (Steptoe, Pollard & Wardle, 1995; Prescott, Young, O'Neill, Yau & Stevens, 2002; Connors et al., 2001; Conner, 1994). Other factors that influence where individuals purchase their food include health impacts, price, ethical issues and sensory appeal (Steptoe et al., 1995). Fast-food restaurants are obviously not the only sources of food in any given area, and an increase in the number of other sources may reduce reliance on fast-food for sustenance. Moreover, differences exist between genders and other population groups concerning the features of their subjective circumstances that more strongly influence their food choices; for example, features impacting personal health have been shown to be more significant for female populations rather than males, while price may be a more significant variable for lower-income populations relative to higher income ones (Steptoe et al., 1995). Differences in motives for food choice were also noted between several Asian countries and New Zealand (Prescott et al., 2002), a potentially important finding given that many Canadian cities have high numbers of immigrants from these regions and others around the world.

A major theme in the literature concerning food choice is that the majority of the critical factors in this process are closely tied to subjective circumstances of the individual who is making the decision (Furst, Connors, Bisogni, Sobal & Falk, 1996; Stratton & Bromley, 1999; Holm & Kildevang, 1996; Clifton, 2004; Connors, Bisogni, Sobal & Devine, 2001). While physical proximity and other objective variables are important, they themselves are often mediated by an individual's personal context. For example, a recent Asian immigrant might live in an area with a high concentration of fast-food, but may instead prefer to purchase food at a local Asian market because it is more appropriate for their tastes and culture. In order for a complete understanding of the influence of proximity to fast-food or any other type of amenity, the social, cultural and financial context of the area of interest must be uncovered and woven into the analysis.

Regardless of the methods chosen to calculate accessibility, the use of these geographical concepts and analysis techniques remains a potentially powerful ally for research into the social determinants of health. Until relatively recently, it was very difficult to practically describe inequities at the "micro" level in a manner that is easily understood. GIS technology offers a window into the distribution of societal and economic processes as they appear on the landscape, and as such is capable of illuminating health-impacting features within it that were previously difficult to quantify. That said, the process by which these results are obtained, as well as the explanatory power these techniques can offer, should be subject to a high level of scrutiny by any researcher who wishes to employ them. In particular, researchers should closely examine the resources necessary, including costs, skills and time, to ensure these inputs are matched with the ultimate goals of the course of study. If used in concert with other exploratory research methods, such as qualitative interviews or observation, the potential implications for health promoting policy and practice are great.

**Summary and Conclusions**

The recent worldwide concern about obesity has spurred researchers to closely examine many aspects of its increasing prevalence. Much of this work has focused on physiological or lifestyle-oriented features of obesity. Recently, however, there has been an increase in research targeting "obesogenic" environmental determinants of obesity, specifically, how the physical layout of urban areas might contribute to this growing health issue.

In an effort to broaden their approach, health researchers have begun partnering with, and adopting techniques from, several other fields and disciplines. One of the most promising of these partnerships includes the incorporation of geographical technologies, such as Geographic Information Systems, and concepts such as accessibility and spatial equity. These approaches allow health researchers to visualize, with relative ease, the distribution of amenities that may undermine or promote population health in an urban setting. The level of accessibility to these amenities can quantify the potential health risk or reward posed by any predefined environmental variable, such as parks, playgrounds or fast-food.

There are several different ways of defining and calculating accessibility. These range from the relatively simple (e.g. coverage) to more sophisticated (e.g. minimum/average cost, gravity potential), with each method having several strengths and weaknesses in terms of their simplicity, ease of calculation, and precision. These factors should be considered under any circumstances in which these techniques are to be employed. For example, although the coverage method is a relatively simple model of accessibility, it can still be quite useful for certain tasks. Much of the work conducted on food deserts, or areas with little to no sources of retail food, uses this model to determine where these areas are located. Conversely, areas of high concentration can be determined by the same process. Therefore, this technique is capable of providing an adequate basis for accessibility research on a population level. As well, the results of this method are quite easy and effective to display, making the dissemination of maps and other related information easy and effective with a minimal level of expertise and effort.

In an effort to make measures of accessibility more relevant to the populations of interest, the gravity potential model addresses several assumptions of less sophisticated models by including factors that influence personal choice into the calculations. On paper, any effort to more properly reflect real-life situations is welcome. However, these calculations are even more computationally intense than other models, which can limit researchers who do not have access to such expertise. Further, questions can be raised about whether it is possible to quantify complicated objective and subjective influences on behaviour, as illustrated by the example of situational impacts on food choice.

The application of any accessibility model to health research creates a number of questions around the explanatory capacity that can be attributed solely to these geographical concepts. In other words, accessibility measures can uncover a great deal about how the urban physical environment is structured. What it cannot answer, however, are questions concerning the effects that these environments actually have on population health risk factors and outcomes.

As such, it is important for researchers to allocate enough time to discussions regarding how their overall research question can be linked to these models, the resources necessary for each to be undertaken, and what contextual factors need to be included in order for the research to be meaningful to the population of interest. The health impact of residing in an area of high fast-food concentration is largely unknown unless, for example, it is determined that the people there actually purchase food from these places. Accessibility models are unable to determine whether there is actually any health impact (e.g. higher rates of obesity) of living in an area of high fast-food concentration, unless they are combined with other qualitative or quantitative data sources. As well, health promotion research should ideally be conducted with a more participatory orientation, with input solicited from the populations that are being studied; if the complexity of the results obtained from a GIS project is so great that only heavily-trained academics can interpret or replicate them, then the gap between the researchers and those who are affected by the research may become great. This may prohibit the larger public from buying into the research and results, which could prevent desired policy changes from developing. Thus, these geographical concepts and techniques are very well-suited to be used as a foundational piece of research, or in a broader mixed-methods format study, rather than as a standalone piece. Efforts to address these concerns when including geographic methods in health promotion research will result in well-supported, powerful inferences, conclusions, and future directions for health promotion.

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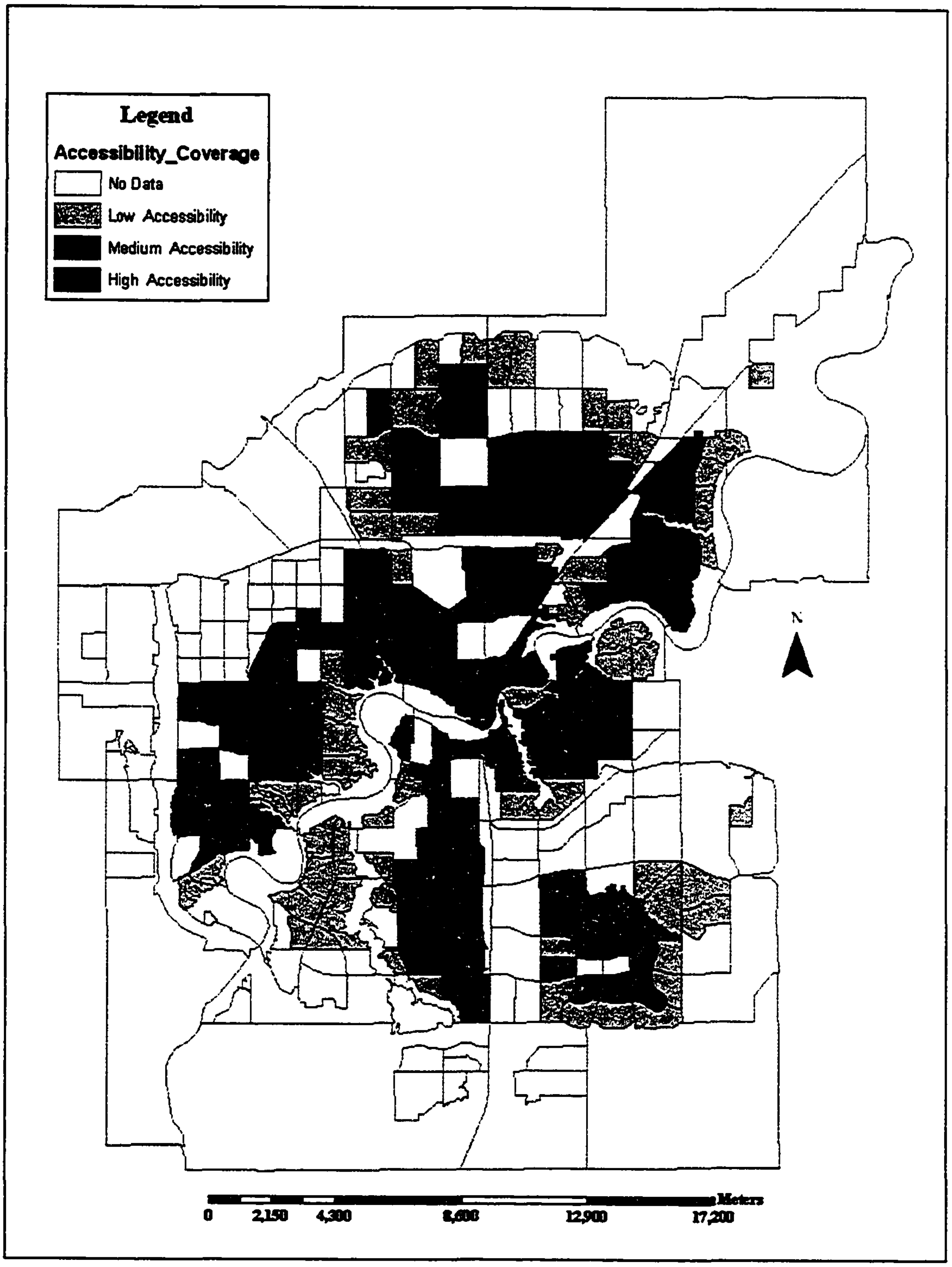
# List of Appendices

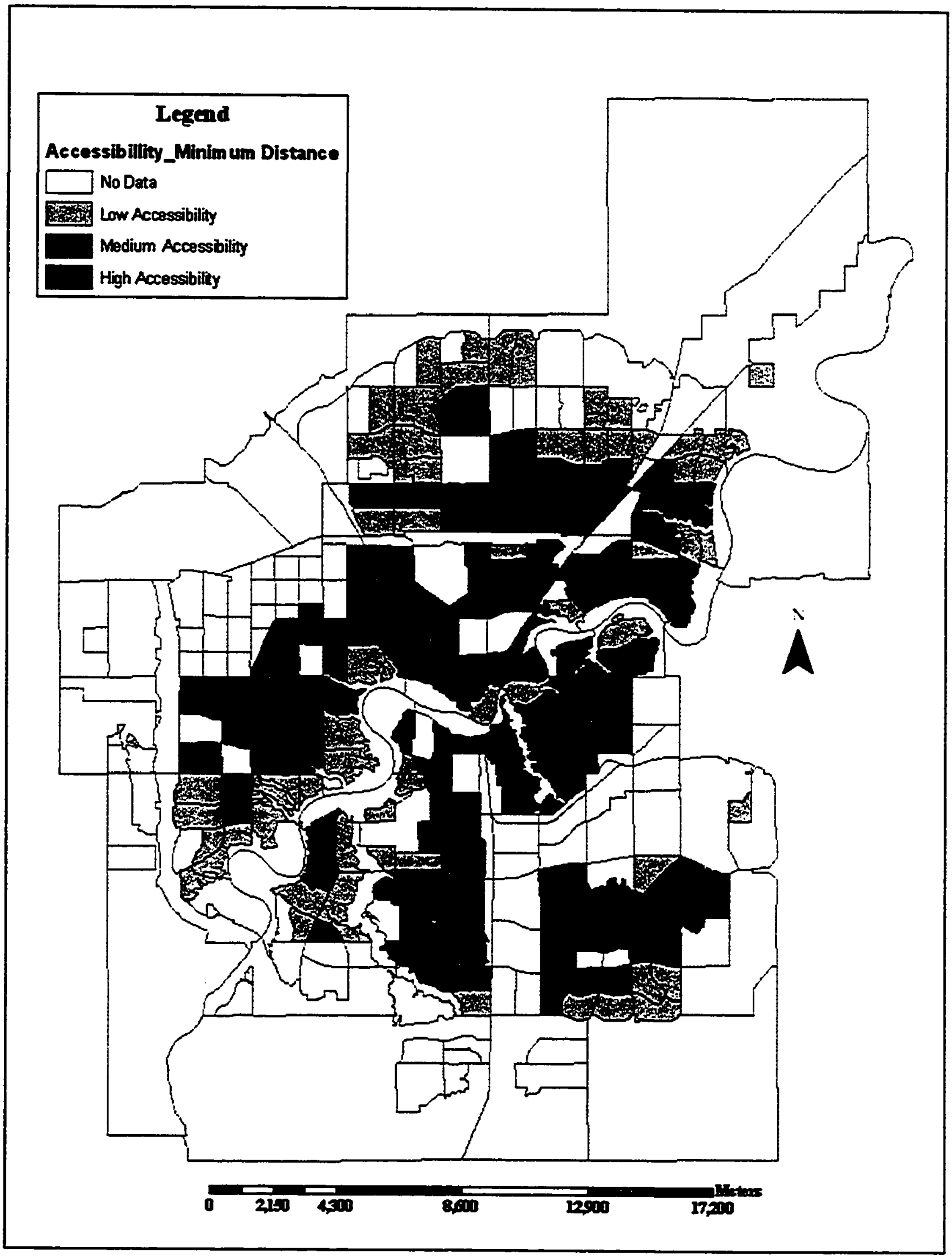
# Appendix A

## Map of coverage model fast-food accessibility



## Appendix B

**Map displaying accessibility to fast-food using minimum cost methods**



# 4. CONCLUSIONS AND GENERAL DISCUSSION

## 4.1 Chapter Overview

*This chapter will summarize the main conclusions drawn from each of the two preceding papers, followed by a general discussion and expansion of the major issues relevant to this thesis. The issues to be discussed will include the unique contribution these papers will make to the literature concerning the built environment and its impact on health, as well as an exploration of some of the issues facing interdisciplinary teams working on such issues. An expanded presentation of the limitations of this work will follow, and will be accompanied by a series of recommendations for future work on the social and built environmental determinants of obesity.*

## 4.2 Main Conclusions

Many neighbourhoods within the City of Edmonton contain a high number of fast-food restaurants. Most of these neighbourhoods are clustered around the downtown core of the city, while other fast-food-dense areas include those which contain shopping centres and those bordered by major, arterial transportation routes. In several downtown neighbourhoods, residents are faced with over 100 fast-food restaurants within their immediate environment.

A Multivariate Analysis of Variance (MANOVA) revealed that as the concentration of fast-food restaurants increased in a particular neighbourhood, so too did all five of the chosen sociodemographic variables (unemployment, low income, no high school, housing renters and New Canadian immigrants). A discriminant function analysis (DFA) resulted in three indicators of relative deprivation (unemployment, low household income, and housing renters) that were predictive of residing in an area of higher fast-food concentration. A fourth variable, lack of a high school diploma, was also predictive of greater exposure to fast-food outlets. This means that neighbourhoods in the city that are already relatively deprived of financial and social resources are also exposed to more opportunities for eating fast-food, which has been labeled a long-term risk to human health (Jeffery & French, 1998; Pereira et al., 2005). These findings may begin to outline some of the environmental differences that may contribute to the higher observed prevalence of obesity and other related health conditions in lower-status populations.

The second paper incorporated these results with work completed in a related project to provide a comparison of two distinct methods of calculating accessibility to urban fast-food restaurants, *coverage* and *minimum distance*. It was found that both accessibility methods produced similar areas of neighbourhood-level fast-food concentration, despite conceptual and practical differences. These differences, which included issues such as precision, time and human resources, were examined in detail. Although the level of precision attainable through a relatively sophisticated GIS-based accessibility calculation such as minimum distance is remarkable, it also requires a highly specialized and skilled research team, more research dollars, and often difficult-to-access data sources to complete. In contrast, simpler accessibility calculations such as the coverage method sacrifice some of this precision for results that are easier to obtain and interpret, which may be aligned more precisely with the limited resources available to many community-based agencies and practitioners.

Because of the large differences in resources required, health promotion researchers should be careful during the planning of any GIS/accessibility-related project to ensure that the time and resources allocated to this type of research are balanced with the desired precision of the outcomes. Further, GIS-based methods are not necessarily sufficient on their own in providing adequate explanatory power concerning socially-determined health conditions; instead, they might be better used as a basis for further research using other methodologies (e.g. qualitative, observation), which would provide a broader social or environmental context for the more specific geographically-based determinants of health.

This section provided a condensed summary of the results obtained from the two papers presented in this thesis. The focus will now be turned to a broader discussion of how these findings relate to the general literature, including the effect of the built environment on obesity and health, the potential relationships between geography and health promotion, and potential issues facing multidisciplinary teams working on such complex health concerns.

## 4.2 General Discussion

### 4.2.1 *Fast-food Accessibility and Neighbourhood Socioeconomic Status*

Paper 1 documents one of the first known studies of the link between sociodemographic indicators and fast-food restaurant access in a Canadian urban centre. While studies in other countries have addressed similar topics or research questions, the current study is one of the first to include several social indicators (e.g. immigration status, housing status) outside of the traditionally-used socioeconomic status variables (i.e. income, employment status, academic achievement) in its examination of the built environmental determinants of obesity. Similarly, this is one of only a few papers to specifically examine the accessibility of fast-food in a municipal environment, and to include all appropriate fast-food outlets within the study area. Others have either focused on different variables, such as opportunities for physical activity (Estabrooks, Lee & Gyurscik, 2003), playgrounds, (Talen & Anselin, 1998; Hewko, Smoyer-Tomic & Hodgson, 2002), Video Lottery Terminals, (Gilliland & Ross, 2005), or overall mortality and health status (Ross, Tremblay & Graham, 2004); have conducted their examination at a different geographical level, e.g. national (Pereira, Kartashov, Ebbeling, Van Horn, Slattery, Jacobs Jr., & Lubwig, 2005), state (Maddock, 2004), multi-site municipal (Block, Scribner & DeSalvo, 2004); or have only used a sample of fast-food restaurants in a municipal area (e.g. Block et al., 2004). While this study may be of a smaller scale than many of those referenced above, it provides a comprehensive glimpse into the fast-food environment of a Canadian urban centre.

Despite differences in methods, geographical level or variables under examination, the majority of these studies have concluded that there is a potentially powerful relationship between the built urban environment and the chronic condition of obesity. The linkages are particularly strong when viewed in reference to several aspects of socioeconomic status at the neighbourhood level. For instance, differential access to amenities for physical activity were found between high and low socioeconomically-classed neighbourhoods in a small, Midwestern-US city, with poorer neighbourhoods having fewer free-for-use amenities at their disposal than those of higher class (Estabrooks et al., 2003). Similarly, an Australian study found lower-income neighbourhoods to have two-and-a-half times more fast-food restaurants than those of higher-income (Reidpath, Burns, Garrard, Mahoney & Townsend, 2002). These examples illustrate the possibility of a built environment/obesity interaction at the local level.

Taking a broader perspective, three times as many supermarkets were found in higher-income areas compared to lower-income areas across three major US urban centres, with a corresponding increase in the numbers of fast-food restaurants, pubs and bars also found in those areas (Morland, Wing, Diez Roux & Poole, 2002). Another US analysis found a significant relationship between state-level obesity rates and both the raw numbers of fast-food outlets in the state, as well as the number of fast-food outlets per square mile (Maddock, 2004). Finally, a 15-year longitudinal study concluded that both Black and white American adults who increased their intake of fast-food over that period to over twice per week gained 4.5 kg more body weight and were twice as likely to become insulin resistant than those who kept their fast-food intake at a consistent low level (Pereira et al., 2005). Thus, a body of evidence is beginning to mount that not only links fast-food consumption to obesity, but suggests that fast-food availability and other obesogenic factors are more prevalent in areas of lower status.

4.2.2 *Accessibility and Health Promotion – Issues and Insights*

The second paper provides a closer look at some of the conceptual and methodological issues surrounding the environment/obesity interaction, and how these impact the calculation of accessibility to an urban amenity such as fast-food.

Macintyre and her colleagues (1990) have commented on a distinct lack of emphasis on the physical characteristics of area-based units (e.g. neighbourhoods) that may have a hand in explaining some of the health differences noted between communities and the people who inhabit them. The authors also recommend "...that the important research that partials out the relative effects of individual social class from the effects of area of residence should be complemented and extended by research which directly examines features of local environments which might influence health, and which might be amenable to social reform" (Macintyre, Maciver & Soomans, 1990; p. 219).

Combining other forms of research with existing geographically-based methods is one way of clarifying the relationship between obesity and the built environment. However, this is not to diminish the importance of choosing the most appropriate geographically-based method to use, and ensuring that it is employed correctly and with as much precision as possible. This paper devoted a fair amount of space to a discussion of the strengths and weaknesses of several methods of calculating accessibility to fast-food and its subsequent influence on obesity, from the perspective of the health promotion researcher or practitioner. Several facets of the process were examined, from time and human resources to complexity of interpretation and replicability; it was concluded that a less computationally intense method for calculating accessibility would be more appropriate as it provided a sufficiently detailed output without being overly complex or time-consuming. From a conceptual and practical perspective, the coverage method was the best fit for the task.

Depending on the parameters surrounding the accessibility research question, the coverage method might not be the most appropriate choice. Obesogenic urban environments are so complex that it may require a different method, or a combination of several methods, in order for the issue at hand to be properly assessed. A distance-based method may be more ideal for quantifying how accessible various amenities are from certain areas of the city – for example, the average distance from predominantly Asian neighbourhoods to Asian supermarkets, or the minimum distance from city high schools to the nearest fast-food outlet. These issues are different because they do not focus on concentration as the parameter of interest – instead, the distance or time required to access these particular features is of greater concern. The issue of causality (does greater distance to the amenity directly result in decreased accessibility?), is still not directly eliminated. But, because of the more specific nature of the questions being asked, many of the influences related to personal circumstances are somewhat controlled or limited.

In Canada and other nations around the world, it has been strongly argued that much of the blame for the increased incidences of illnesses such as obesity, diabetes and cardiovascular diseases can be placed on social factors like income distribution and other facets of socioeconomic status (Acheson, 1998; Raphael, 2001). It is also true that both of the accessibility models compared in Paper 2 were useful for delineating areas of higher and lower fast-food concentration throughout the city. However, because of the social nature of the ultimate outcome under study (obesity), neither of these models are able to sufficiently describe any causal mechanism linking place (i.e. neighbourhoods of residence) with this condition.

For this reason, it was recommended that this type of research be complimented by another, using an alternate, supportive method. Not only would this provide a mode of triangulating findings, but it would serve to move this line of research closer to the all-important causal explanation. One such method that has potential to fill this role is the body of work on food choice. Researchers studying food choice have employed a variety of methods, from quantitative surveys to open-ended interviews and focus groups, and in so doing have created a set of knowledge that compliments the work of the current papers under discussion (Steptoe et al., 1995; Holm & Kildevang, 1996; Clifton, 2004).

One of the more applicable findings within the food choice literature is that proximity (perhaps the "lay" equivalent of geographical accessibility) is not the only factor influencing food choices; it is not necessarily even the most important factor (Steptoe et al., 1995). Other life circumstances such as income status, employment status, family status, culture/ethnicity, personal tastes/preferences and even vehicle ownership all play a major role in determining where people shop for and purchase their food (Steptoe et al., 1995; Prescott, Young, O'Neill, Yau & Stevens, 2002), including how often they may patronize fast-food restaurants. Combined with the fact that there is a high degree of interpersonal variability between individuals as to how much each of these factors influences their food choice, and the fact that these influences can change on a yearly, weekly or even daily basis, the task of determining broad trends in this area becomes extremely difficult. Regardless, exploration into these influences and how they are shaped by personal circumstances would be useful in any research where accessibility to an urban amenity (e.g. fast-food) is of interest.

The use of such methods requires a multi-pronged approach that is well-suited to multidisciplinary research teams. Managing a set of research studies into such a complex issue as obesogenic food environments is a task that requires more than one theoretical outlook, and a broad base of strengths, if it is to be completed to the fullest. This is certainly true in the case of the current studies being discussed, as they were conceptually grounded in the social determinants of health (i.e. focused on social justice and equity), but were carried out using methodology from the disciplines of geography and computing science. It would be an overstatement to suggest that any single one of these fields would be capable of conducting this type of research in as broad and inclusive a manner as is possibie by several working together.

Although interdisciplinary team research can be very positive and productive, it is certainly not the easiest of research environments in which to operate. Part-and-parcel with incorporating various conceptual backgrounds and skills into the research is their associated balancing, to ensure that all parties are being utilized and appreciated to their fullest. Conversely, interdisciplinary teams must constantly revisit the overall goals and objectives of the research being conducted, in order to ensure that all of these perspectives are balanced. As such, there will be times where it is more appropriate to focus on the concepts and methods of one field rather than another, and it is the responsibility of the individual team members to appreciate and embrace them. Despite the fact that there may be conceptual and ideological differences during these periods, a healthy interdisciplinary team should constantly focus on the strengths, the learnings and the overall goals of their work together if the common research agenda is to be moved forward in a productive fashion.

One of the major themes in this field of urban environment/obesity research is that regardless of the level of analysis, the relationship between socioeconomic status, exposure to obesogenic environments, and rates of obesity are relatively consistent. It is well established in developed countries that people of lower status have higher rates of obesity than higher-status populations (Raine, 2004), while the relationship between lower status and higher exposure to obesogenic environmental influences is gaining support. Especially compelling is that these findings are consistent across several ecological levels, from the broad (e.g. National) to the more specific (e.g. municipal; see above for examples). As further studies are conducted examining both these relationships and the levels at which they are taking place, other important facets of these interactions are sure to come to light.

What is less clear are the mechanisms operating at these ecological levels and within obesogenic urban environments that are actually influencing obesity rates. The majority of the studies mentioned above are correlational in nature, and rely more on the principles of statistical relationships than on an actual delineation of causal processes. In contrast, few studies examine these relationships more specifically, or through the use of exploratory methodologies such as observation or interviews. This is likely because a basis for closer examination is often reliant on the results provided by these types of quantitatively-based studies, for which a consistent format or method has not yet evolved. It is safe to assume that once similar results are found across a variety of processes and variables, the investigation will progress towards examining their underlying causal mechanisms and how these can be applied to policy-oriented solutions for change.

The two papers presented in this thesis provide a unique contribution to the literature on the social determinants of obesity. The first provides an empirical description of the neighbourhood-level relationship between sociodemographic indicators and the concentration of fast-food restaurants, while the second examines some of the conceptual and practical issues surrounding the application of geographical methods to health promotion practice. This research has illuminated a strong relationship between several indicators of relative deprivation and fast-food concentration, and is supportive of conclusions reached by similar work, but falls short of a causal link between those issues and obesity rates. Much of this gap can be explained by the fact that obesity may be determined largely by interactions among a variety of social factors that are untapped by statistically-oriented research, such as family status or type of employment. The field of research focused on the mechanisms underlying food choice is a good model for what is necessary if these knowledge gaps are to be filled, as they use a variety of methods to assess some of the nuances mentioned above. These issues can also be better addressed by a multidisciplinary team that has expertise in several of the necessary fields and research styles, and who will work to address these issues at as many different ecological levels as possible. While there are limitations to this work, there are also many potential directions that can be taken to make the relationship between obesity and the built environment more clear and precise.

## 4.3 Limitations

There are several limitations applicable to both papers that deserve discussion. For the first, the most important limitation is the lack of explanatory capacity attributable to the method that was used. This is true relative to both the relationship between the research question and the ultimate outcome (obesity), as well as the relationship between the placement of fast-food outlets and broader social factors. As described above, this study was a simple examination of the distribution of fast-food outlets within the City of Edmonton – it did not contain any health information (i.e. obesity statistics) that would allow for a more concrete relationship to be established between fast-food accessibility and obesity. Similarly, this study did not take into account any of the broader policies of governments, corporations, or other institutions that influence the placement of these restaurants. Therefore, it is also not possible to establish why these outlets were placed where they were, or if there is any relationship between these reasons and the sociodemographic factors that were included in the study.

It is true of this analysis that accessibility to fast-food outlets was measured from a person's neighbourhood of residence. This assumes that people are most likely to access fast-food from their homes, which may not be the case – should a fast-food restaurant be patronized by a consumer during a lunch break from work, or during a commute to/from work, it would not be reflected in this study. It can be assumed that these visits to fast-food outlets comprise a significant number of the total access values, which could be a confounder to conclusions based on fast-food accessibility from the home.

This study was also limited by the number of different types of statistics that were available at the neighbourhood level. While many of the variables that have been consistently associated with increased rates of obesity (e.g. household income levels, educational achievement) were available, many others were not. Since Statistics Canada does not aggregate to the level of municipal neighbourhoods, interesting variables such as vehicle ownership and specific ethnicity were not able to be included. This is especially disappointing in the case of vehicle ownership, as this heavily influences the distance and frequency of urban travel.

Also of note is that the distribution of fast-food outlets throughout the city is not static, both in location and in time. As the population of the city grows and expands outwards, so too does the total number of fast-food restaurants. This calls into question the long-term validity of the current results, as the magnitude of the increase of fast-food restaurants in Edmonton is unknown. A similar question mark can be attached to the external validity of the findings. There are many broad features that influence the placement of fast-food, from government regulations, population size, city planning and zoning, transport systems, and culture. Because these features can be very different depending on the areas being examined, comparisons between areas may not be possible.

### 4.4 Future Directions

It has been mentioned in several places throughout this discussion that this analysis, and the variables contained within it, are only the tip of the iceberg concerning the built environmental influences on obesity. Not only are there a huge number of potential influences, but there are also a number of different methods through which they can be uncovered and assessed. Because the study of the built environment/obesity interaction is relatively young, longer-term directions for this work are only a matter of speculation; however, some ideas for these directions and their potential impacts on health-promoting policy changes will be suggested and discussed.

Quantitative analyses of the built environment are generally focused on relating aspects of the urban social and financial environment, such as socioeconomic status, family status, culture/ethnicity, crime and traffic, to features of the physical environment or to a number of health outcomes like obesity, cardiovascular disease or even self-reported health status. Studies have taken a number of approaches in the inclusion of these variables, from using one or two to creating large, multivariate analyses. Although it is beyond the scope of this section to weigh the relative merits of these variables against each other, those pertaining to socioeconomic status have received a relatively large amount of attention as population-based descriptors. Although variables like income and employment status are indeed useful and relatively easily accessible as statistics, many other factors that also influence this environment/population interaction may be subsumed within it. For example, family status (single parents, number of children) or type of employment (part/full time, shift work, manual labour) bear heavily on the both the level of income and the time available in which it can be spent, but are rarely incorporated into such studies. Similarly, vehicle ownership and ethnicity/culture have great influence over food shopping preferences and how far one is able to travel to satisfy those preferences.

Because of the potential impact of these non-traditional socioeconomic variables, further studies incorporating them are recommended.

Despite the utility of the aforementioned variables, the actual practical impacts they have on an individual's lifestyle (either beneficial or detrimental) will remain hidden if they are explored only through the use of statistics. It is quite possible that what one person or family perceives as a restrictive level of income is in fact quite livable for another, and these differences may be in part explained by a variety of other lifestyle choices or situational circumstances (e.g. only buying food that is on sale; living across the street from a large, cheap supermarket; having no dependents). The assessment and inclusion of these mediating mechanisms and their subsequent influence on food-related behaviour is best done using qualitative methods such as interviews or focus groups, or by observing how people are interacting with the environments that are being examined. The details that emerge from this type of study will compliment the data gathered from the more quantitatively-oriented work, and will provide both the context and detail that is missing from statistically-based investigations.

The expansion of the literature to include new variables and methods is one way to hone in on those that are having the greatest impact. Another way is to focus a study on a specific physical area or on a specific population group. There may be characteristics of a particular urban physical environment (other than the obvious higher concentration of fast-food outlets) that may contribute to people who live there consuming a high amount of fast-food – for example, what is the role of transportation networks and public transit in food access? Or, what is the impact of higher levels of fast-food access to members of a certain ethnic community? The application of different research techniques to these types of scenarios would yield a rich study of these physical characteristics or peoples that could be nested within the broader context explored by existing work, and would be useful for the creation of leptogenic public policies.

Other directions that can be taken are slightly broader in scope. One of these is the longitudinal tracking of fast-food outlets over time, to see if there is any change in how they are distributed throughout the area of interest. The source of data for the reported studies in this thesis, Capital Health Department of Public Health, requires that all businesses selling food be inspected either every six months or one year, depending on the type of establishment. This means that this data set is constantly being updated, even as businesses open, close or relocate, making a longitudinal analysis possible with very little change to the overall methodology. As the data set has been logged approximately once a year since 1997, a small retrospective view is also possible. If these data were combined with neighbourhood-level socioeconomic data during the same period, it would be possible to track whether fast-food restaurants are moving in any sort of pattern relative to these demographic indicators.

Even broader would be an analysis of the social, cultural and governmental environments that are surrounding these neighbourhood-level processes. Western culture is one that contributes to a toxic health environment through its reliance on and prevalence of time-saving convenience foods, vehicle-oriented urban plans, high-stress occupations and increasingly sedentary leisure activities. While many of these influences are not directly related to the access to or consumption of fast-food, their mere presence indicates a cultural shift toward a generally unhealthy and obesity-promoting environment. Similarly, government programs and structures contribute indirectly to fast-food consumption by allowing such things as direct advertising to children, agricultural subsidization, tax breaks for large corporations, and by dissolving the social safety net of income assistance. Again, the linkages between these broad-level constructs and fast-food consumption are relatively indirect, but are no less important as causal mechanisms than the more specific details explored in this paper and in others. As such, more time needs to be spent drawing on relationships between the broad and specific ecological levels if the issue is to be fully discussed.

Finally, it is well-known that obesity is not just a consequence of an obesogenic food environment, but also of an environment that is not conducive to physical activity. Thus, a comprehensive approach to tackling the environmental effects of obesity would include aspects of physical activity as well as those of nutrition. Many of the same techniques as described above and in previous sections have been used by physical activity researchers, including both concentration and distance accessibility calculations (e.g. Sallis, Hovell, Hofstetter, Elder, Hackley, Caspersen & Powell, 1990; Estabrooks et al., 2003) and those including aspects of socioeconomic status. As the research base in the field of nutrition is expanded, so too should the complimentary aspects of the built environmental influences on physical activity.

As expected, there are a large number of directions in which research into the built environmental influences on obesity can be taken. The addition of new variables to existing analyses, the more specific examination of different areas or population groups, and the use of different methodologies to compliment the detail of quantitative analyses are only a few. The inclusion of aspects of the urban environment/obesity interaction at broader ecological levels, such as cultural and governmental, would provide some external context within which these specific analyses are entrenched. Last, obesity is not simply a problem of food access and consumption; other aspects such as physical activity should be researched in a similar fashion and combined with the work mentioned above to provide a more complete and powerful picture of what influences this complex condition. As evidence from these different streams is established, it will be more likely that practitioners and policy-makers will be able to confront and ultimately reverse this epidemic of obesity.

4.5 References

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# APPENDIX I – REVIEW OF THE LITERATURE

## I.1 Overview of the Chapter

*This chapter is intended to provide an overview of the literature concerning obesity and its relationship with the physical or built environment. While Chapter One briefly introduced the major concepts and research questions surrounding this interaction and the papers within this thesis also addressed them, this literature review will provide much more depth into this relationship and the contexts that surround them. More specifically, this chapter will discuss the obesity epidemic in Canada, existing conceptions of obesity, the social determinants of obesity and the social ecological framework, environmental influences on physical activity and healthy eating, and finally the physical or built environmental impacts on healthy and fast-food purchasing. This review will provide a full context within which the two thesis papers and their respective contributions can be placed.*

## I.2 Introduction

The prevalence of obesity in Canada has tripled since the early 1970's, and with it the risk of developing cardiovascular diseases, diabetes, physical disabilities and other health conditions (Katzmarzyk, 2002). Interventions based on lifestyle-oriented facets of obesity's development have largely been unsuccessful at slowing its increase. This has spurred researchers to examine more closely the broader social determinants that may have a hand in explaining why obesity is so difficult to treat and prevent. One determinant that has received an increased amount of attention in this regard is the physical or built environment, and specifically how the structure of this environment influences lifestyle choices such as engaging in physical activity and consuming unhealthy foods. While this field of study is relatively young, a body of evidence is beginning to mount that demonstrates linkages between physical environmental characteristics such as the placement of fast-food restaurants and sociodemographic characteristics (e.g. income levels), which may have some impact on the increased obesity rates in certain populations relative to others.

## I.3 The Obesity Epidemic

In the developed world, as well as in some developing nations, the prevalence of obesity has reached epidemic proportions (WHO, 2003). Obesity, with other related non-communicable diseases such as hypertension and cardiovascular disease, has replaced infectious diseases as the major causes of death and disability in these regions. Canada, a wealthy country with vast resources, is not exempt from this trend. The massive effect these conditions have on the health care system is beginning to show, constituting a potential crisis.

A review of health surveys completed from 1972 to 1992 revealed that the measured prevalence of overweight and obese Canadian men (Body Mass Index [BMI] $\geq 25$ kg/m$^2$) rose from 47% to 58% during that time. Overweight and obesity in women increased from 34% to 41% in the same period (Torrance, Hooper & Reeder, 2002). Another review found that the prevalence of obesity (BMI $\geq 30$ kg/m$^2$) in Canadian adults, according to a sequence of self-reported national health surveys (i.e. Health Promotion Survey, National Population Health Survey), increased from 5.6% in 1985 to 14.8% in 1998 (Katzmarzyk, 2002a). The latest data from self-report surveys, the 2000-01 and 2003 Canadian Community Health Surveys, found the national average of obesity (BMI $\geq$ 30) to be 14.9% (Statistics Canada, 2002; Statistics Canada, 2004). Self-reported survey methods tend to underestimate rates of obesity relative to measured data, as people tend to underreport their weight when asked, meaning the increase in obese individuals may be more pronounced than what is being captured by the current assessment (Katzmarzyk, 2002b). Nevertheless, these figures paint an undeniable picture that the prevalence rates for obesity have rapidly increased in Canada.

Although these numbers by themselves are a cause for concern, the health risks that are associated with obesity are another. High scores for BMI, waist-to-hip ratio (WHR) and waist circumference (WC) have all been closely linked to many non-communicable, chronic diseases. For example, obese individuals are at a higher risk for Type 2 diabetes, coronary heart disease and stroke, various forms of cancer, and respiratory conditions than individuals of normal weight (World Health Organization, 2000). While an obvious outcome of many of these conditions is premature death, obese individuals are placed at a higher risk for disabilities that can decrease their overall health and quality of life.

A serious side-effect of the increase of obesity-related conditions and diseases is the burden it places on the health care system, and other institutions of Canadian society. The annual direct and indirect costs of obesity, including such impacts as health system costs and lost work time due to illness, disability or premature death, have been estimated at approximately $4.3 billion per year in Canada (Katzmarzyk & Janssen, 2004). Thus, obesity has the potential to affect not only the individuals directly experiencing it or one of its related conditions, but also families, workplaces and others who need to access the health care system.

I.3.1 *Existing Conceptions of the Determinants of Obesity*

Several conceptions of obesity have been proposed and researched since it has emerged as a health issue of public attention. While each conception has merit and contributes to the explanation of the epidemic, continued intervention efforts within each have found little overall effectiveness in combating the problem. The following section briefly introduces the two most prominent conceptions of obesity, biology/physiology and lifestyle, and the basic focus of each. An alternative explanation is then introduced, focusing on the socio-ecological aspects of obesity that have recently risen to prominence; specifically, factors in the physical environment that may predispose certain populations to obesity relative to others. An explanation of the potential contribution of this field, in regards to the relative ineffectiveness of previously described interventions, is also offered.

I.3.1.1 Biology / Physiology / Genetics

In its simplest form, obesity occurs when more energy is taken into the body than is expended through the body's activity. This situation, termed an "energy imbalance", causes the body to store the excess energy as fat, which in turn increases the mass of the body (Lev-Ran, 2001). Although this explanation is relatively simple, it underlies all of the accelerating and mitigating factors that will be described in further sections of this paper. In other words, a factor that increases a person's chance of becoming obese can invariably be accounted for by an increase in this physiological energy imbalance.

The influence of human genetics on obesity provides a useful illustration of this point. It has been hypothesized that genetics contributes anywhere between 20 and 75% of the variability of body weight and composition within a population (Hill, Wyatt & Melanson, 2000). Genetically controlled phenotypes, such as metabolism and hormonal systems, simply increase the likelihood that a positive energy balance will occur. Thus, some people are genetically predisposed to having a higher risk of developing obesity than others, but the resulting positive energy balance is what physically results in extra weight. This risk can be exacerbated by other influencing factors as well. Thus, the genetic propensity for obesity expresses itself in an environment that promotes a positive energy balance.

A classic case of the role of genetics in obesity is that of Aboriginal peoples. Native people, especially those in Northern environments, have been hypothesized to carry what has been termed the "thrifty gene", which evolved to help protect these largely nomadic, hunter-gatherer societies against famine in sparer times. Physically, this gene is expressed as a higher percentage of body fat, resulting in higher weight gain of pregnant women and higher birth weights of Aboriginal children (Dyck, Clomp & Tan, 2001). However, since the transition to relatively a sedentary lifestyle, the decrease in the amount of energy expended coupled with the presence of this "thrifty" gene has resulted in extremely high rates of obesity among Aboriginal people.

Like the many other influences on obesity, genetics does play a role in determining who develops obesity and to what degree. The actual magnitude of this influence remains largely undetermined, as is true with the many other factors to be explored in later sections. What is clear is that each of these influences contributing to a person's risk of obesity promote a positive energy balance, which can lead to excess weight being stored by the body.

I.3.1.2 Lifestyle

Further to the biological and physiological determinants outlined above, unhealthy lifestyle choices have received the brunt of the blame for the increasing obesity epidemic. In terms of the energy imbalance described earlier, people are increasing the amount of sugar and fat that they consume, while the compensating factor of physical activity (energy expenditure) has remained the same or decreased (Bruce & Katzmarzyk, 2002). As evidence concerning the changes in lifestyle trends over the past 50 years is published, a striking and influential picture of why the population is becoming increasingly obese is being painted.

In the area of eating, trends in food/energy consumption patterns are a major indicator of the lifestyle component of obesity. Canadian data on food consumption and energy intake are relatively incomplete compared to other countries; however, they still illuminate some alarming trends. Food availability data, which provides a crude summary of consumption, show that the food energy available per Canadian increased 14% from 1991 to 2001 (Statistics Canada, 2003). A more valid indicator is actual energy consumption data, which is more readily available in the US than in Canada. There, statistics demonstrate that average energy intake for all age groups increased between surveys in 1977-78 and 1994-96, from 1791 to 1985 kcals per day, respectively (Neilsen, Siega-Riz & Popkin, 2002). At the population level, this is a significant increase.

In Canada, however, the limited data that are available suggest that the overall energy intake for nearly all age-sex groups decreased between 1972 and 1998, with a substantial decrease in the amount of consumed energy from fat (Gray-Donald, Jacobs-Starkey & Johnson-Down, 2000). This result may be partially explained by self-reporting bias, given the increased popular awareness of fat and fat intakes, but this is unlikely to be a major factor. More plausible is that food consumption patterns have shifted in other directions besides this decrease in fat intake.

This can be demonstrated by an examination of the changes in the types of foods that people are eating, and how they are eating them. The last 30 years have seen an increase of over 100% in the amount of soft drinks available per person in Canada (Statistics Canada, 2003), as well as a corresponding increase in the consumption of processed snack foods and meals eaten outside of the home (Neilsen, Seiga-Riz & Popkin, 2002). The percentage of meals and snacks eaten at fast-food establishments in the US increased 200% over an 18-year period (1977-1995), a statistic that illustrates the enormous impact this source of food has relative to obesity (National Restaurant Association, 1998; cited in French, Story and Jeffery, 2001). Data from the US suggest that although the overall fat intake of American children declined 3% from 1987 to 1995 (Johnson, 2000), their overall energy intake has increased sufficiently to provide a correlation with trends in BMI and obesity (Ludwig, Peterson & Gortmaker, 2001). These numbers indicate that although food availability and consumption patterns are changing, with superficially positive indicators (i.e. decreased energy from fat), they are not resulting in positive health benefits at the population level.

While changes in the type and amount of food people are eating contribute its share to the recent increase in obesity, the magnitude of the increase is being fuelled by more than this factor alone. Figures regarding physical activity levels, the other side of the energy balance equation, have also been included as a factor of why obesity rates have been increasing so quickly. Because physical activity performs the function of expending energy, it has been said to have a protective effect against obesity (Hill, Wyatt & Melanson, 2000); however, simply put, Canadians are not participating in enough activity to override the amount of energy that they are consuming. The latest statistics, from the 1998/99 National Population Health Survey, labeled approximately 50% of Canadians as sedentary and approximately 75% of Canadians as being insufficiently active to show a health benefit. Physical inactivity among Canadian adults has decreased since 1981, a positive trend, but is still quite high (Bruce & Katzmarzyk, 2002). The same set of surveys found that approximately 58% of children between 12 and 19 years of age were physically inactive, with a slightly higher percentage seen in girls. Other, more direct observations of school-aged children using accelerometers (which measure moderate to intense physical activity) revealed that only 12.6% of Grade 11 boys and 6.9% of Grade 11 girls were active enough to show a health benefit (Campagna, Ness, Murphy et al., 2002). This study also showed a marked decline in the amount of physical activity over the course of the school career, from Grade 3 to 11, and also casts doubt on the oft-used self report and parent-report techniques used to assess children's levels of activity because of their tendency to overestimate. Regardless of the method of assessment, it is clear that most Canadians of all ages are not active enough to compensate for their energy intakes.

These changes in physical activity levels over time, for both individuals and for populations, can be more closely examined by looking at how people are spending their time. More specifically, sedentary activities like television watching and computer use have become the most popular leisure time pursuits for children and many adults. Conversely, only 54% of Canadian children aged 5 and 14 were involved in organized sport in 1998 (Kremarik, 2000), while 76% of children engaged in sedentary activities (e.g. television, computer/video games) after school (CFLRI, 2002). Similarly, household spending on cable TV and computers increased by 253% and 500%, respectively, between 1982 and 1999; in the same period, spending on athletic equipment and recreation fees both increased by only 8% (Kremarik, 2002). All these statistics indicate a shift in the priorities of Canadians towards leisure-time activities that are sedentary in nature.

The effects these lifestyle changes have on a population level is intuitive, and has not gone unnoticed. In the past 30 years, government agencies and non-profit groups have created and implemented initiatives targeting these unhealthy lifestyle traits of Canadians, from the perspectives of both healthy eating and physical activity. Two such programs, ParticipACTION and Canada's Food Guide to Healthy Eating, are profiled here because they attained a relatively high profile and cost millions of dollars to produce. Both of these initiatives focused on specific lifestyle-oriented aspects of obesity prevention. In the case of ParticipACTION, television ads were created that attempted to convince Canadians to be more active – efforts ranged from comparing the fitness level of a 30-year-old Canadian to that of a 60-year-old Swede, to having spokespeople profile different types of physical activities and providing advice on how people could get involved (Canadian Broadcasting Company, 2004). Canada's Food Guide to Healthy Eating is more straightforward, in that it simply provides a reference that illustrates how many servings of the various food groups Canadians should be eating in order to be healthy. Given the evidence of the effect of unhealthy lifestyles presented above, these programs seem as intuitive as the issues that spurred their creation. However, the nearly threefold increase in obesity over the same time period speaks volumes about their effectiveness, a point that deserves further exploration.

I.3.2 *New Approaches to Addressing Obesity*

The behavioural and physiological aspects of obesity have been well determined and documented, which has led to various lifestyle factors (i.e. eating unhealthy foods, inactivity) bearing the brunt of the responsibility for its occurrence. With such attention focused on these factors, a) why has obesity reached the point of epidemic, and b) why does it continue to increase? A major criticism of biological and lifestyle-oriented health interventions is that they tend to ignore or downplay external influences that lie outside of the individual's control (Evans, Barer & Marmor, 1994; Berkman & Kawachi, 2000).

An issue with individual determinants of obesity is that it is assumed that these processes act in isolation. Further, these arguments are based on the premise that all individuals have freedom of choice, or control over the decisions that they make relative to their lifestyles. While this is true to a certain degree, there are many processes operating at broad (e.g. social, cultural) levels that also exert an undetermined amount of influence on an individual's risk for obesity and other co morbid illnesses (Raphael, 2001). An important consideration here, mentioned during the earlier discussion on human genetics, is that more than one influence acting together (e.g. genetic predisposition and poor lifestyle choices) results in a dramatic increase in the risk for obesity. In effect, these processes provide a context for individual choice. A "causal web" matrix has been proposed by the International Obesity Task Force, which illustrates many of these influences across various levels, from international to those having a more "micro" orientation (Kumanyika, Jeffery, Morabia, Ritenbaugh & Antipatis, 2002); it is included here as Figure 4.1. The broader influences affect everyone living within a society, making them critical yet relatively unexplored facets of obesity risk and prevention.

The causal web and its broader conceptualization have drawn more attention to the broader social determinants of health, including income, social status and the physical and social environment, as alternative factors in the increasing prevalence of obesity and how efforts toward its reduction should be undertaken. Simply put, one is far more likely to be able to change their lifestyle if their personal situation and resources available to them allow it. This relatively new thread of thinking lessens the burden of responsibility for poor health from individual choices and lifestyles, and places it in the realm of societal, cultural and ecological factors within which a person lives.

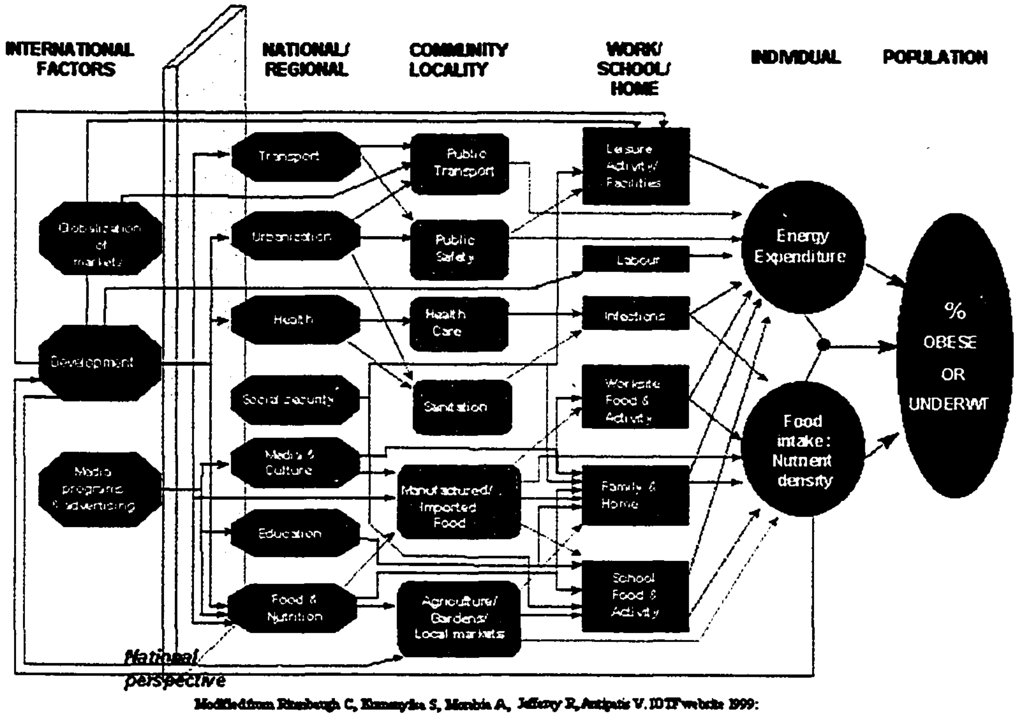


Figure 4.1. IOTF Obesity Causal Web.

I.3.2.1 Obesity in a Social Ecological Framework

Given the difficulties emerging from the literature of biological and lifestyle-oriented aspects of obesity, other avenues to its exploration were not long in coming. One of the more promising areas of this work has used the social ecological framework from health promotion (e.g. Green & Kreuter, 1999; Stokols, 1996). In these frameworks, the area of interest is generally broken into several levels ranging from specific (e.g. microsystems) to broad and general (e.g. macrosystems) (Bronfenbrenner, 1989). By breaking an issue into these levels, the processes operating at each level can be delineated and the relationships between them explored in greater detail.

An interesting application of social ecological model to the problem of obesity has been termed the ANGELO (Analysis Grid for Environments Linked to Obesity) framework (Swinburn, Egger & Raza, 1999). This framework has been proposed as a tool useful in classifying environments as either contributing to obesity or contributing to its reduction – these environments have been termed obesogenic and leptogenic, respectively. Beginning with an ecological model including influences, mediators and moderators of obesity, Swinburn et al. outline the various factors in the environment that make it more likely for people to become obese. These include physical characteristics, like the prevalence of accessible opportunities for physical activity and the number of healthy and unhealthy eating establishments, as well as the broader social mores of the community or culture being examined. These social aspects encompass population level things like income, social cohesion and governmental social systems such as welfare and minimum wages. In sum, the ANGELO framework is a useful tool for expressing some of the relatively unexplored aspects of obesity through the use of a social ecological ideology, and organizes these aspects in a manner that will aid further research.

The complexities of social ecological models often dictate that they serve as guides, rather than full explanations. In the present case, a description of the nature and impact of every environmental and social influence on the development of obesity would be extraordinarily difficult, and perhaps too complex for any applied use. Therefore, it is more useful to approach the issue by exploring more specific facets, and relating them back to the general issue in context. For this study, spatial access to opportunities for physical activity and food procurement, and how this relates to the concept of the obesogenic environment, is the specific facet in question. Although the distribution of healthy and unhealthy food sources is, in reality, an issue of the physical environment, it is also influenced by factors operating at broader ecological levels and will be discussed in that context.

I.4 Environmental Factors Influencing Obesity

The idea of environmental influences on health came into prominence in the mid-1980's with the publication of the Ottawa Charter for Health Promotion (World Health Organization, 1986). The Charter drew attention to factors beyond lifestyle choices to broader social forces active in today's society. More recently, the "population health approach" (Health Canada, 2000) assembled a list of items that determined, with varying degrees of influence, the health of the general public. Among these are income and social status, ethnicity and the physical environment. These determinants of health have been used to further insight into "non-traditional" reasons for disease prevalence.

In terms of the population health approach, both income and social status as well as the environment play a role in the obesity epidemic, although the extent to which they do so is relatively unclear compared to more behaviourally-oriented determinants. The first, income and social status, refers to a combination of indicators including income, employment status and education. When combined, an increased prevalence of obesity is correlated with lower SES in women, but is inconclusive for men (Sobal & Stunkard, 1989). More specifically, lower levels of education and occupational status were positively correlated with higher prevalence of obesity in women, while only low educational attainment was conclusively related to obesity in men (Macdonald, Reeder, Chen & Despres, 1997). This may be partially explained by more men being employed in physically demanding low-status jobs. Yet the magnitude of the overall relationship between SES and obesity remains unclear, especially in Canada, because of the lack of nationally-representative data, and requires further exploration.

Community studies of specific populations present a more explicit demonstration of obesity rates in Canadian communities. Many have been conducted within Aboriginal reserves, and the results from these settings are striking. One study, of Ojibwe adults in two separate communities, reported an obesity rate (BMI $\geq$ 30) of 29%, almost double the national average (deGonzague, Receveur, Wedll & Kuhnlein, 1999). In another setting, a multi-cultural inner-city section of Montreal, 41% of children aged 9-12 years were obese (O'Laughlin, Paradis, Meshefedjian & Gray-Donald, 2000). Although small and lacking the external validity of larger studies, these examples of the relationship between ethnicity/culture and obesity raise an alarm that has yet to be captured by nationally representative data.

I.4.1 *Environmental Influences on Physical Activity*

Several aspects of the environment influence the ability of individuals to engage in energy-expending activities. These influences range from social aspects, to sociodemographic and financial, to the physical environment. The individual power of each of these influences is unknown, since research on them is relatively new, but compelling evidence of their impact is mounting.

The social influences on physical activity are perhaps the best researched of the group, as the concept fringes on the relatively established sciences of psychology and sociology. Here, the main issues are the social pressures and constraints faced by people that may prevent them from engaging in physical activities. A major influence is social support or the lack thereof – many individuals are unwilling or nervous to engage in an activity such as walking if they have to do it alone (Ball, Bauman, Leslie & Owen, 2001). This may be exacerbated by other aspects, such as the physical environment, which will be described later. Other individuals may not be able to participate in any activities because they work or are taking care of a family, which simply reduces their time and motivation (Anderson, Butcher & Levine, 2003). Although social influences on physical activity are relatively simple, they have a profound effect on the ability for many people to engage in opportunities for physical activity.

More complex is the relationship between demographic factors and rates of physical activity. Variables such as the population density of a person's neighbourhood, their ethnicity, age and sex can influence their ability to be physically active. In the case of ethnicity, differences have been found between African-American and Caucasian children in terms of their activity and fitness levels (Lindquist, Reynolds & Goran, 1999). Older people often have health conditions that restrict their freedom of movement and motivation, or live in situations that are lacking in social support, making it difficult for them to be active (O'Brien Cousins, 1998). All of these influences relative to different demographic variables include various aspects of both social support and/or the physical environment, but are equally powerful as determinants of physical activity in their own right.

Broad-level policies from a variety of sectors can have a profound effect on the ability of a person to be physically active. For example, the availability of school physical education programs has lessened across the country, leading to children having a restricted amount of choice in their school curriculum. As would be expected, student participation in physical education programs declines sharply after Grade 8, the year when the majority of Canadian schools make these classes optional (Canadian Association for Health, 2003). Similarly, the cost of organized minor sports and sports equipment has risen dramatically in past years, leaving lower income families less able to participate (CFLRI, 2000).

Another method of examining the influence of the physical environment is through the use of qualitative "environmental auditing". Here, characteristics of the physical environment, such as cleanliness, other aesthetics, the number of sidewalks, bike paths, traffic density and others are charted using a qualitative audit instrument (Pikora, Bull, Jamrozik, Knuiman, Giles-Corti & Donovan, 2002). These tools allow for a "profile" of a particular neighbourhood to be developed, one that shows whether the area is conducive to people engaging in physical activity. The main hypothesis behind the audit tool's development was that people in under-developed, unaesthetic neighbourhoods would be less likely to participate in physical activity than individuals in well-developed areas with walking trails, adequate lighting and light levels of vehicular traffic.

Finally, research concerning the physical environmental determinants of physical activity is becoming increasingly common. Included in this are things like the physical structure of neighbourhoods, including transportation structures and the proximity of accessible opportunities, as well as aesthetic and safety issues of the areas in question (Pikora, Bull, et al., 2002; Pikora, Giles-Corti, Bull, Jamrozik & Donovan, 2002; Rutten, Abel, Kannas, von Lengerke, Luschen, Rodriguez-Diaz, Vinck & van der Zee, 2001; Macintyre & Ellaway, 1998). Newer cities, such as Edmonton, are increasingly being planned according to car travel; as a result, communities are becoming farther and farther removed from the downtown core, a phenomenon known as "urban sprawl" (Frumkin, 2002; Handy, Boarnet, Ewing & Killingsworth, 2002). One result of sprawling cities is that individuals no longer have any incentive to incorporate physical activity into their daily lives, such as commuting by walking or cycling, because their workplaces are simply too far away. As well, as traveling by car becomes more and more popular, the emergence of arterial transportation routes has made active transport difficult. For example, of Canadians living within 8 kilometres of their destination, 72% never choose cycling as a mode of transport, citing the dangers of traffic and lack of cycling lanes (Go For Green, 1998). This and other characteristics of newer cities are beginning to emerge as topics of interest for those looking at the link between physical environment and obesity.

A pioneer in this line of research was Sallis, who in 1990 published one of the first papers examining the proximity of opportunities for physical activity to people in various areas of San Diego (Sallis, Hovell, Hofstetter, Elder, Hackey, Casperson & Hackey, 1990). This study was one of the first to uncover a relationship between the distance to amenities and participation in physical activities, with longer distances to an opportunity being correlated with less frequent use. A recent study by Estabrooks et al. extended this conclusion by finding accessibility differences between neighbourhoods of varying socioeconomic levels and opportunities for physical activity (Estabrooks, Lee & Gyurcsik, 2003). Here, socioeconomically-disadvantaged neighbourhoods had fewer free-for-use amenities for physical activity within them than higher status neighbourhoods, generally meaning that individuals residing in those neighbourhoods would be required to travel further to use those amenities. Other researchers have applied increasingly sophisticated techniques to assess the spatial accessibility of other types of opportunities for physical activity, such as playgrounds (Talen & Anselin, 1998) and parks (Talen, 1997), and other urban amenities (Hewko, Smoyer-Tomic & Hodgson, 2002). This area of research provides a glimpse of how opportunities for these types of activities are distributed throughout urban areas, and if there are any disparities between these areas in terms of the other factors mentioned above.

I.4.2 *Environmental Influences on Healthy Eating*

Many of the issues raised in the previous section, from the social to the demographic aspects, are also contentious when food access is the area of focus. However, the ways in which people are affected by these influences are different. While physical activity is an important part of individuals' leading healthy lives, even completely sedentary people can live full lives. In contrast, the access and consumption of food is critical to the survival of all animals, giving it a consequence more severe than simply being physically inactive. This next section details some of the influences and trends that affect people's ability to obtain healthy and nutritious food.

One of the more puzzling health issues to emerge in recent years is that individuals living with low income and food insecurity are more prone to obesity than their higher-income counterparts (Center on Hunger and Poverty & Food Research Action Center, 2003). Intuitively, it was thought that if one was hungry and could not afford food, then one would be thinner. Recent data suggests otherwise; as mentioned above, low SES individuals are more likely to be obese than other socio-economic groups (Macdonald, Reeder, Chen & Despres, 1997).

The major reasons behind this contradictory condition are the types of foods being eaten by these individuals, and how they are being eaten. Diets that are lower in fat, and higher in amounts of fruits and vegetables, are more expensive than those that are more energy-dense (Travers, Cogdon, McDonald, Wright, Anderson & MacLean, 1997). The food purchasers of food insecure households often choose more energy-dense foods, as these are more filling and need not be purchased as often (Olson, 1999). This line of research was recently supported by Drewnowski and his colleagues, who conducted an analysis of the cost per caloric unit of a variety of foods. The results of this analysis suggested that foods high in calories (and often also high in sugar or fat content) tended to be cheaper than healthier foods such as fruits and vegetables, making them a more efficient choice for individuals and families looking to "fill up" on limited food budgets (Drewnowski & Specter, 2004).

As well, families living with moderate to severe food insecurity (i.e. sometimes or often not able to purchase appropriate and adequate food) can often experience what has been termed a "feasting/fasting" cycle of food consumption (McIntyre, Raine, Glanville & Dayle, 2001). Here, families may eat very little at lean times of the month (e.g. the week before social assistance cheques are issued), and then consume higher than normal amounts of food when it is again available to them. The foods available from food banks, which are heavily relied upon during these lean times, are not nutritionally optimal (Tarasuk & Beaton, 1999). This process of feasting and fasting, combined with more energy-dense foods, can lead to an increase in obesity over time.

Other environmental influences on healthy eating, although broader and more far-reaching, are the policies that govern institutions, cities and countries. School policy has recently been a focus of healthy eating advocates, as many school boards have signed contracts with major beverage companies (e.g. Coca-Cola, Pepsi) allowing them to exclusively sell their products in schools. Although a recent agreement with these companies has eliminated the sale of soft drinks in Canadian elementary schools, these products have been largely replaced by juices and other beverages that are also very high in sugar and calories. This practice, along with targeted advertising, is well established in a broad range of educational institutions from elementary schools to large universities. The quality of the food served in school cafeterias and in school breakfast and lunch programs in the US has also been found to be lacking in nutritional quality (French, Story, Fulkerson & Gerlach, 2003).

The concept of urban sprawl described above also has a long-term effect on the ability of some people to purchase healthy food (Frumkin, 2002). As outlying suburban communities are created, they attract relatively wealthy individuals and families away from the downtown core. Businesses then follow suit, moving their stores to where the money and purchasing power is located, while closing operations in less profitable areas. The people remaining in the inner city are then faced with either traveling to the increasingly outlying stores to purchase food, or staying in the city and shopping at smaller, more expensive stores. One Nova Scotia study found a significant difference between the prices of the same foods between inner-city stores and suburban ones (Travers, 1997). These smaller stores often have fewer options for individuals of lower income that might allow them to stretch their money further, such as a greater variety of unprocessed products or bulk food sections. Fewer healthy choices, such as fresh fruits and vegetables, are available; those that are available are often expensive and of poor quality (Rankin, 2001).

An American study analysed the numbers of supermarkets in urban centres of Mississippi, North Carolina, Maryland and Minnesota, relative to the neighbourhood's ethnic composition (percentage African-American or Caucasian) and relative wealth. It was found that there were over three times more supermarkets in wealthier neighbourhoods as compared to poorer neighbourhoods, and that areas with higher concentrations of Caucasians were four times more likely to have a supermarket near them than an area populated predominantly by African-Americans (Morland, Wing, Diez Roux & Poole, 2002). Translated into terms of the people being served, there was one supermarket for every 3,816 people in the Caucasian neighbourhoods, but only one supermarket for every 23,582 people in African-American neighbourhoods (Morland et al., 2002). While some of this difference can be explained by variations in the demographic characteristics of these neighbourhoods (e.g. higher population density and smaller land area of inner-city neighbourhoods with higher concentrations of African-American people), the difference in these statistics is striking.

Beginning in the late 1990s, a series of papers were published that introduced and explored the concept of urban "food deserts" (Beaumont, Lang, Leather & Mucklow, 1995: cited in Cummins & McIntyre, 2002; Clarke, Eyre & Guy, 2002). This term quickly began to represent the relative deprivation from healthy food choices that until that point had only been anecdotally observed in lower-income areas of the UK (Whelan, Wrigley, Warm & Cannings, 2002). By definition, food deserts are "those areas in inner cities where cheap, nutritious food is virtually unobtainable. Car-less residents, unable to reach out-of-town supermarkets, depend on the corner shop where prices are high, products are processed and fresh fruit and vegetables are poor or non-existent" (Laurence, 1998: cited in Whitehead, 1998; p. 189). Researchers have since begun to document where these food deserts exist, as well as related issues such as its effects on food availability and cost (Cummins & Macintyre, 2002) as well as the effect of a new supermarket opening on consumers' shopping behaviour and food choices (Whelan, Wrigley, Warm & Cannings, 2002).

It is true that low-income individuals are less mobile, having lower rates of car ownership, and thus are more reliant on access to food opportunities that are closer to them (Morland et al., 2002; Acheson, 1998). In areas that are relatively deprived of supermarkets, residents must be able to find other sources of food; in the case of the Morland et al. study, the authors noted that the number of fast-food restaurants and bars decreased as the wealth of the neighbourhood increased. These findings support other work from Australia that found two-and-a-half times more fast food restaurants in lower-income areas than in those of higher status (Reidpath, Burns, Garrard, Mahoney & Townsend, 2002). Similarly, a recent US study found significantly more fast-food restaurants in predominantly black neighbourhoods than in those with predominantly white residents, suggesting that the placement of these outlets may be somewhat racially motivated (Block, Scribner & DeSalvo, 2004).

Increased access to these restaurants is significant because the consumption of fast-food has been linked to several adverse health behaviours and conditions. Jeffery and French (1998) found a positive relationship between fast-food consumption, TV viewing and obesity among their women participants; a similar later study linked fast-food with poorer overall dietary quality, increases in body weight, and decreases in physical activity within its all-female sample (French, Harnack & Jeffery, 2000). The same study also found that greater fast-food intakes were more likely to occur among women of non-white ethnicity and of lower income (French et al., 2000). A more recent paper positively correlated increased weight gain and insulin resistance (potentially leading to the development of Type 2 diabetes) among their participants who consumed fast-food meals more than twice a week compared to those who did not (Pereira, Kartashov, Ebbeling, Van Horn, Slattery, Jacobs Jr & Ludwig, 2005). Finally, bringing accessibility and health issues together, Maddock (2004) found that the raw number of fast-food restaurants as well as the number of restaurants per square mile we positively correlated with state-level rates of obesity in the United States. These studies are beginning to show the relationship between fast-food consumption and ill health, and provide an impetus for more of these types of relationships to be explored.

Although the effect of the built physical environment on healthy eating is less established than its effect on physical activity, this new work is demonstrating some substantial differences in the food environments within neighbourhoods of varying characteristics. The lack of neighbourhood level fast-food access data, as well as attempts to explore how these variations actually affect residents, is a major gap in Canadian health surveillance. Considering the magnitude of the differences found in other studies around the world, and their potentially negative impact on the health of an urban population, a closer examination of the distribution of fast food outlets in Edmonton is of high interest.

I.5 Accessibility

Many of the papers from the above sections have in common the concept of accessibility, or the ease of which a person can move from a starting point (origin) to another point of interest (destination) (Hansen, 1959). There are many different ways that accessibility can be measured, depending on the situational parameters such as the population, area or amenity/destination under study (Talen & Anselin, 1998; Hewko, Smoyer-Tomic & Hodgson, 2002). Regardless of these differences, many of the studies described above have accessibility as an underlying theme (e.g. Whelan et al., 2002; Reidpath et al., 2002).

The papers presented in this thesis examine a few of the available methods for calculating accessibility to an urban amenity. The method described in the first paper is a modified *coverage* method, which uses the concentration of the amenity of interest within a predefined area (or "buffer") to determine an area's relative level of accessibility. Very simply, the more opportunities available to a resident of the area, the more accessible it is to them. Of critical importance is the definition of the buffer area, which can be limited by any sort of natural feature (e.g. rivers or other bodies of water) or artificial boundary (e.g. political boundaries such as national, regional or municipal borders). In situations involving urban environments, other factors must be considered. In particular, simpler buffer areas use a straight-line Euclidean distance that radiates out from the origin, which creates a simple circular area. A more sophisticated way to calculate this buffer area is to use the distances or travel times as they would occur on the actual street networks, which more accurately reflect real-life travel routes and barriers. Although seemingly minor considerations, these different facets of defining buffer areas and boundaries can produce drastic differences in how accessibility is viewed in this context (Talen & Anselin, 1998).

The second type of accessibility calculation method concerns *travel cost*, and can also be computed in a number of ways. The term travel cost generally refers to the time, distance or monetary cost involved in traveling from an origin to a destination. There are two major ways of calculating travel cost-based accessibility: minimum cost, which is the cost associated with traveling from the origin to the nearest available destination, and average cost, which is the mean cost associated with traveling from the origin to a selected number of available destinations. As in the previous example of coverage accessibility, distances or travel times can be based on either a straight-line Euclidean distance or derived from actual street networks, depending on the characteristics of the destination, travel mode and population of interest.

The simplest way of calculating travel cost accessibility is by using minimum Euclidian distance. Depending on the desired level of sophistication or other considerations, this calculation can be made substantially more complicated through the introduction of one or more of the above-mentioned variations. For example, accessibility to grocery stores might be most appropriately measured by averaging the street network distances to the nearest five stores – this way, important considerations such as car travel (street network distances) and personal choice (average of five closest opportunities) are included in the calculation. In contrast, Hewko et al. (2002) chose to employ minimum Euclidian distance to measure accessibility to urban playgrounds because most of the trips to these destinations would be made on foot, and would most likely use shortcuts such as walking paths along with street networks. Although some situations call for more complex accessibility calculations, the results are more reflective of real-life situations and circumstances.

The last method of calculating accessibility discussed in this thesis is called *gravity potential*. Very simply, gravity potential-based measures add an attractiveness-based weighting to another accessibility method, such as the ones described above, to make differentiations between destinations in terms of how close, useful or appropriate each might be (Song, 1996). In other words, if destination A and destination B are equal distances away, but A has some feature that makes it more attractive than B, it will be seen as being more accessible according to the gravity potential method. Although there are many different ways in which gravity potential accessibility can be calculated, the major purpose of this technique is to make accessibility more relevant to the people or places being studied.

Important to the calculation of accessibility, regardless of the method employed, are the characteristics of the origin point. Before any accessibility calculations are attempted, it must be decided whether the origin is representative of a person or of a population – in other words, whether accessibility is being calculated from a specific point or from a larger area. The origin point within an area (e.g. a municipal neighbourhood) is often placed at its geographic centre, and is called a *centroid*. Although this centroid is intended to be representative of all residents of the area, it assumes that the population is equally distributed throughout the area and may not accurately reflect where people are actually living. This can lead to the accessibility of that neighbourhood being misrepresented through the introduction of this "aggregation error" (Hewko, Smoyer-Tomic & Hodgson, 2002), especially if many calculations are being made from that point (common in accessibility methods such as average cost). A solution to this is to use finer-resolution data to move the neighbourhood centroid to a position more representative of the population distribution, and perform accessibility calculations from that point (Hewko et al., 2002). Similar to the addition of a gravity potential "quality" coefficient, giving attention to issues of centroid placement is an important step in ensuring the accessibility measurement reflects the population as accurately as possible.

I.6 Summary of Literature Review

In the past 30 years, obesity has become a major health issue in the Canadian population and around the world. Obesity is caused by a positive energy imbalance, which is when the energy that is taken into the body by eating is greater than the amount of energy expended through physical activity. Lifestyle choices and shifting food consumption patterns have been targeted as the major reasons for this epidemic; the amount of energy available per Canadian has increased significantly in recent years, and most Canadians are not physically active enough to compensate for these increases. Corresponding increases in meals eaten outside of the home and fast-food consumption, which has been linked to weight gain and diabetes, have also been noted. However, interventions focusing on changing these unhealthy lifestyles have thus far met with little success in decreasing the prevalence of obesity.

This has spurred health researchers to begin exploring the social determinants of health, or the contextual factors that surround these individually-oriented lifestyle choices. Level of income and other socioeconomic influences have long been associated with many different health outcomes, including obesity. More recently, attention has been given to the built environmental influences on obesity, including features such as urban sprawl and the physical accessibility of obesogenic (obesity-promoting) and leptogenic (protective against obesity) amenities. Research from the UK, the US and Australia have all demonstrated a relationship between area of residence and level of access to physical activity and food amenities. Specifically, several studies have documented that higher concentrations of fast-food restaurants exist in relatively deprived areas than in richer areas, leading researchers to hypothesize that this increased level of access to unhealthy fast-food may play a role in the increased rates of obesity observed in these populations.

In order to assess this relationship, many researchers have used some variation of the geographical concept of accessibility, or the ease at which a destination can be accessed from an origin point. Many different methods of calculating accessibility exist, some of which focus on the concentration of destinations within an area, and others which rely on the distances to the closest or to a group of destinations. Other more sophisticated accessibility methods integrate a coefficient of quality into the calculations, giving more weight to more "desirable" destinations than to others. Within any accessibility calculation method, there are several considerations that require attention and can vary depending on the variables or the area under investigation. These considerations include using a straight-line distances or street network grids, or where the most appropriate origin point is located if accessibility is being calculated from an area. Although these considerations seem like relatively small steps, major differences in both the results and the resources needed to obtain them can be seen depending on the choices made during the planning of such a study.

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## APPENDIX II – METHODS

### II.1 Overview of the Chapter

*This chapter will provide a complete review of the methods used for this thesis. It begins with an examination of the variables and data used for the two papers, including their characteristics and their sources. This will be followed by a complete description of the procedures used to calculate the results presented in the two papers, including how the fast-food outlets were electronically mapped and the neighbourhoods sorted, and how the data were analysed using a Discriminant Function Analysis (DFA). Limitations of these methods will also be introduced and discussed.*

### II.2 Data Selection and Sources

Two different sources of data were used for these thesis papers; one concerning fast-food outlets, and one concerning neighbourhood-level sociodemographic characteristics. This section will describe the selection criteria surrounding each of these data sets, the sources of this information, and how it was organized such that it could be included in these studies.

#### II.2.1 *Fast-food Outlets*

Fast-food restaurants are famed for offering foods very high in fat, salt and sugar, evidenced by the high-profile attention they have recently received regarding their relationship to obesity. Fast-food restaurants serve a variety of types of foods; the main commonality is that the food is served in a walk-up counter-style of service, and it is mainly intended to be eaten without cutlery. The food is also generally preprocessed, and prepared in a highly mechanized, standardized fashion. Following this definition, types of restaurants that will be included in this analysis are those that serve hamburgers, French fries, fried chicken, pizza, submarine and pita sandwiches, tacos, doughnuts, and "Asian-style" foods (i.e. Chinese, Japanese). The only distinction or exclusion within these categories is that only Asian-style restaurants that operate as kiosks within shopping centres will be included (e.g. Manchu Wok); those that operate as standalone restaurants, although they may serve their foods as "takeout", will not be included as fast food. This is because the food served at these establishments is done so mainly as a sit-down service, and often does not fall into the highly standardized methods of preparation common to major fast-food chains.

Information about all fast-food outlets within Edmonton city limits was obtained through a partnership with the Capital Health Region, Department of Environmental Health. The environmental health inspectors in this department keep a comprehensive database of all the establishments that are inspected, including necessary location information such as street addresses and postal codes. Capital Health regulations require that all restaurants, including those that sell fast-food, be inspected and certified every six to twelve months – as a result, this database is constantly being updated and is a very reliable, comprehensive source for fast-food service information in the Edmonton region.

II.2.2 *Sociodemographic Characteristics*

The demographic characteristics used in this thesis are the neighbourhood-level proportions of low-income people, unemployed people, those without high-school education, people who rent their housing and New Canadian immigrants. The first three of these variables (income, unemployment and education) comprise the main factors of socioeconomic status, and have been used in many studies as indicators of relative deprivation. The last two statistics of housing and immigration status are less commonly used, but are included here in an attempt to determine if there is any relationship between them and access to fast-foods.

The demographic information used in this analysis was obtained from Statistics Canada, which conducts a federal census every five years – these particular data were collected in 2001. The categories of data mentioned above are collected at many geographical levels, including Census Metropolitan Area (CMA, or city-wide), census tract and standard neighbourhood, with the neighbourhood level being employed in the current study. Statistics Canada does not officially aggregate data to the level of municipally-defined standard neighbourhoods, so a special run for these data were requested by a third party (Edmonton Social Planning Council) and obtained for the current research project by Dr. Karen Smoyer-Tomic, University of Alberta.

## II.3 Procedure and Analysis

The procedure and analysis for this project was conducted in three stages. First, neighbourhoods were ranked according to how many fast-food outlets were accessible to them. Sociodemographic data were then added to the neighbourhood database, such that these variables could be compared across categories of access, and it could be determined if any sociodemographic variable was predictive of living in an area with a high level of access to fast-food. Finally, a map was produced that plotted all three categories of fast-food access, so that areas of concentration could be delineated. Each one of these stages will now be described in detail.

II.3.1 *Sorting Neighbourhoods According to Access*

This section details the categorization of each neighbourhood into high, medium or low relative access to fast-food, and how it links to both the mapping and further quantitative analysis. Three steps will take place to determine the basic level of access, which is defined by the total number of opportunities in each neighbourhood (i.e. more opportunities equals higher access). This process of determining access is based on the "coverage" method employed in spatial GIS work, a full description of which has been provided by Talen and Anselin (1998).

In the coverage method, accessibility is determined by the number of potential destinations within a predefined "buffer" area. In many cases, a buffer is defined by extending a radial line outwards from the origin point, which results in a circular area. However, because this process uses linear or "as the crow flies" distance, it has been found more appropriate to calculate buffer areas using street network distances which more accurately reflect urban access conditions such as walking or driving. Alternatively, existing boundaries such as municipal divisions (e.g. neighbourhoods, community leagues) or natural obstacles (e.g. rivers, mountains) can be used for the same purpose. For the current study, municipally-defined standard neighbourhoods (which cover approximately six city blocks by six blocks) were used as the buffer area.

To provide a realistic and replicable representation of local access, the total number of fast-food opportunities for any specific neighbourhood will include the restaurants in the neighbourhoods immediately adjacent to it. For example, if Neighbourhood X is immediately surrounded by four other neighbourhoods, the total number of fast-food outlets available to a resident of Neighbourhood X is the sum of those within Neighbourhood X *plus* those within the surrounding four neighbourhoods. Once the total number of fast-food outlets for each neighbourhood was established, they were summarized in a table and sorted from highest to lowest raw access score. Although a relatively simplified method of calculating accessibility, these methods will provide both a delineation of areas of relative concentration as well as allowing for the socioeconomic variables to be compared.

The next task was to divide the neighbourhood into levels of relative access to fast-food outlets. This was done using a tertile split, which divided the neighbourhood set into three groups of relatively equal size: the "low access" group (n = 70) encompassed the range of 0 to 10 fast-food outlets, the "medium access" group (n = 67) ranged from 11 to 19 outlets, while the "high access" (n = 67) group ranged from 20 to 156 outlets. Categorical labels (i.e. low = 1; medium = 2; high = 3) were then assigned to each access level, which allowed comparisons between levels in the stages to follow.

II.3.2 *Comparing Neighbourhoods on Sociodemographic Variables*

Once the raw access level of each neighbourhood was established, the investigation turned to determining if there were any socio-economic differences between neighbourhoods with these varying levels of access. As mentioned previously, the demographic variables examined here will include the three components of socio-economic status (average household income, employment status and level of education), as well as two others (housing renters and recent Canadian immigrants). A Discriminant Function Analysis (DFA) was conducted to determine if there were any differences in these sociodemographic variables across the three levels of access, as well as to determine if any of the sociodemographic variables were predictive of having a high level of access to fast-food.

The obtained sociodemographic data, in the form of neighbourhood proportions, was added to the database containing raw neighbourhood access scores and levels. Discriminant Function Analysis was then used to analyze any trends in the sociodemographic dependent variables across the three levels of the independent access variable, and to determine which of the dependent variables are best predictive of living in an area of high fast-food access. Although there are other potential ways of analyzing these data (e.g. logistic regression), DFA was chosen mainly because of the fact that it is a measure of how well a set of predictor variables *predict* membership in a specified group. For this study, this power of classification or predictive ability was more relevant to the research question than that of logistic regression, which focuses more on the attribution of variance in the dependent variables explained by the independent variables. Further, if logistic regression was chosen to analyze these data, the three levels of the independent variable (high, medium and low) would require the use of a multinomial model that is substantially more complicated. Using a more standard binomial logistic regression, which is conceptually simpler, would necessitate that one of the independent categories be dropped, which would impact the richness of the analysis. Therefore, because of the exploratory manner in which the current research question is framed, and its' relative conceptual simplicity of the classification process, DFA was deemed a more appropriate choice.

DFA first runs a Multivariate Analysis of Variance (MANOVA) to determine if there were significant differences in the sociodemographic variables, and a series of functions that determine the predictive power of the dependent variables across each fast-food access level. Outputs from the MANOVA include a table of descriptive statistics, as well as Wilks' Lambda and F-values as a test for significance. Should the MANOVA result in significant differences between levels of the independent variables, DFA goes on to produce a series of functions that explain the largest proportion of the variance attributed to each predictor variable – the statistics produced here are the percentage of the variance accounted for by each discriminant function, and Eigenvalues, which are a measure of the importance each predictive variable has on the process of classification, and are tested for significance through the use of the Chi-square Goodness-of-Fit test. The next output is the Structure Matrix, which provides Pearsonian Structure Correlations between each predictor variable and each discriminant function. Finally, the discriminant functions are used in an attempt to classify each case into one of the grouping variable categories, in this case the fast-food access level. Raw scores and proportions of correctly-placed cases are given, with chance in the current analysis being equivalent to n(largest group)/# of groups, or 70/3 = 23.3% - the classification process is considered to be successful if the "hit ratio" (the proportion of correctly classified cases) is higher than what would be expected by chance.

### II.3.3 *Mapping Citywide Access to Fast Food*

The final stage of the research was to map opportunities for fast food access across the City of Edmonton. The purpose of this map is to display areas in the city that have a higher level of relative access to fast-food outlets, and to determine where areas of high and low fast-food concentration are located. The use of this mapping technology allows for these areas to be visualized and patterns in access levels across the city to be delineated.

The mapping for this project was done using ArcGIS 8.3 (ESRI, 2004), a GIS software package. A base map of the City of Edmonton, with boundaries of the municipally-defined standard neighbourhoods, was obtained from the Spatial Data Library at the University of Alberta. Using ArcGIS, data concerning the relative level of fast-food restaurant access was joined to the map information, and added as a display variable. The display colours were then changed to reflect the gradient of fast-food access levels, starting from light grey for the lowest level of access to black for the highest access category. Neighbourhoods with no fast-food access data, such as those zoned as industrial or commercial, were left white. Once the data were all included and clearly differentiated on the map, other map items such as scale bar, legend and north arrow were added.

## II.4 Methodological Limitations

As this project has been constructed in a relatively simplified manner, it has limitations that deserve exploration. The most prominent data that are not included in this study are direct measures of obesity in Edmonton, at either the neighbourhood or individual level. The major issue is that of availability: while some obesity-related data exists at the individual level, through other research programs and projects, community-level obesity information remains unavailable. Although the inclusion of this individual level data would add to the strength of this study, it would also add a high degree of complexity. Multi-level ecological studies require a large amount of attention to be paid to the congruence and relativity of the different measures of data between levels. This is to ensure the work does not fall victim to the "ecological fallacy" (Macintyre & Ellaway, 2000), where similar data measured on two or more different levels (e.g. individual and population) can lead to different results. Given that these issues would expand this study beyond its scope and feasibility, it was decided that direct measures of obesity would be omitted until they can be reasonably and prudently included.

Until such time, however, no substantive conclusions will be offered about the relationship between the environment, as explored in this work, and the rates of obesity within those environments. This project is an initial glance into how the physical environment in Edmonton is structured, and about the relationship between this physical environment and sociodemographic characteristics. In this study, indicators were chosen on the basis of their connection to the relative risk of obesity development, rather than an actual measure of obesity. There is an established body of literature linking various aspects of socio-economic status with risk for obesity (e.g. families with low household incomes are at higher risk; see Introduction for further examples). It is reasonable to hypothesize that an individual who lives in a low-income neighbourhood, and who is faced with one or more obesogenic environmental influences (e.g. as high access to fast food outlets), is more likely to be obese than an individual facing fewer of these risk factors. Therefore, this study will produce the beginnings of a model of the physical environmental influences on obesity, but will not answer the question of whether individuals living in these types of environments are actually more or less obese.

The strength of the relationship between urban physical environment and health conditions like obesity has varied between studies and study locales (e.g. Troped, Saunders, Pate, Reininger, Ureda & Thompson, 2001; Giles-Corti & Donovan, 2002; Lee & Cubbin, 2002). Because of the multi-faceted complexity of both variables, external validity of such work is limited. As well, as this study will conclude with a proxy measure of obesogenic environmental influences, and not distinct obesity statistics (e.g. population measures of BMI, WHR), it is only possible to infer the relative strength of the chosen variables. However, the results of this study will provide a glimpse into the nature of the environment-obesity relationship within urban Edmonton, and will provide the basis for the further, more specific exploration (e.g. multi-level analyses, specific populations or areas) that could follow.

In terms of the analysis, it was briefly mentioned that there are a number of different ways that the relationships between all the variables could have been investigated. The main contenders for this task were Discriminant Function Analysis (DFA) and Logistic Regression (LR), which essentially serve a similar purpose. Each of these tests have strengths and weaknesses; logistic regression is newer, more common and more resistant to violations of assumptions than is DFA, while DFA is slightly easier to interpret, is more focused on prediction than LR, and does not require the data to be truncated.

In this study, there were questions surrounding a violation of an assumption of DFA, heterogeneity of covariance of the predictor variables, which would not have been an issue if LR was the chosen statistical procedure. It was possible that this violation could have reduced the power of the test, which is a potential limitation. However, Tabachnick and Fidell (1996) mention that DFA is robust to this violation if sample sizes are equal or large, which is the case here. Because of this, the other advantages of DFA became more apparent and made it a more appropriate choice for this work. Specifically, a binomial LR would allow for only two fast-food access categories to be included, which would subtract from the richness of the analysis. A multinomial (more than two group) LR is possible, but is substantially more complicated as a procedure than is DFA, which allows more than two independent variables with relative ease. Also important for this particular study is the fact that DFA is more focused on the predictive abilities of the dependent variables, or how well they predict membership in each of the fast-food access categories, while LR focuses more on the attribution of variance among each of the predictor variables relative to the grouping variables. This is a small difference, but important as it relates better to the exploratory nature of the research question under study. Therefore, for these reasons, DFA was chosen as the most appropriate statistical procedure for this work.

## II.5 Summary of Method

The process of this study took place in two major stages, one involving the compilation and analysis of demographic characteristics for these mapped neighbourhoods, and one involving the mapping of access to fast food opportunities using GIS technology. The purpose of these stages was to first describe and categorize Edmonton neighbourhoods according to their relative access to fast-food, and then to investigate whether any sociodemographic characteristics were predictive of specific access levels. The map was produced as a visual accompaniment to these analyses.

Neighbourhoods were listed and ranked according to how many fast-food outlets were located within the actual neighbourhood, as well as the neighbourhoods that immediately surrounded it. Location information for each of the fast-food outlets was obtained from the Capital Health Region, Public Health Division. This database was then divided into three sections based on a tertile split, which created high, medium and low access categories. Sociodemographic data, including the three components of socio-economic status as well as recent Canadian immigrants and housing renters, were added to the database. Discriminant Function Analysis was then used to investigate whether there were any differences in these sociodemographic characteristics between the three fast-food access categories, and then to find out if any of the sociodemographics were predictive of living in a high fast-food access area. Finally, a map was produced using a GIS software package that provided a visual accompaniment to the above analyses, and provided a clear picture of where fast-food concentration areas were located throughout the city.

The major limitation of this study is that it does not concretely examine the question of whether specific obesogenic environments, in this case increased access to fast-food restaurants, actually cause higher rates of obesity. As a small study, it simply provides a beginning look into how the physical environment is structured as it pertains to fast-food access in an urban setting – causal inferences were not possible without actual individual- or community-level obesity data, which was unavailable. Other potential limitations arose during the selection of the procedure for statistical analysis, but these limitations were seen as being outweighed by the positive aspects of DFA relative to other possible alternatives.

II.6 References

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**APPENDIX III – ETHICS**

*This Appendix includes a letter from the Health Research Ethics Board Panel B, University of Alberta, stating that ethical review was not necessary for this project.*