OVERWEIGHT AND OBESITY IN ONTARIO

UNDERSTANDING THE INDIVIDUAL- AND CONTEXTUAL-LEVEL RISK FACTORS FOR OVERWEIGHT AND OBESITY IN ONTARIO: A MULTILEVEL ANALYSIS

By

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ABSTRACT

Over the last several decades, overweight and obesity have reached epidemic proportions in many developing countries, including Canada. These conditions have been identified as major risk factors for chronic disease and disability in many different contexts. Further, overweight and obesity have become a public health problem in and of themselves. The various symptoms and co-morbidities associated with these chronic conditions place a great deal of stress on the Canadian health care system, generating great economic concern.

This research takes a population health approach to the study of obesity, examining the complex relationships between individual behaviours and characteristics, human biology, and aspects of the local social and physical environment. To achieve these ends, a subset of the national Canadian Heart Health Surveys (CHHS, 1986-1992) specific to the province of Ontario was linked to neighbourhood-level data from the 1991 Canadian Census. Following this linkage multilevel analyses were applied to these hierarchical data. Preliminary findings indicate substantial area-level variation in body mass index (BMI) and waist circumference (WC), and an important role for neighbourhood level variables even after adjustment for individual demographic, socioeconomic, and behavioural characteristics.

For example, living in areas with lower average dwelling values was associated with a higher BMI (2.728 kg/m^2) for women in comparison to areas with a high average dwelling value. These findings provide evidence that the underlying mechanism driving the increasing prevalence of overweight and obesity may be an environment that promotes high risk behaviours and lifestyles. The findings from this study provide support to the notion that at-risk individuals and at-risk neighbourhoods (low socioeconomic status) should both be targeted when designing and implementing health promotion policy.

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CHAPTER ONE INTRODUCTION

On a global scale, obesity has reached epidemic proportions, and is a major contributing factor to dramatic increases in the rising rates of various chronic disease and disabilities. Recent approximations estimate that worldwide, 1 billion adults are overweight and at least 300 million can be classified as obese (World Health Organization [WHO], 2006a). Although obesity is found in many developing countries, the condition is especially prevalent in economically developed countries; where typically between 10% and 20% of people are obese (Katzmarzyk, 2002). In the Canadian context, recent data from Statistics Canada confirms that over the past twenty-five years, adult obesity rates have doubled, while childhood obesity rates have nearly tripled (Health Canada, 2005). More specifically, the 2004 Canadian Community Health Survey (CCHS) found that 36% of Canadians aged 18 years or older could be classified as overweight, and almost 23% of the adult population could be classified as obese based on self-reported measures (Canadian Institute for Health Information [CIHI], 2004). It should be noted that these estimates are most likely conservative, as self-reported weight is typically underestimated, and self-reported height is typically overestimated (Bélanger-Ducharme & Tremblay, 2005). Nevertheless, by combining several sources of self-reported BMI measures, the increasing prevalence of overweight and obesity across Canada becomes quite clear (Appendix A).

In the last several decades, obesity has emerged as an important public health priority in Canada prompting attention from clinicians and policy makers alike (Heart and Stroke Foundation, 2006). A chronic condition such as obesity places a great deal of stress on the Canadian health care system, with substantial economic consequences. According to the most recently available data, the health care costs attributable to these conditions account for 2.5% of total health care expenditure in Canada (Katzmarzyk & Janssen, 2004).

Two complementary forces are thought to be the underlying mechanisms driving the increasing rates of overweight and obesity. Energy balance is ultimately determined by the difference between caloric consumption (energy intake) and physical activity (energy expenditure). Thus, individual behaviours and lifestyle choices play a major role in the onset of obesity. With rising incomes in developed countries, diets high in fats, saturated fats, and sugars have become increasingly popular. Simultaneously, there has been a shift towards less physical activity with increases in transportation, technology in the home, more passive leisure time activities, and less physically demanding work.

Perhaps the most important contributory factors to this energy imbalance at the population level result from substantial changes in society linked to economic growth, modernization, urbanization, and globalization of food markets which alter behavioural patterns of communities (WHO, 2003). These societal changes promote environments which foster the widening gap in energy intake and expenditure at the individual level. These environments have been defined as *obesogenic environments*, and are characterized by aspects of the environment that limit opportunities for physical activity, and access to healthy foods (Hill & Peters, 1998). This shift towards unhealthy environments is thought to be the main driving force underlying the current obesity epidemic (WHO, 2003; Katzmarzyk, 2002; Hill & Peters, 1998).

Much of the available epidemiological research related to obesity has been conducted in select parts of Western Europe and the United States. Comparatively, there has been a disparity in research conducted in a Canadian setting. Additionally, very little is known about how an individual's physical and social environments mediate the relationships between known risk factors at the individual-level, and obesity (WHO, 2006a; Katzmarzyk, 2004). The Canadian Heart Health Surveys Follow-up Study (CHHSFS), proposed in 2004, is a response to this gap in the epidemiological environment and health literature. The objectives of this thesis, will contribute to the completion of one of the specific aims of the broader CHHSFS.

1.1 Research Context

The CHHSFS builds upon the existing Canadian Heart Health Surveys (CHHS), a national database of provincial cross-sectional surveys conducted between 1986 and 1992 (Canadian Heart Health Surveys Research Group [CHHSRG], 1997). These data were collected from 10 Canadian provinces as the second phase of the Canadian Heart Health Initiative (CHHI), with funding provided by the provincial departments of health, and Health Canada (CHHSRG, 1997). The CHHS include detailed individual-level demographic variables, and cardiovascular disease risk profiles collected from a representative sample of the population of non-institutionalized adults between the ages of 18 and 74 (Macdonald, Reeder, Chen et al., 1997). These surveys are the most recent of their kind to have included anthropometric (human body) measurements as measured and recorded by a clinician (Reeder, Angel, Ledoux et al., 1992). The ultimate purpose of the CHHSFS is "to develop a national research program to study the impact of individual- and community-level factors on the relationships between obesity, other chronic disease risk factors, and mortality" (Katzmarzyk, 2004, p. 12a). The three specific aims of the research programme are:

1) To investigate the influence of social and environmental determinants of health on the relationship between obesity and other concurrent chronic disease risk factors;

2) To examine the influence of obesity and other chronic disease risk factors on mortality; and

3) To identify the heterogeneities associated with social and environmental determinants of health in the relationships between obesity, chronic disease risk factors and mortality (Katzmarzyk, 2004).

The objectives of this thesis fall within the scope of the first specific aim of the CHHSFS.

1.2 Research Objectives

This thesis focuses on a subset of the CHHS data specific to the province of Ontario, collected in 1992. Broadly, the goal of this research is to gain a better understanding of the role of place in the development of overweight and obesity in Ontario. To achieve this end, three specific objectives will be addressed:

1) To investigate the relationships between specific individual-level determinants of health and obesity status;

2) To explore the range of contextual-level variables mediating these relationships; and

3) To determine the relative contributions of individual- and contextual-level factors to the development of obesity

These objectives will be accomplished by linking the individual-level CHHS data for Ontario to a contextual-level data set compiled from the 1991 Canadian census which includes indicators of the local social and physical environment. Organizing the data in this manner will result in a hierarchical data set of individual-level information, clustered within geographical units. Linking the existing cross-sectional data to community-level data will set the stage for a comprehensive empirical investigation of the relationship between obesity, individual risk factors, and the social and physical environments. Quantitative methodologies including multivariate multilevel analyses will be applied to the combined data set to achieve the objectives outlined above.

1.3 Contributions

This research will make theoretical, methodological, and substantive contributions to the health geography literature. Theoretically, this investigation of overweight and obesity is informed by the population health approach. This conceptual framework embraces a broad definition of the possible determinants of health including individual behaviours and characteristics, human biology, and aspects of the social and physical environment (PHAC, 2006; Evans & Stoddart, 1994). By adopting this approach, this research will contribute to the existing body of empirical investigations within the literature that have applied a population health perspective to health geography questions. Further, this thesis may advance the development of the population health framework by strengthening the existing knowledge of the broadly defined determinants of health. Secondly, by placing a distinct emphasis on the role of place in shaping overweight and obesity, this research will contribute to the growing focus on place effects in the health geography literature.

Methodologically, this research falls into a group of studies in the field of health geography concerned with exploring the extent of association between social and environmental aspects, and individual health outcomes (Kearns & Moon, 2002). This thesis will employ multilevel statistical techniques to investigate the relative and absolute effects of context on the development of overweight and obesity. Although these techniques have been popular for several decades in sociology, only in the last ten years has this approach been applied to phenomena in health geography (Pampalon, Duncan, Subramanian et al., 1999). Further, the majority of multilevel health studies have been conducted in the United Kingdom and the United States (Kearns & Moon, 2002). This research will extend the relatively small class of Canadian multilevel studies of health.

Substantively, this research will contribute to the environment and health literature and epidemiological knowledge of obesity and cardiovascular disease risk factors in three ways. Firstly, the relationship between obesity and various demographic and socioeconomic factors has been well documented in many contexts; however, most of these studies have been conducted in the United States, Europe, and Asia (Katzmarzyk, Janssen & Ardern, 2003). Canada differs from other countries in a number of ways including population demographics, distribution of social and economic resources, and availability and quality of health care (Katzmarzyk, 2004; Ross, Wolfson, Dunn et al., 2000). Thus, a Canadian investigation of overweight and obesity is necessary, and could identify certain determinants specific to the Canadian population. Secondly, the majority of studies of overweight and obesity have focused on identifying the relationships between individual-level characteristics and behaviours and weight status. To date, there has been little emphasis on exploring the underlying heterogeneities in the observed relationships (Katzmarzyk, 2004). By investigating a range of contextual variables that may mediate relationships at the individual level, the goal of the second objective of this thesis is to provide a more robust understanding of these heterogeneities. Finally, there is currently a poor understanding of the role of the social and physical environment in the development of obesity, despite a growing consensus that these dimensions may be the primary influences on the observed drastic increases in global prevalence (WHO, 2006a; Hill & Peters, 1998). By examining both individual- and contextual-level effects, this thesis aims to close this gap in knowledge by providing a better understanding of the role of the local social and physical environment in the development of overweight and obesity.

1.4 Chapter Outline

This thesis has been organized into six chapters. The following chapter reviews the relevant theoretical, methodological and substantive literature informing this research. Chapter three presents a detailed discussion of the development of the research design, as well as the quantitative methodologies employed throughout. Chapter four includes the results from the multivariate regression, and Chapter five presents the results of the main multilevel analyses. Finally, Chapter six will discuss the important theoretical, methodological and substantive contributions stemming from these results. The thesis will conclude with recommendations for future research.

CHAPTER TWO LITERATURE REVIEW

This chapter reviews the pertinent literature related to the theoretical, methodological and substantive underpinnings of this research. First, the development of the population health framework, and the broadly-defined determinants of health is reviewed to illustrate its place in health research (PHAC, 2006; Health Canada, 2001; Evans & Stoddart, 1994). This discussion is accompanied by a brief review of the evolution of medical to health geography in order to firmly position this research within the field of health geography. Secondly, review of neighbourhood and health literatures highlight the importance of *place* to heterogeneities in health and health behaviours, and a review of multilevel analytical studies provides a methodological grounding for contextualized health research. This methodological discussion is followed by a review of the empirical research concerning overweight and obesity, and identifies the established individual- and contextual-level risk factors associated with these conditions.

2.1 Theoretical Context

2.1.1 The Shift in the Definition of Health and the Population Health Approach

2.1.1.1 The definition of health

Traditional health research, in the early part of the twentieth century, was conducted under the theoretical framework of *biomedical individualism* (Krieger, 1994). Three main ideas are central to this framework: (1) health is regarded as the biological absence of disease or illness, focusing on a lesion appearing in an otherwise healthy body (Kearns, 1993); (2) a population's risk for disease is viewed as the sum of the individuals' risks "as mediated by their 'lifestyles' and genetic predisposition to disease" (Krieger, 1994, p. 890); and (3) disease intervention can be controlled at the individual (or patient) level, via the health care system (Evans & Stoddart, 1994). Through the 1940s and 1950s, however, the definition of health and the nature of health research in general began to shift.

In 1948, the World Health Organization [WHO] proposed a new official definition of health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2006b). Opposition to this definition surfaced for numerous reasons. For example, critiques suggested that the term *complete* is immeasurable or that health is not a state, but a means to an end (Curtis & Taket, 1996). As Gatrell (2002) indicates, the 1948 definition of health describes a utopian state, and that by this definition "most if not all of us are unhealthy at all times!" (p. 4). In response to these and other criticisms, the WHO has since proposed a new definition; one where health is regarded as "the extent to which an individual or group is able to realize aspirations and satisfy needs, and to change or cope with the environment. Health is therefore seen as a resource for everyday life, not the objective of living; it is a positive concept encompassing social and personal resources as well as physical capacities" (WHO, 1984). This definition indicates that health is a resource not only linked to the biomedical notion of health, but also the ability to adapt to and cope with factors associated with one's environment. This definition provides a solid foundation upon which the population health framework has been built.

2.1.1.2 The population health framework

The development of a novel framework for addressing population health was in large part inspired by the new definition of health as well as the epidemiological transition experienced in developed nations (Krieger, 1994). While the *specific etiology*[1] concept of the biomedical model proved effective for describing communicable diseases and developing appropriate intervention techniques (e.g. sterilization, vaccination), the limitations of the model were exposed as chronic diseases such as cardiovascular disease and cancer began to play an increasing role in population health (Curtis & Taket, 1996). Chronic and degenerative diseases are comparatively more complex, with multiple causes based equally in biology as well as in culture and society (Meade & Earickson, 2000). As the leading causes of mortality and morbidity in developed countries shifted from infectious to chronic diseases, it became apparent that a new conceptual model for addressing the health of the population was necessary (PHAC, 2002).

A 1974 document titled *A new perspective on the health of Canadians: a working document*, that has come to be known as *The Lalonde Report*, began the development of a new conceptual framework for population health built upon the WHO's broadened definition (Health Canada, 1981). Through review of the relevant literature, Lalonde (1981) constructed a framework of the determinants that had been linked to health through empirical investigation. Lalonde's *Health Field Concept* grouped the determinants of health into four broadly defined categories: lifestyle, environment, human biology, and health care organization. This model expanded upon the biomedical idea of health, and Lalonde argued that factors extraneous of the accessibility and provision of health care services could impact human health (Health Canada, 1998).

The health field concept embraced the idea that a particular disease may be multi-causal, and argued that any health problem could be examined under the four categories of the health field concept "in order to assess their relative significance and interaction" (Health Canada, 1981, p. 33). The central thesis of the *Lalonde Report* was that "future improvements in the level of health of

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[1] *Specific etiology* refers to the one cause (or germ) that is both necessary and sufficient for each disease. (Meade & Earickson, 2000).

Canadians lie mainly in improving the environment, moderating self-imposed risks and adding to our knowledge of human biology" (Health Canada, 1981, p. 18). The assumptions associated with the health field concept began a revolution with respect to the determinants of health. However, these assumptions were not without criticism. It was quickly recognized that the health field concept's excessive focus on lifestyle could lead to a *victim-blaming* mentality that could produce ineffective or harmful interventions (Pearce & Davey Smith, 2003). For example, a victim-blaming approach to obesity could lead to stigmatization, which risks offsetting gains in physical health with poor mental and social health (Catford, 2003). Further, this approach ignores any potential role played by the social and physical environment in the development of health (Glouberman & Millar, 2003). Building upon the work of Lalonde in 1974, two documents in 1986; *Ottawa Charter for Health Promotion* (WHO, 1986) and *Achieving Health for All: A Framework for Health Promotion* (Epp, 1986); further expanded the determinants of health. This expansion placed a greater focus on the broader social, economic and environmental factors that influence health (PHAC, 2002).

Although Canada has been viewed as a leader in the development of the population health approach, quite similar streams of thinking emerged elsewhere. In the United Kingdom, Rose (1985) similarly acknowledged that an individual-centred approach (or a biomedical approach) to improving population health is indeed limited – both for the individual and for the population. Individual based intervention alone "does not seek to alter the underlying causes of disease but … identif(ies) individuals who are particularly susceptible to those causes" (Rose, 1985, p. 36). A biomedical approach may effectively truncate a disease distribution by addressing high-risk individuals; however, the primary goal of the population health concept is shifting the distribution towards zero. Rose argues that the causes of incidence rates may differ from the causes of individual cases within a particular population (Marmot, 2001).

In 1997 the Canadian Federal, Provincial and Territorial Advisory Committee on Population Health issued a report defining population health as:

> "the health of a population as measured by health status indicators and as influenced by social, economic, and physical environments, personal health practices, individual health capacity and coping skills, human biology, early childhood development and health services." (FPT Advisory Committee on Population Health [ACPH], 1997).

The overall goal of the population health approach to "maintain and improve the health of the entire population, and reduce the inequalities in health between population[2] groups" (Tonmyr, MacMillan, Jamieson et al., 2002, p. 123). According to Rose (1985) by studying the characteristics of populations as well as individuals, a population strategy aims to achieve this by defining and removing the underlying causes that make a disease common.

Using the central goal of improved population health, members of the Canadian Institute for Advanced Research developed a framework of the determinants of health as inspired by the Lalonde Report and as refined by other major public health documents published since the 1970s[3]. Evans and Stoddart's (1994) conceptual model of the population health approach appeared as part of the landmark publication *Why are some people healthy and others not?* This model (Figure 2-1) conceptualises the complex interactions between the determinants of health: the social and economic environment, the physical environment, personal health practices, individual capacity and coping skills, and health services. More specifically, the key factors that influence health and well-being include: income and social status, social support networks, education, employment and working conditions, physical environments, geography, biology and genetic endowment, personal health practices, personal coping skills, healthy child development, health services, gender and culture (PHAC, 2006). The population health perspective acknowledges the complexity and interrelatedness of the determinants of health, and uses these factors to examine why some populations are healthier than others (Health Canada, 1998).

Of particular importance in this model is the concept of the individual response in terms of behaviour and biology. In contrast to Lalonde's health field concept, the population health framework is extended to make a clear distinction between the social and physical environment and individual response. This distinction recognizes that characteristics of the social or physical environment (in interaction with genetic endowment) can influence an individual's response, both behaviourally and biologically (PHAC, 2006). For example, it has been observed that tobacco use (a behavioural response) can be socially conditioned through, for example, heavy tobacco advertising (Evans & Stoddart, 1994). More recently, on a global scale, the WHO has organized the commission on social determinants of health to provide evidence that policies which improve social conditions can improve health at the individual-level, and reduce health inequities between and within countries (WHO, 2007).

The second key addition to this model is the notion that individual response and behaviour, as well as the definition of disease in the traditional sense, are both recognized as influences on health and function. In addition to the clinically defined concept of disease, *Health & Function* in the model developed by Evans and Stoddart encompasses the notion of illness, regarded as a subjective state of health as defined by the individual. As depicted in the model (Fig. 2-1),

[2] This can be defined geographically or politically, as in a country, although physical boundaries are not always necessary, as when referring to groups of people sharing common characteristics (e.g. ethnicity, religion) who are scattered throughout a particular geographical or political unit
[3] For example, Epp (1986) *Achieving health for all: a framework for healthy promotion*

both disease and illness are viewed as having "a very important (negative) influence on well-being" (Evans & Stoddart, 1994, p. 46).

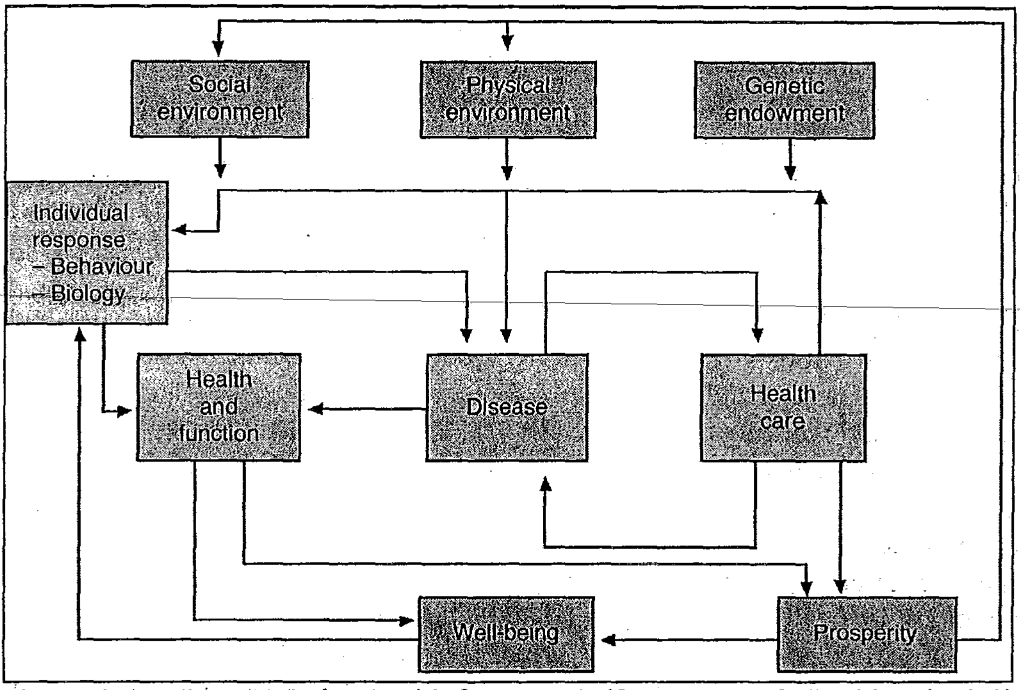

Figure 2-1: The population health framework (from Evans & Stoddart (1994))

Finally, the relationship between health care and the health of a population is substantially more complex than the curative patient-treatment relationship (a subset of Fig. 2-1 consisting of two components: disease and health care). The relationship as depicted in the model addresses the complications with over-provision of health services. This problem was first noted by Lalonde, in that "the consequence of the traditional view is that most direct expenditures of health are physician-centred," (p. 12) and too large a proportion of these expenditures are spent on a curative health care system. Alternatively, a population health approach focuses on *all* components that enhance the health (e.g. social support, environmental clean-up) and well-being of the overall population to help ensure appropriate resource allocation (PHAC, 2006; ACPH, 1994).

Identifying and assessing the relative importance of the many factors that influence health is one of a number of benefits of adopting a population health framework. Firstly, there is an understanding that a given population is not merely the sum of its constituents. This implies that health interventions at the individual level may not always be the most effective approach to improving health status. In fact, health interventions may occur at several different levels,[4]

[4] In this context, levels may be viewed as any scale at which health interventions may occur. For example, individual-level (patient-level), community-level, or nation-wide interventions

and these strategies may not necessarily be directly linked to the health care system (Centre for Urban Population Health [CUPH], 2005). Secondly, as implied by the previous point, the population health approach has an increased focus on preventive measures, as compared to the reactive, curative nature of the health care system (Health Canada, 1998). By examining between- and within-population differences in health status, this approach to health aims to shift a disease distribution curve toward zero (Rose, 1985).

Another strength of the population health perspective lies in the multidisciplinary nature of the approach; which encompasses the fields of geography, sociology, demography and education among others. It is necessary for a number of disciplines to work under this framework, since many of the proposed intervention methods and determinants of health fall outside the scope of the health care sector (ACPH, 1994). A multidisciplinary approach also contributes to health policy development by providing depth of information, as decision makers can be informed by knowledge stretching across multiple fields (Health Canada, 1998).

Finally, the economic benefits of developing a healthy population should be considered. It is obvious that a healthier population would require less support in the form of health care and/or social benefits. For example, Katzmarzyk and colleagues (2000) argue that a 10% reduction in the population rates of physical inactivity could potentially reduce health care expenditures by $150 million per year in Canada. Another economic benefit emerges as a more direct result of improving the health of an entire population. A healthy population is viewed as more productive, contributing more to national growth and development, and is better able to sustain itself for the long-term (Health Canada, 2001).

Despite these significant benefits the population health approach has received some resistance. One of the more prominent criticisms has been identified as the *prevention paradox* (as in Hunt & Emslie, 2001; Rose, 1985). Although this framework has the potential to positively influence the health of populations, often each participating individual will not experience any short-term benefits (Hunt & Emslie, 2001). An example from Rose (1981) highlights the issue further:

> "if all men up to age 55 reduced their cholesterol level by 10%, one in 50 could expect to avoid a heart attack on average yet 49 out of 50 would eat differently every day for 40 years and perhaps get nothing from it" (p. 1850)

Such a problem results in poor motivation (and justifiably so) from participating individuals. Indeed, this lack of motivation is echoed in the medical community as a result of lower success rates in comparison to those that may be witnessed through clinical trials (Rose, 1985). However, the prevention paradox issue has been acknowledged and throughout the development of the framework:

> "A long term commitment will be needed. Although population health strategies offer some short term benefits, their real payoffs will come primarily in the middle to long term" (ACPH, 1994).

The population health approach has also been criticized for ignoring the broader social and political processes (for example, globalization or class structure) underlying health inequalities (Richmond, Elliott, Matthews et al., 2005; Poland, Coburn, Robertson et al., 1998). Yet despite these criticisms, the population health perspective has become an important framework for health, health research, and health promotion strategies and policies in Canada, the United States, Western Europe, Australia and elsewhere (Health Canada, 2001).

For the purposes of this research, a population health approach will be applied to the study of overweight and obesity in the adult population of Ontario. This research centres on the complex nature of the determinants of obesity. Of particular interest are the interactions between disease (risk factors for cardiovascular disease), health and function, individual response (biology), and the social and physical environments in which individuals are situated (Figure 2-1). Specifically, this research focuses on examining the heterogeneities that may be related to gender, individual behaviours (e.g. physical activity, diet), individual and community socioeconomic status (SES) and other community characteristics in the relationship between overweight, obesity and cardiovascular risk factors.

2.1.2 From Medical Geography to Health Geography

In much of the literature surrounding the evolution of medical geography to health geography, it is typical to divide the subdiscipline into two distinct streams: the traditional, and the contemporary. The traditional stream is concerned with the spatial analysis of both patterns of disease and disease etiology (with a long tradition in health research), and patterns of health service provision and organization (which emerged concomitantly with the quantitative revolution in the 1960s) (Gatrell, 2002; Curtis & Taket, 1996). The traditional stream has a strong history related to medical cartography and geographical epidemiology, or the mapping and modeling of infectious diseases (Rosenberg, 1998). An excellent and well-known example of this type of study is John Snow's study of cholera incidences in London, England in the 1850s (Shaw, Dorling & Mitchell, 2002; Eyles & Woods, 1982). By constructing a map of cholera incidence, Snow's work illustrated an association between disease and the physical environment. These types of studies, known as disease ecology, or ecological-associative studies, have been characterized by their immersion in positivism, and their use of quantitative methods from the "relatively uncomplicated, to the more sophisticated" (Eyles & Woods, 1982, p. 80).

Additionally, as the doctrine of specific etiology dominated the idea of how disease occurred during the century beginning in the mid-1800s, research in this traditional strand viewed the concept of space as a passive container within which characteristics can be studied and recorded (Kearns & Moon, 2002; Meade & Earickson, 2000; Eyles & Woods, 1982). More recently, there has been a movement within medical geography to encompass a broadened knowledge of environment and health relationships.

The shift within medical geography began with a similar shift witnessed in the definition of health as described in the previous section of this thesis. As the notion of health shifted from more than the absence of disease, the contemporary stream of medical geography began to emerge. The contemporary stream of medical geography, as identified by Curtis and Taket (1996), includes three strands that embrace the socio-ecological concept of health. The humanist strand, structuralist/materialist/critical strand, and the cultural strand, which respectively focus on health, health-related behaviour, and health care provision from the point of view of the user; the interactions between individuals and structural and material influences on health experience and health services; and the importance of space and place to individuals and their health (Curtis & Taket, 1996). The contemporary stream of medical geography challenges the medico-centricity of traditional approaches, and focuses on contextualization of health and illness as occurring within social, economic, political, cultural and environmental processes (Dyck, 1999).

This shift distinctly refocused concerns of disease (as in the traditional stream) to an increasing interest in well-being, and broadened models of health and health care (Kearns & Moon, 2002). The development of the three strands of the contemporary stream mark the shift of *medical geography* to the more holistic *geography of health and health care*. In addition to the evolution of models and definitions of health, and the construction of the population health framework, the movement towards the geography of health and health care is viewed as an integral part of defining the geographer's role in health and environment and health research (Elliott, 1999).

In addition to an emphasis on well-being and the socio-ecological concept of health, the move from traditional medical geography to health geography has placed an equally influential emphasis on the notion of place (Kearns & Moon, 2002). It is important to note that the investigation of place effects on health is not new to the study of health. In fact, until the dominance of the biomedical, specific etiology paradigm in the 19th century, place had been a key concern to medicine for 2,000 years (Meade & Earickson, 2000). The inclusion of environmental aspects in health research can be traced to ancient Greece, and Hippocrates' *Airs, Waters and Places*, where it is stated:

> "Whoever wishes to investigate medicine properly,
> should proceed thus: in the first place to consider
> the seasons of the year, and what effects each of

> them produces…Then the winds, the hot and the cold…We must also consider the qualities of the waters…and the ground…and the mode in which the inhabitants live, and what are their pursuits" (From Meade & Earickson, 2000).

From this, it is clear that Hippocrates' understood the importance of socio-environmental interaction centuries before place re-emerged as a central theme in health research.

During the past two decades, medical geographers have shifted their focus from the distribution and spatial analytic views of disease and health care services (though these efforts have not been abandoned) to more complex notions of place (Andrews & Moon, 2005). Within health geography, place is no longer synonymous with space, and it is not viewed as a mere container, but rather an "operational 'living' construct which 'matters'" (Kearns & Moon, 2002) to the development of health. Indeed, many investigators conclude that aspects of the social and physical environments in which people live are of significance specific to health experience, and these aspects often uncover reasons for unexplained geographical variation in health outcomes (Macintyre, Ellaway & Cummins, 2002; Duncan, Jones & Moon, 1999). The development of medical geography to embrace a more holistic view of health, as well as a refocus on place has been a large part of the response to the lack of theory, methodology and understanding of health, illness and health care provision and organization in our society (Meade & Earickson, 2000).

Given this evolution, and in particular the understanding that research in health geography needs to be sensitive to the fact that place is a socially constructed and complex phenomenon (Jones & Moon, 1993), three broad approaches to the study of health and place compose the field. In an effort to tease out the effects of place on health, the theoretical underpinnings of these approaches have varied from positivist to political-economic and humanist traditions (Kearns & Moon, 2002). Firstly, there has been a group of studies grounded in the specifics of localities. Such studies are concerned with investigation of community responses to threats (e.g. Luginaah et al., 2002) or place-specific aspects of health services. Secondly, a group of studies developed exclusively by qualitative geographers has concerned itself with the notion of *landscape*[5] (Andrews & Moon, 2005). This work places great emphasis on the cultural importance of place as it relates to the production and consumption of health care, and health promotion. Finally, the third set of studies claiming place-awareness is comprised of the various studies employing multilevel modeling (see for example, Duncan et al., 1999; Diez-Roux, Nieto, Muntaner et al., 1997) to explore the extent of association between aspects of the social and physical environment and disease or health (Curtis & Taket, 1996). These studies reflect the enduring quantitative research paradigms of medical geography, and have

[5] For a more in-depth discussion of therapeutic landscapes, see Gesler, 1996.

been found to be "more faithful to external reality and effective as an empirical means of 'capturing place'" (Kearns & Moon, 2002, p. 611), in comparison to traditional quantitative techniques. It is within this third group of studies that the research objectives of this thesis fall. A more in-depth discussion of multilevel modeling follows in later sections of this chapter (Section 2.2.3)

Refocusing on the social and environmental context of health and disease has research questions in health geography moving away from traditional observational and descriptive studies, and towards questions "of the intersection of individual level biological and behavioural variables with social and environmental factors" (Elliott, 1999, p. 241). The "decentering of a medical focus" (p. 250) within the discipline has further opened questions of health and health care to a wider audience in academia (Dyck, 1999). Research questions are investigated by drawing on the concepts and techniques of medical anthropology, sociology, economics, and psychology and adding a spatial and ecological perspective, thus "bridging the gap between the social and the physical and biological sciences" (Meade & Earickson, 2000, p. 6).

2.2 Heterogeneities in Health Outcomes and the Role of *Place*

2.2.1 Context versus composition

Often, the risks associated with good or bad health are not distributed evenly throughout a population; as defined by geographical boundary or some other common characteristic, for example, work environment (Kawachi, Subramanian & Almeida-Filho, 2002). With the increasing focus on the role of place in geographical research, health geographers may approach such phenomena with the question: "how much of the health differences between different groups...are accounted for by population *composition* or by the *context* in which those populations live?" (Shaw et al., 2002, p. 126). Such questions present the challenge of disentangling the individual-level and area-level influences on health outcomes. A context versus composition approach provides an empirical framework for investigating these questions.

Compositional effects refer to the influence on health status as affected by the characteristics of the individuals situated in particular places (Macintyre et al., 2002; Giles-Corti & Donovan, 2002). Contextual effects refer to aspects of the local physical and social environment that influence the health of all individuals living within a particular place (Macintyre et al., 2002; Reidpath, Burns, Garrard et al., 2002). Macintyre and colleagues (2002) further extend this dichotomous framework of context and composition to include a *collective* group of characteristics associated with place. The collective dimension draws attention to the socio-cultural and historical features of places (Macintyre et al., 2002). Though the collective explanation holds great importance to the examination of place effects on health, for this particular research emphasis will be placed on the compositional and contextual factors that are associated with overweight and obesity due to data limitations.

Variations in health outcomes or behaviours are indeed due in large part to compositional effects, whereby particular types of people who are at a high risk for disease are found to be clustered within particular places (Duncan, Jones & Moon, 1998). The association between many individual behaviours or characteristics and poor health has been well-documented. For example, smoking (Health Canada, 2006), sedentary lifestyle (Giles-Corti & Donovan, 2002), and low levels of individual income (Waitzman & Smith, 1998) and education (Sundquist & Johansson, 1998) have all been shown through empirical investigation to be associated with numerous adverse health outcomes such as mortality and morbidity rates.

Conversely, variation in a health outcome may, in part, be due to a particular characteristic or feature of the social or physical environment that is putting a population at a higher risk for ill health (Shaw et al., 2002). For example, Araya and others (2006), determined that even after controlling for numerous individual (compositional) characteristics, neighbourhood variation of mental health status remained, with the largest proportion of the variation explained by neighbourhood level socioeconomic status, a particularly influential aspect of the social environment (Marmot, 1998). Similarly, Humpel and colleagues (2002) found that accessibility, opportunities for physical activity, and aesthetic attributes of place were significantly associated with the likelihood of being physically active; a known health promoting behaviour (Health Canada, 2006). The study additionally reported that local weather and perception of area safety were also linked to physical activity, although the relationship was less strong (Humpel, Owen & Leslie, 2002). These findings indicate that contextual characteristics of the physical environment may also influence health status.

Some research suggests that compositional and contextual effects should be viewed as independent and mutually exclusive. Sloggett and Joshi (1994) found that excess mortality rates in areas that had been previously designated as deprived, were "wholly explained by the concentration in those areas of people with adverse personal or household socioeconomic characteristics" (p. 1470). However, contemporary views of health problems indicate that contextual effects, operating at various geographical scales, can mediate health relationships at the individual level (Curtis & Taket, 1996); that is, "our 'health' and our 'geographies' are inextricably linked" (Gatrell, 2002, p. 3). Furthermore, there is a growing consensus within the field of health geography that improvements in public health may be achieved by altering aspects of the environments in which people are situated (Macintyre et al., 2002; Humpel et al., 2002).

In contrast to the mutual exclusivity hypothesis, it is typically found that neither the compositional factors, nor contextual factors alone are sufficient enough to completely explain the development of a particular health outcome (Kawachi et al., 2002; Shaw et al., 2002). In fact, both dimensions are thought to simultaneously contribute to health status, although not proportionally so. Most investigators conclude that while where you live certainly matters for health, it probably does not matter as much as who you are (Pickett & Pearl, 2001). Much research focused on explaining geographical variations and heterogeneities in health outcomes tend to focus on teasing out the relative contributions of compositional and contextual effects.

Fundamentally, there are three issues to be addressed when exploring contextual versus compositional effects. As proposed by Kawachi et al. (2002), in order of complexity these tasks are: *compositional explanation*, *contextual heterogeneity*, and *individual-contextual interactions*. Compositional explanation involves distinguishing compositional explanations from contextual explanations.[6] Similar types of people based on individual characteristics will typically have similar health outcomes without regard to where they live (Merlo, Yang, Chaix et al., 2005). However, if similar types of people in different places experience a range of outcomes for a particular health phenomenon, it is possible that an aspect of place is influencing individual health (contextual effect). The second issue to be addressed is the unpacking of contextual heterogeneity, or the differential variation in places (Duncan et al., 1996). For instance: "places with high rates of poor health for one social group may have lower rates for others, and vice versa" (Kawachi et al., 2002, p. 650). That is, contextual effects have a genuine independent effect on individual health and/or health behaviour. Finally, the issue with the greatest complexity addresses compositional-contextual interactions. These interactions arise when contextual characteristics differentially affect different population groups as defined by individual characteristics (Kawachi et al., 2002). For example, in a recent multilevel study of 201,221 adults clustered in 50 areas in the United States, Subramanian and Kawachi (2006) found that area-level income inequality had a greater statistically significant effect on the self-rated health of individuals with incomes greater than $75,000 compared to their less affluent counterparts. Relative contributions of contextual and compositional effects will be a central focus of this thesis, and particular emphasis will be placed on the role of the neighbourhood environment in the development of overweight and obesity.

2.2.2 Neighbourhood and Health

While there is certainly a large compositional component to overweight and obesity status, the most current thinking points to environmental factors as the primary culprit for the increasing prevalence of these conditions (Cohen, Finch, Bower et al., 2006, WHO, 2006a). To explore the effects of context on overweight and obesity, this research focuses on neighbourhood of residence as the geographical unit. Many different characteristics of the neighbourhood have been linked to a wide range of population health indicators including physical health, health perception, and mental health outcomes (Subramanian, 2004). Since the reconceptualisation of the role of place, much research within health

[6] However, as Macintyre et al. (2002) explain, making this distinction between compositional and contextual aspects may not always be as simple and clear upon first glance. It is suggested that the related literature should be drawn upon greatly to help guide when classifying characteristics.

geography has focused on investigating the role of neighbourhood level socioeconomic factors that shape the distributions of health outcomes (Diez-Roux, Merkin, Arnett et al., 2001). The associations between physical aspects of neighbourhood such as housing quality, exposure to environmental toxins, and access to amenities have received similar attention (Evans & Kantrowitz, 2002).

Perhaps the most obvious impacts on health are the factors associated with the physical environment. These aspects of place tend to be more visible, and their impacts may conceptually be more easily understood in comparison to mechanisms underlying the impacts of the local social environment. The most obvious example of how the physical environment can influence individual health is the case of environmental toxins or pollution, and there is a substantial quantity of research in this field (Shaw et al., 2002). The effects of neighbourhood quality and housing quality on health after accounting for individual characteristics have been a more recent topic of interest.

Neighbourhood quality; measured by number and quality of the amenities and facilities available for residents to enjoy, access to essential services, and perception of neighbourhood safety; has been directly linked to health (Wilson, Elliott, Law et al., 2004; Shaw et al., 2002). Individuals living in neighbourhoods characterized by a lack of stores selling wholesome foods, and limited facilities for physical activity such as gyms and spas (Boslaugh, Luke, Brownson et al., 2004) or walking paths (Ross, 2000), have been found to be at a higher risk for cardiovascular disease, and related risk factors such as hypertension and obesity (Isaacs & Schroeder, 2004). Neighbourhoods with a high proportion of stores that sell energy dense foods (e.g. fast-food outlets) have been linked to comparable outcomes (Reidpath et al., 2002). Additionally, research focused on neighbourhood-level accessibility of essential municipal services have found inverse relationships between access to services such as police, fire, and sanitation and both injury mortality rates (Cubbin, LeClere & Smith, 2000) and risk of infectious disease (Evans & Kantrowitz, 2002).

Perception of the local physical environment has likewise been associated with health behaviours and psychological health outcomes (Wilson et al., 2004). Individuals who perceive their neighbourhoods as unsafe or unpleasant (for example, high automobile traffic rates, many broken windows on their street, poor condition of sidewalks) are far less likely to engage in health promoting behaviours such as walking outside, or other physical activities (Cohen et al., 2006; Boslaugh et al., 2004; Ross, 2000). Further, studies examining the effects of the neighbourhood environment on mental health have often focused on individual's perceptions of the local physical environment (Araya, Dunstan, Playle et al., 2006). Poor neighbourhood perception has been shown to affect psychosocial health outcomes such as self-assessed stress levels (Human Resources and Skills Development, 2001), depression (Ross, 2000), and risk of social isolation (O'Campo, 2003).

Finally, public health concerns about the effect of housing quality and health have become an important focus within environment and health research.

Poor quality housing, characterized by being in need of major repairs, dampness, cold, poor indoor air quality or residential crowding can be damaging to both physical and psychological health (Shaw et al., 2002). Dampness, moulds, cigarette smoke and other allergens found in older homes have been associated with poor respiratory health, especially within children and other susceptible populations (Evans & Kantrowitz, 2002). Additionally, research investigating homes in need of repairs, and homes with substandard construction suggest a link with higher risk for physical injury (Matte & Jacobs, 2000). Although more controversial, work investigating the link between housing quality and mental health suggests that psychological health is affected through demoralization associated with living in a neighbourhood with numerous poor-quality homes (Shaw et al., 2002).

The role of the social aspects of neighbourhood in the development of physical and mental health has long commanded attention from medical/health geographers (Shaw et al., 2002). Particular focus has been given to the influence of neighbourhood-level socioeconomic status (SES) as measured by deprivation indices, absolute and relative income, education levels, employment status, and social class (Giles-Corti & Donovan, 2002; Robert, 1998). Neighbourhood SES is regarded as an accurate indicator of the local social environment associated with a particular area (Evans & Katrowitz, 2002).

A distinct inverse gradient between neighbourhood SES and a broad range of health outcomes has been reported in numerous epidemiological and ecological studies (Evans & Kantrowitz, 2002). An investigation of general mortality trends in urban Canada, explored the relationship between all-cause mortality and neighbourhood income level over a 25 year period (Statistics Canada, 2002). Figure 2-2 indicates the inverse relationship between the probability of living to seventy-five, and neighbourhood income quintile for Canadian adults from 1971 to 1996. Similar studies have revealed the same inverse relationship between

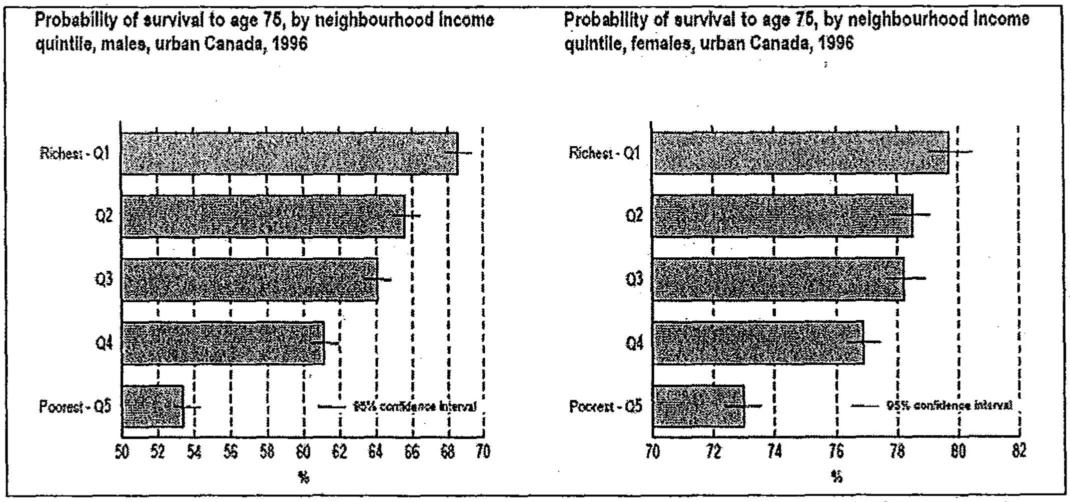

Figure 2-2: Survival to age 75 by neighbourhood income (Statistics Canada, 2002)

neighbourhood-level income and injury mortality (Cubbin et al., 2000), health adjusted life years (HALYs), and annual years of life lost (YLLs) (Muenning, Franks, Jia et al., 2005).

The influence of neighbourhood SES on disease morbidity rates has likewise been a great focus of many medical/health geographers (Pickett & Pearl, 2001). Neighbourhood SES has been frequently linked to numerous conditions including cardiovascular disease (Leyland, 2005; Jenum, Stensvold & Thelle, 2001; Davey Smith, Hart, Watt et al., 1998; Kaplan & Keil, 1993), overweight and obesity (Cohen et al., 2006; Robert & Reither, 2004; Reidpath et al., 2002; Sundquist & Johansson, 1998; Ellaway, Anderson & Macintyre, 1997), coronary heart disease (Diez-Roux et al., 2001; Diez-Roux et al., 1997), stroke (Brown, Guy & Broad, 2005), asthma (Juhn, St. Sauver, Katusic et al., 2005), and mental health outcomes (Araya et al., 2006). Although the majority of these studies used different methodologies and different definitions of the boundaries of *neighbourhood*, each found a statistically significant association between neighbourhood-level SES and increased risk of experiencing an adverse health outcome. These results are consistent with work by Ross and colleagues (2004) in Montréal, Canada concerned with the effect of neighbourhood on self-reported health status. Ross found remarkably similar results in terms of size and direction of statistical coefficients, and in terms of the proportion of variation in health status attributable to neighbourhood-level variables regardless of the actual boundary definition of neighbourhood.

Additionally, low neighbourhood SES has been linked to a number of health related behaviours, typically exhibiting a similar inverse relationship. That is, residents of lower SES neighbourhoods are less likely to engage in health promoting behaviours, and more likely to engage in behaviours known to be deleterious to health. For example, living a sedentary lifestyle (Fisher, Li, Micheal et al., 2004; Giles-Corti & Donovan, 2002; Diez-Roux, Link & Northridge., 2000; Ross, 2000; Sundquist, Malmström & Johansson, 1999), smoking (Ross, 2000; Sundquist et al., 1999; Duncan et al., 1999; Duncan et al., 1996; Duncan et al., 1993), excess alcohol consumption (Chaix & Chauvin, 2003; Duncan et al., 1993), and eating an unhealthy diet (Janssen, Boyce, Simpson et al., 2006; Reidpath et al., 2002) have all been inversely associated with neighbourhood SES.

Currently there is no scientific consensus on an optimum indicator of neighbourhood- or area-level SES. Typically, studies tend to use some measure of household income, employment income, low income incidence or income inequality (Pickett et al., 2005; Stafford & Marmot, 2003). Alternative measures of SES are also used with some consistency, including average dwelling values (Cozier, Palmer, Horton et al., 2007; Buzzelli, Jerrett, Burnett et al., 2003; Veugelers, Yip & Kephart, 2001), and neighbourhood education levels (CIHI, 2006; Pickett & Pearl, 2001; Veugelers et al, 2001). Several measures of neighbourhood-level SES will be explored in this research.

More recently, social cohesion and number of social interactions[7] have been identified as significant predictors of health, and psychological health in particular as a result of segregation and isolation (Cohen et al., 2006; Kawachi & Kennedy, 1997). Growing evidence, however, suggests that the breakdown of social cohesion is linked to SES, and results from a large gap between rich and poor (large income inequality) within a particular neighbourhood or community (Kawachi & Kennedy, 1997). The psychosocial stress of living near the bottom of this hierarchy is a suggested explanation for the association with numerous health outcomes (Pickett et al., 2005). A study of neighbourhoods in England and Scotland found that individuals in areas of high income inequality had low trust in others within the neighbourhood, felt less attached to the neighbourhood, had little respect for others in the neighbourhood, and had relatively poorer self-rated health (Stafford & Marmot, 2003). These social factors, which would fall under the collective dimension as defined by Macintyre et al. (2002) relate directly to quality of life and social relationships.

The range of evidence within this literature suggests that characteristics of the social and physical neighbourhood environment can have a significant influence in the development of individual health. There is currently a poor understanding of the role of the neighbourhood environment in the development of obesity and cardiovascular disease (WHO, 2006a; Katzmarzyk, 2004; Sunquist et al., 1999). This thesis aims to contribute to this gap in the literature by investigating the relative contributions of aspects of the physical and social environments to the development of these conditions.

In addition to exhibiting independent effects on health, it has been argued that aspects of the physical neighbourhood environment may be a consequence of the social environment, and vice versa (Araya et al., 2006). For example:

> "a poorly maintained built environment with derelict buildings and rubbish might affect the sense of social cohesion in a neighbourhood....but it is also possible that poor social cohesion might lead to a poorer built environment as residents might have little interest to look after their common areas" (p. 3078).

As this example suggests, the relationship between individual behaviours and the social and physical environment is quite complex. Investigation of the relationship between place and health thus requires an approach and methodology that is able to capture the complexity involved (Curtis & Taket, 1996).

[7] Although grouped under contextual characteristics in this thesis, social cohesion and number of social interactions fall within the collective dimension as defined by Macintyre et al. (2002).

2.2.3 The Multilevel Analytical Approach to 'Place Effects'

As discussed previously in this chapter, there are three groups of studies concerned with exploring the extent of association between aspects of the social and physical environment and disease or health (Kearns & Moon, 2002). One of these groups is comprised of studies employing multilevel statistical techniques[8] (e.g, Duncan et al., 1999). Multilevel modeling has been used by sociologists for several decades to investigate contextual effects for a variety of individual outcomes including voting behaviour, education, and attitudes (Diez-Roux, 1998). More recently, this approach has been used in health geography for disentangling the compositional and contextual effects on health and health behaviours, although to date in this field multilevel techniques have mostly been a fascination of the United Kingdom (Kearns & Moon, 2002; Pampalon et al., 1999). While further chapters of this thesis will discuss the technical aspects, development, and criticisms of this quantitative approach, the current section focuses on the literature that has employed this technique to investigate place effects on health outcomes, perceptions, and behaviours.

One group of multilevel studies has focused on the geographical variation of disease morbidity rates, including cardiovascular disease (Leyland, 2005; Diez-Roux et al., 2000; Sundquist et al., 1999), coronary heart disease (Diez-Roux et al., 1997), obesity (Janssen et al., 2006; Robert & Reither, 2004; Chaix & Chauvin, 2003; Sundquist et al., 1999) and asthma (Juhn, 2005). The majority of the studies found that neighbourhood had some effect on the development of disease, independent of compositional characteristics. For example, in their study of Canadian adolescents, Janssen and others (2006) conclude that both individual- and area-level socioeconomic status independently contributed to the development of obesity, and suggest intervention at the school-level, rather than at the individual level. Robert and Reither (2004) reported similar conclusions, finding that community disadvantage in the United States explained a high proportion of the variation in obesity status between black and non-black populations.

Further, Diez-Roux (2000) found a relationship between three of four cardiovascular disease risk factors and neighbourhood-level income inequality, and that there exists an interactive effect between income inequality and individual income, though the relationship was stronger for women than men. High area-level income inequality has similarly been linked to poor self-rated health in the United States (Lopez, 2004) and Scotland (Craig, 2005). Sundquist et al. (1999) found that more deprived neighbourhoods were at a greater risk for numerous cardiovascular disease risk factors after adjusting for individual SES. Leyland's (2005) research on Scottish adults found a statistically significant bivariate relationship between cardiovascular disease and both individual SES and neighbourhood deprivation scores. However, after both were included in the

[8] Also referred to as hierarchical linear modeling (Merlo, 2003), or random effects modeling (Goldstein, 1991).

multilevel model, significant association at the individual level did not remain, and neighbourhood deprivation scores dominated the relationship.

A second major group of multilevel studies have reported contextual effects on health-related behaviours. Place effects on smoking (Leyland, 2005; Chaix & Chauvin, 2003; Sundquist et al., 1999; Duncan et al., 1999, 1996, 1993), alcohol consumption (Chaix & Chauvin, 2003; Duncan et al., 1993), diet (Janssen et al., 2006; Chaix & Chauvin, 2003), and physical activity levels (Janssen et al., 2006; Fisher et al., 2004; Diez-Roux et al., 2000; Sundquist et al., 1999) have been investigated using multilevel techniques. For example, Duncan et al. (1999) found significant between-ward differences in smoking behaviour were affected independently and significantly by neighbourhood deprivation scores in Britain. Likewise, in a study of physical activity levels among older adults in 56 neighbourhoods in Portland, Oregon determined that neighbourhood-level variables "jointly accounted for 84% of the variation in walking activity between neighbourhoods, whereas the four individual level variables jointly accounted for only 26% of the within-neighbourhood variation in walking activity" (Fisher et al., 2004, p. 56). Clearly, the key strength of using a multilevel approach to model variance in health outcomes lies in quantifying the relative contribution of place and individual characteristics.

Many researchers have highlighted the importance and usefulness of multilevel modeling within the context of health geography (Subramanian, 2004; O'Campo, 2003; Kearns & Moon, 2002; Duncan et al., 1996, 1993). This technique reflects the movement in health geography towards a focus on more contextualised research, and offers one way of restoring an environmental dimension to traditional epidemiology (Macintyre et al., 2002; Diez-Roux, 1998). By acknowledging the structure of individuals clustered within contexts, and allowing for variation within- and between-contexts, multilevel modeling is "both more faithful to external reality and effective as an empirical means of 'capturing place'" (Kearns & Moon, 2002, p. 611). The central focus of this thesis is to examine the interactions between a particular health outcome, individual behaviours and aspects of the local social and physical environments. It is clear from the examples discussed in this section, that multilevel techniques are an appropriate methodological approach for understanding the role of the environment in the development of overweight and obesity.

2.3 Overweight, Obesity and Cardiovascular Disease

Obesity, defined as the presence of excess body fat, has been linked to numerous adverse health effects and risk factors such as type 2 diabetes mellitus, hypertension, gall bladder disease and some cancers (Kim, Meade & Haines, 2006; Pickett, Wilkinson & Kelly, 2005; Wannamethee, Shaper & Walker, 2005; Trakas, Lawrence & Shear, 1999; Rabkin, Chen, Leiter et al., 1997; Reeder, Sethilselvan, Després et al., 1997, Reeder et al., 1992). In particular, there exists clear evidence that overweight and obesity are important risk factors for cardiovascular disease (CVD), currently the leading cause of death in Canada

(Health Canada, 2005). Further, obesity has been linked to adverse psychological outcomes (e.g. low self-esteem, depression) (Wardle & Cooke, 2005).

A chronic disease such as obesity, with numerous co-morbidities, places a great deal of stress on Canada's health care system, generating great economic concern. In 2001, national medical costs directly and indirectly attributable to adult overweight and obesity were respectively estimated at $1.6 billion, and $2.7 billion, or 2.2% of total health care expenditure (Katzmarzyk & Janssen, 2004).

To date, little is known about how physical and social environments mediate the health outcomes associated with overweight and obesity. Although a general U-shaped relationship has been shown between body mass index (BMI) and health outcomes in different settings, most studies have been conducted in the United States, Europe and Asia (Katzmarzyk et al., 2003). In the few studies that have been conducted in Canada (e.g. Katzmarzyk, 2002), there has been limited emphasis on exploring the underlying heterogeneities in the observed relationships. This thesis aims to address these gaps by examining the complex interactions between overweight, obesity, individual characteristics, and the local social and physical environments in a Canadian-specific context.

2.3.1 Individual Risk Factors for Overweight and Obesity

Currently, there is a general understanding of the relationships between overweight and obesity and a range of different risk factors at the individual level. These risk factors vary from demographic characteristics to behaviours and lifestyle choices (Chambers & Swanson, 2006). Firstly, several studies from various geographical contexts have found overweight and obesity to be associated with age and sex. In general, BMI increases with age (McTigue, Larson, Valoski et al., 2006; Trakas et al., 1999; Cairney & Wade, 1998; Ledoux et al., 1997b; Macdonald et al., 1997; Reeder et al., 1992) and BMI is higher for males than females (Willms, Tremblay & Katzmarzyk., 2003; Trakas et al., 1999; Cairney & Wade, 1998; Ledoux et al., 1997b; Macdonald et al., 1997; Reeder et al., 1992). Since these relationships are so prevalent in overweight and obesity analyses, the majority of studies using quantitative analyses introduce age and sex into statistical models as control variables (Zhang & Wang, 2004).

Secondly, there is a large body of literature concerning the association between individual-level socioeconomic status (SES) and weight status. Though socioeconomic status is difficult to explicitly define with one variable or characteristic, particular attention has been paid to the influence of education level and measures of income or wealth. A smaller portion of studies have examined the effects of other measures of SES on weight status, including occupational attainment and marital status (Robert & Reither, 2004; Chaix & Chauvin, 2003; Cairney & Wade, 1998). Each of these studies found a similar inverse relationship between occupation and BMI. Additionally, Cairney and Wade (1998) found an inverse relationship between marital status and BMI. However, in general these relationships were less strong than alternative indicators of individual SES such as income and education (Chaix & Chauvin, 2003). As a general trend, individuals with lower levels of SES tend to be at a higher risk for many adverse health outcomes, both mental and physical (Isaacs & Schroder, 2004). A recent international review of obesity research argues that the largest burden of obesity in a particular country is found in the lowest SES groups (Monteiro, Moura & Conde, 2004).

Lower education levels have been consistently associated with higher values of BMI (McTigue et al., 2006; Robert & Reither, 2004; Isaacs & Schroder, 2004; Willms et al., 2003; Trakas et al., 1999; Sundquist et al., 1998; Macdonald et al., 1997). Education is considered a key to advancement economically and socially within developed countries, since individuals with better educations are more likely to have higher social status, and obtain better jobs (Isaacs & Schroder, 2004). For example, Robert and Reither (2004) found a negative association between BMI and education (measured continuously) in a multilevel analysis of communities in the United States. Categorizing education into less than high school, high school, and college or higher, Zhang and Wang (2004) found the same inverse relationship with adult BMI over a thirty year period. Similarly, Macdonald et al. (1997) found that those with an elementary school education or less were twice as likely to be obese than those who had completed a university degree.

Some research goes so far as to identify income as the single most powerful predictor of health (Isaacs & Schroder, 2004). The majority of studies concerned with overweight and obesity have examined at least one measure of income or wealth (Janssen et al., 2006; Robert & Reither, 2004; Isaacs & Schroder, 2004; Zhang & Wang, 2004; Willms et al., 2003). For example, Janssen and colleagues (2006) found that individual-level SES, as measured by family wealth and perceived family wealth, were inversely associated obesity in Canadian adolescents. In their multilevel study of adult populations in the United States, Robert and Reither (2004) found that both categorized income and assets were negatively associated with BMI in women; although racial disparities persisted. Chaix and Chauvin (2003), report the same well-documented inverse relationship between household income and overweightness in adults living in France.

Individual behaviours as risk factors for overweight and obesity have received similar attention (e.g. Gruber & Frakes, 2006; Janssen et al., 2006; Chaix & Chauvin, 2003; Trakas et al., 1999; Sundquist et al, 1998; Rabkin et al., 1997; Ledoux et al., 1997). In general, there are three main individual behaviours thought to influence weight status: smoking, diet and physical activity levels (Sundquist & Johansson, 1998). While smoking status is usually found to be linked to weight status, the results are quite mixed. Most often smokers are more likely to be overweight (Gruber et al., 2006; Chaix & Chauvin, 2003; Sundquist et al., 1999; Sundquist & Johansson, 1998); however, some research suggests that non-smokers are more likely to have a lower BMI (Trakas et al., 1999).

Since overweight and obesity result from "a chronic energy imbalance, whereby intake exceeds expenditure" (Katzmarzyk, 2002, p. 1039) by definition, it is clear that diet (energy intake) and physical activity levels (energy expenditure) both play a role in the development of these conditions. Rabkin et al. (1997) found that the prevalence of physical inactivity in Canadian adults was positively associated with BMI levels, except in the lowest BMI category. Furthermore, Green and colleagues (1997) indicated that individuals in the same sample in the highest BMI categories were content with their weight, and were less likely to try to reduce their weight by increasing personal physical activity levels. Additional research on diet and unhealthy eating has indicated that consuming a large proportion of energy-dense foods as opposed to wholesome foods is similarly linked to high BMI levels in adults (Health Canada, 2005) as well as adolescents (Janssen et al., 2006).

These demographic, socioeconomic and behavioural risk factors for overweight and obesity are often interrelated, and cannot be viewed as mutually independent. For example, there is a close correlation between income, education, and individual health-related behaviours that exists in many contexts (Janssen et al., 2006). A lack of education renders low-income individuals with relatively deficient knowledge about health and health information, and a decreased ability to problem-solve (Isaacs & Schroder, 2004). This suggests that those individuals who practice high-risk behaviours may not realize the consequences of their actions, or know how to cope with these consequences when they surface. This is supported by studies that have found that lower levels of occupation, income and education are strongly associated with, for example, smoking and lifetime smoking duration (Siahpush et al., 2005). From this review, there is a substantial base of epidemiological evidence to suggest a link between various individual-level characteristics and overweight and obesity. It will be necessary to consider and include these known risk factors for overweight and obesity in the main analyses of this thesis.

2.3.2 Contextual Factors Contributing to Overweight and Obesity

As mentioned previously, obesity has reached epidemic proportions in many developed countries, including Canada (Katzmarzyk, 2002). Although much research has been dedicated to the importance of individual characteristics in the development of overweight and obesity, these factors cannot fully explain the dramatic rise in these conditions (Cummins & Macintyre, 2006). In Ontario, differences in individual risk factors for obesity such as smoking, diet, and level of physical activity can only explain about 30 per cent of the geographical variation in cardiovascular disease deaths (Jaglal, Bondy & Slaughter, 1999). Thus, it is currently understood that the underlying mechanisms driving the increasing prevalence of obesity must be characteristics of the social and physical environment that promote lifestyles and behaviours that put individuals at a higher risk of being overweight (Cummins & Macintyre, 2006; Willms et al., 2003; Hill & Peters, 1998). There are two complementary streams of research into the environmental determinants of obesity, relating to the social and physical environmental determinants respectively (Reidpath et al., 2002).

Those studies concerned with the aspects of the physical environment have examined the development and existence of *obesogenic environments*; defined as "environments that encourage the consumption of food and/or discourage physical activity" (Hill & Peters, 1998, p. 142). For example, Giles-Corti and Donovan (2002) found that access to popular recreation facilities (public open space, beach, parks, and walking trails) directly influenced the likelihood of an individual being physically active. These and other characteristics; such as street connectivity, and number of destinations within walking distance; have been combined to develop a *walkability index* for neighbourhoods that is correlated with the recommended daily physical activity recommendation of 30 minutes per day or more (Frank, 2000). Residents of more walkable neighbourhoods tend to be more physically active and thus less overweight than those living in less walkable neighbourhoods (Saelens, Sallis, Black et al., 2003; Frank, 2000; Ross, 2000).

Changes to the physical environment alone cannot fully explain the increase of obesity in developed nations. The remaining variation in weight status points to social factors as likely contributors to the emerging epidemic (Cohen et al., 2006). A number of recent studies concerned with the social environmental determinants of obesity have generally focused most attention on socioeconomic status (SES) and income inequality, with a minor, yet growing focus on the influence of social capital or cohesion (Reidpath et al., 2002). In general, findings indicate a negative association between obesity and contextual SES (Janssen et al., 2006; Robert & Reither, 2004; Sundquist et al., 1999; Ellaway et al., 1997). That is, as area-level SES decreases, the risk of being overweight or obese increases. For example, Ellaway and colleagues (1997) found that neighbourhood deprivation scores significantly predicted BMI as well as waist circumference (WC) after controlling for sex, age, social class, smoking behaviour, and individual deprivation. Similarly, a multilevel analysis of neighbourhoods in Sweden yielded results indicating that individuals in the most deprived areas had an increased risk of being a smoker, being physically inactive, and being obese (Sundquist et al., 1999). Further evidence suggests that these relationships may be stronger for people with low individual income (Pickett et al., 2005; Stafford & Marmot, 2003).

Income inequality, or the relative distribution of income within a particular area, exhibits a similarly negative association with weight status after controlling for individual effects (Pickett et al., 2005; Chang & Christakis, 2005; Diez-Roux et al., 2000; Kahn Heath Jr., Tatham et al., 1998). A recent ecological study of 21 developed countries found that obesity and calorie consumption were associated with income inequality (Pickett et al., 2005). Additionally, multilevel analyses have linked higher levels of income inequality to higher BMI (Chang & Christakis, 2005; Diez-Roux et al., 2000) as well as abdominal weight gain (Kahn et al., 1998). Although these area-level effects have been shown to be significant in many contexts, the actual mechanism by which these factors affect weight gain is still speculation (Reidpath et al., 2002).

Proponents of the 'income inequality affects health' hypothesis argue that social cohesion is a powerful mediating factor in the relationship between income inequality and health (Feldman & Steptoe, 2004). In a multilevel analysis of neighbourhoods in the United States, Cohen and colleagues (2006) recently reported that measures of collective efficacy – including relationships with neighbours and other indicators of social cohesion – are significantly associated with obesity and cardiovascular disease. The study goes on to suggest that future interventions to control population weight status address the social environment at the community level (Cohen et al., 2006). By examining individual-and contextual-level effects, the goal of this research is to establish the relative contribution of compositional and factors to overweight and obesity, and guide an appropriate policy response.

2.4 Summary

This chapter began by reviewing the underlying theoretical constructs that have informed this investigation of the potential determinants of overweight and obesity in Canadian adults. The next section outlined the complexity of health heterogeneities, and discussed the independently important roles played by contextual and compositional effects. The final section reviews previous research conducted on overweight and obesity as health outcomes. The remaining chapters of this thesis describe a multilevel investigation of overweight, obesity, and cardiovascular risk factors in 165 neighbourhoods in Ontario, Canada. The following chapter presents a detailed discussion of the methodologies employed.

CHAPTER THREE METHODS

This chapter describes the rationale for, and details of the research design and methods selected for addressing the research objectives of this thesis:

1) To investigate the relationships between specific individual-level determinants of health and obesity status;

2) To explore the range of contextual-level variables mediating these relationships; and

3) To determine the relative contributions of individual- and contextual-level factors to the development of overweight and obesity

The Canadian obesity epidemic has equally affected each province and territory of the country, and both national and provincial rates have been rising steadily since 1970 (Katzmarzyk & Mason, 2006; Appendix A). For the purposes of this research, focus will be placed on a representative sample of the adult population from the province of Ontario. Since the data of interest for this research included confidential information related to human participants, it was subject to an application to the McMaster Research Ethics Board before analysis could begin (Appendix B).

3.1 Research Design

A quantitative paradigm was adopted for this research. When used appropriately, quantitative methods provide reliable, generalisable, and objective measurements of health outcomes and their covariates (Maxim, 1999). Due to the nature of the research question, it was necessary to employ a method that could capture, variation in a health outcome both between- and within-geographical units. While the relationship between overweight and obesity has been well-established at the individual level, numerous studies have found that neighbourhood-level variables have a substantial influence on the development of these conditions (e.g. Sundquist et al., 1999; Ellaway, Anderson & Macintyre, 1997). In order to investigate potential contextual-level covariates of these conditions, multilevel modeling was selected as an appropriate methodological approach.

When geographical grouping exists, observations from within each group are often dependent upon the characteristics of that group, violating the assumption of observation independence (Garson, 2007). Traditional statistical methods are prone to certain statistical errors or fallacies associated with ignoring the potential dependence of observations, two of which are discussed in detail further in this chapter (Section 3.3.2.1). Alternatively, multilevel modeling incorporates the hierarchical structure of clustered data into analyses, and accounts for this possible dependency (Goldstein, 1995). Analysing the data in this manner allows for differences between individuals, and between contextual units to be effectively studied simultaneously in their interaction with the outcome variables.

3.2 Sample Construction and Data Collection

3.2.1 Individual-level data

As previously discussed (Chapter 2), it is necessary to simultaneously investigate both individual-level and contextual-level risk factors to fully understand the gamut of determinants of health outcomes and health behaviours (Gatrell, 2002; Duncan et al., 1999). With respect to this study of overweight and obesity, data at the individual-level was obtained as a subset of the Canadian Heart Health Surveys (CHHS). The CHHS are a national database of population based cross-sectional surveys colleted between 1986 and 1992, as implemented by provincial health departments under the supervision of a principle investigator in each of 10 provinces (CHHSRG, 1997; MacLean, Petrasovits , Nargundkar et al., 1992). The surveys were carried out in collaboration with the National Health Research and Development Program of Health Canada, the ministries of health, and support from provincial Heart and Stroke foundations (Katzmarzyk, 2004). The target population for the Ontario provincial survey was defined as non-institutionalized men and women between the ages of 18 and 74 (MacDonald et al., 1997).

The sampling frame used in this study was the Ontario Health Insurance Plan (OHIP) register. Since each resident of Ontario has to be registered and listed on the medical register, the OHIP register has complete coverage of the population of Ontario (Nargundkar, 1992). Stratified, two-stage, replicated probability sample designs were used to collect the data (CHHSRG, 1997). Primary sampling units (PSUs) were constructed from Ontario Health Units, and a sample of these units was selected with a probability of selection proportional to the unit population (MacLean et al., 1992).

Using these health insurance registries as sampling frames, the population of interest in the selected PSUs was stratified into six age-sex groups; men and women aged 18-34, 35-64, 65-74 (Canadian Heart Health Database Centre [CHHDC], 1997). This allowed estimates to be obtained for risk factors among young, middle aged, and old aged groups. The data from the Ontario Heart Health Surveys (OHHS) (n=2 538) includes detailed demographic, lifestyle, and socioeconomic information, cardiovascular disease risk profiles, as well as anthropometric indicators as measured and recorded by a clinician. Of those invited to participate in the survey, 2 538 individuals completed a household interview, where respondents were visited in their homes and demographic data, socioeconomic data, knowledge of cardiovascular disease risks, and attitudes and opinions on heart related issues were collected (CHHDC, 1997). A copy of the Ontario Heart Health Survey questionnaire is included in Appendix C of this thesis.

The second stage of data collection required respondents to attend a clinic for anthropometric measurements and blood sample collection two weeks following the household interview (CHHDC, 1997). Measures were taken in the morning, after fasting overnight, with respondents wearing light clothing (Torrance, Hooper & Reeder, 2002). For each respondent, the data recorded in the clinic was measured and recorded by trained nurses. Approximately 80% of the original 2 538 respondents (n=2 039) attended a clinic for further measurements of physical stature and body composition. The two outcomes of interest in this thesis; waist circumference (WC) and body mass index (BMI); were among the measures recorded from these 2 039 respondents.

The individual-level data set is accompanied by two weighting variables calculated for each individual, PWGTC and PWGTQ. These weights are standardized to the age-sex categories of the 1992 Ontario population (n=7 098 674) to allow for calculation of population estimates (CHHDC, 1997). Additionally, the weights take into account the province's sample design, and are adjusted to account for complete non-response at the questionnaire (PWGTQ) and clinical (PWGTC) stages of the data collection (MacLean et al., 1992). Since the outcome variables of interest for this thesis were recorded during the clinical visit stage of the survey, any statistical output presented in this thesis has been weighted using the PWGTC variable.

3.2.2 Contextual-level data

The main focus of this research is to understand both the compositional and contextual risk factors for overweight and obesity in the Ontario population, as measured by WC and BMI. Thus, it was necessary to link the individual-level data to a contextual-level database in an effort to capture any independent effects of the local social and physical environment. Using the postal codes recorded for each respondent in the CHHS Ontario data, a direct record linkage with the data from the 1991 Canadian census was conducted to provide information on each individual's neighbourhood at the forward sortation area (FSA) level[9].

FSA was selected as an appropriate geographical boundary for *neighbourhood* for three main reasons. Firstly, since postal codes were provided with the CHHS data, and census data is readily available at this level of geography, it was relatively efficient to directly link contextual-level data to the individual-level data set. Secondly, the statistical power of multilevel modeling,

[9] FSA refers to the first three characters of a participant's postal code

which serves as the methodological centre of this thesis, is dependent upon both the number of contexts analysed, as well as the number of individuals within each context (Kreft, 1996; Goldstein, 1995). Using FSA as the geographical context provided a more than adequate number of groups (n=163), as well as an adequate number of individuals per group (mean = 15.46, median = 10). Further, as indicated by the findings by Ross and colleagues (2004), the magnitude and direction of statistical estimates, as well as the proportion of variation in health status attributable to neighbourhood-level variables does not change significantly with boundary definition of neighbourhood. For these reasons, FSA was selected as the appropriate level of geography for this research.

The neighbourhood-level census profile was obtained as a custom product directly from Statistics Canada due to limitations of the publicly available 1991 Canadian Census data such as suppression of results, and discrepancies between geographical boundaries. Linking this data to the individual-level data from the CHHS resulted in a hierarchical data structure whereby 2 536 respondents (99.9% of original sample) were clustered within 163 neighbourhoods across the province of Ontario. There was not full coverage of the province of Ontario, and Appendix D contains a map indicating the subset of FSAs that were sampled from for the CHHS. Two individuals were excluded in any analyses involving neighbourhood-level units, as either census records of their particular FSA were not available, or the participant's postal code was not initially recorded.

Finally, in order to calculate a population density variable for each neighbourhood, as well as a variable which categorized a particular neighbourhood as urban or rural, it was necessary to obtain a file with FSA codes and corresponding size in square kilometres (km^2). This particular FSA land area file (1996) was obtained from an online resource; the University of Toronto Data Library Service (University of Toronto, 2006). The size of each FSA was linked manually to the census file, providing sufficient information to construct population density and neighbourhood type variables. The following section will provide rationale for selecting BMI, and WC as outcomes for this particular research.

3.2.3 Measuring Overweight and Obesity

Standard measures of overweight and obesity are difficult to define (Ledoux, Lambert, Reeder et al., 1997a). Body mass index (BMI: kg/m^2) is recognized by the WHO and other national and international health organizations as an appropriate indicator for measuring excess body weight (WHO, 2000). This measure has been used for many population-based studies, due to the simplicity of the measure of weight and height, and the widespread collection of these measurements in population health surveys (Dalton, Cameron, Zimmet et al., 2003). Typically, the classification points define adult normal weight as BMI of 18.5 – 24.9 kg/m^2, adult overweight as 25 – 29.9 kg/m^2, adult obesity as 30 – 34.9 kg/m^2, and superobesity as greater than 35.0 kg/m^2 (Janssen, Katzmarzyk & Ross, 2004; Health Canada, 2003). These cut-points have been defined as a result of numerous studies of the relationship between BMI with mortality and morbidity outcomes (Dalton et al., 2003). Risk of disease has been found to be positively associated with BMI in numerous studies, including work on fatal coronary heart disease, cardiovascular disease, type II diabetes mellitus, and stroke (Kim et al., 2006; Wannamethee et al., 2005; Janssen et al., 2004; Rabkin et al., 1997; Reeder et al., 1997).

Recent research has determined that the relative distribution of body fat, and more specifically, the distribution of fat in the abdominal region is a greater health risk than, for example, lower-body obesity (Janssen et al., 2002). Accumulation of visceral adipose tissue, or fat surrounding the internal organs, has been shown to be predictive of an increased risk of diabetes and coronary heart disease (WHO, 2000; Ledoux et al., 1997b; Reeder et al., 1997). This new evidence has uncovered an important limitation of BMI as a measure of obesity. Abdominal fat includes both subcutaneous fat (found under the skin) as well as visceral fat (surrounding internal organs) (Health Canada, 2003), and while BMI provides a standardized indicator of excess weight, it does not accurately measure abdominal fatness or adiposity (Janssen et al., 2002; Dobbelsteyn, Joffres, Maclean et al., 2001; Ledoux et al., 1997b). Waist to hip ratio (WHR) has also been suggested as an alternative indicator of abdominal obesity in clinical and research settings (Health Canada, 2003). However, there are a number of drawbacks of using such a measure such as a lack of biological interpretation (Dobbelsteyn et al., 2001), and lack of global cut-points (Ledoux et al., 1997b).

Waist circumference (WC) as an alternative measure of abdominal fat distribution is often used as an effective indicator. Despite being highly correlated with BMI (Chan et al., 2003; Onat, Sansoy, Uysal, 1999; Ledoux et al., 1997a), there is a growing consensus that WC is the more appropriate measure for indicating cardiovascular disease risk. For example, Ledoux et al. (1997a; 1997b) and Reeder et al. (1997) found that WC was more highly correlated with other CVD risk factors such as blood pressure, plasma lipid levels, and risk of diabetes mellitus in comparison to BMI. Furthermore, Dobbelsteyn and colleagues (2001) statistically compared the measures of WC, BMI and WHR with respect to their ability to predict single and multiple cardiovascular disease risk factors by analyzing the sensitivity and specificity of the indices. Their conclusions supported findings by others[10] and suggest that WC is the most appropriate predictor of cardiovascular disease.

Due to lack of epidemiological data using WC as a health outcome, there has been some discussion regarding the recommended cut-points to be used (Health Canada, 2003). The WHO provides two risk categories: (1) increased risk is at greater than or equal to 90 centimetres (cm) for men and 80 cm for women; while (2) substantially increased risk is at greater than 102 cm for men and 88 cm for women (WHO, 2000). These cut-points were determined from a study of

[10] See for example, Janssen et al. (2004; 2002), Dalton et al. (2003), WHO (2000), Reeder et al. (1997), Ledoux et al. (1997).

2183 men and 2698 women aged 20-50 from the Netherlands, and the WHO recommends that different populations should develop unique categories (Health Canada, 2003).

Dobbelsteyn and colleagues (2001) evaluated the WC cut-points as predictors for cardiovascular disease for a study group of 10,000 Canadian adults. The most effective cut-points for this population were comparable to the WHO guidelines (> 90 cm for males, > 80 cm for females) (Dobbelsteyn et al., 2001). Expanding upon this research, a recent study in the United States tested the cut-points of greater than 102 cm for males, and 88 cm for females (high-risk categories) in 14,924 adults grouped by BMI category (Janssen et al., 2002). Results of this study found that within each BMI category, those with high WC values were much more likely to have hypertension, diabetes, and the metabolic syndrome even after controlling for individual behaviours and characteristics. For this thesis, both BMI and WC will be used as measures of overweight and obesity.

3.2.4 Variable Types

The outcome variables were analyzed as continuous variables, or variables that can assume any valid numeric value within a specified range (Maxim, 1999). The independent variables from the CHHS were a combination of both continuous and categorical variables. The variables selected for analyses were chosen based upon theory and the related obesity literature, as well as from literature related to chronic disease outcomes in Canada. The variables of interest at the individual-level related to biology and genetic endowment, social status, and individual behaviours and health practices. Table 3-1 provides a full listing of these variables.

As discussed previously (Chapter 2), a number of measures of the local social and physical environment have been consistently shown to be significant determinants of individual health. A list of the related factors available from the 1991 Canadian census is displayed in Table 3-2. From the original neighbourhood-level profile data, several new variables were either derived through calculation (e.g. Gini coefficient), or recoded into categorical variables before being included in the analyses. The majority of the census variables were categorized as Low (lowest 25% of sample), Middle and High (highest 25% of sample), similar to the strategy employed by King and colleagues (2006) in their multilevel study of obesity in Australia. For each variable, the reference category is shown in bold font.

Table 3-1: Individual-level variables of interest

Variable Name	*Type*	*Units/Categories*
Age	Continuous	Years
Sex	Categorical	Male; **Female**
Education	Categorical	**High School Completed**; High School Not Complete
Partner	Categorical	Partner; **No Partner**
Smoke	Categorical	Regular Smoker; **Non-Smoker**
Sedentary	Categorical	**Physically Active**; Sedentary
Alcohol	Categorical	Drinker; **Non-Drinker**
JobType	Categorical	**Full-Time**; Other
Diabetes	Categorical	Diabetic; **Not Diabetic**
Income	Categorical	**Under $12000**; $12000 - $24999; $25000 - $49999; $50000 and Over
Income_Adequacy	Categorical	**Low Adequacy**; Mid Adequacy; High Adequacy
Househld	Continuous	Number of people per household
Hd_knowledge	Categorical	**Knowledge of at least one risk factor of heart disease**; No mention
Family_History	Categorical	History of CVD in family; **No known history**

Reference categories for categorical variables are in bold

Table 3-2: Contextual-level Variables of Interest

Variable	*Categories*
Area_type*	Rural; **Urban**
Owner	Low; Mid; **High % of homeowners**
Major	**Low**; Mid; High % of homes in need of major repairs
1946	**Low**; Mid; High % of homes build prior to 1946
Dwelling_Value	Low; Mid; **High average dwelling value**
Low_Income	**Low**; Mid; High % of low income individuals
H.S.	**Low**; Mid; High % of individuals without their high school education
Unemploy	**Low**; Mid; High % of unemployed individuals
Household_Income	Low; Mid; **High average household income**
Gini Coefficient*	**Low**; Mid; High income inequality

* Denotes variables derived through calculation before categorization

3.3 Analytic Methods

A range of quantitative methods were applied to the linked database in order to effectively capture the relative contribution of contextual- and individual-level factors to the development of overweight and obesity. Preliminary statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), and R - a syntax-based analysis package (SPSS, 2006; Comprehensive R Archive Network [CRAN], 2006). Bivariate and multivariate models with the two outcome measures were calculated using R, and estimates were confirmed using MLwiN (Centre for Multilevel Modeling, 2006). Finally, multilevel analyses were conducted using MLwiN exclusively following a procedure for multilevel analysis as proposed by Hox (1995), and as presented further in this chapter.

3.3.1 Preliminary Statistical Analyses and Variable Recoding

To begin the preliminary analyses, the outcome variables waist circumference (WC) and body mass index (BMI) were examined to determine which regression model would be the appropriate tool for analysis. The univariate analysis of the outcome variables followed four main steps. Firstly, a number summary was calculated for each variable, which included the first and third quartiles, median, mean, minimum and maximum values. Secondly, a histogram of the variable was graphed along with a density estimation curve, in order to assess the overall distributions of the variables. After determining that the distributions were approximately normal, the density estimation curve was graphed on top of a normal curve with a 95% confidence envelope again to assess the overall shape of the distributions. Finally, a box-whisker plot of each variable was examined to estimate the extent and number of outlying cases.

For both outcome variables, the distributions were approximately normal, and the relationships with continuous independent variables were close to linear relationships. These two facts indicate that ordinary least squares (OLS) regression was an appropriate method of modeling the data. When the assumptions of OLS regression are satisfied, as they were for these data, the estimators produced by the regressions are the best available linear unbiased estimators (Fox, In Press). In particular, the means of the sample distributions for each outcome variable, BMI and WC, accurately measure the central tendencies of their distributions.

Preliminary analyses of the remaining continuous, independent, individual-level variables followed similar steps as were applied to the outcome variables. Categorical variables were assessed using frequency analyses. Based on these preliminary univariate analyses, independent variables at the individual-level were recoded as follows: EDUCATION, EMPLOYMENT TYPE, and MARITAL STATUS were dichotomized into binary variables with categories HIGH SCHOOL - COMPLETED versus HIGH SCHOOL - NOT COMPLETED, FULL-TIME EMPLOYMENT versus OTHER, and MARRIED/COMMON LAW versus OTHER, respectively.

3.3.2 Bivariate and Multivariate Analyses

As discussed previously in this chapter, the variables of interest (Tables 3-1, 3-2) selected for univariate analyses were originally selected based upon theory and the literature. The next step in the analysis was to assess the relationship between these variables and the outcome variables, BMI and WC, using simple bivariate OLS regressions, scatterplots for continuous variables, and side-by-side box-whisker plots for categorical variables. Scatterplots and side-by-side box-whisker plots were used to identify any unusual or outlying cases in the data, and to provide a graphical representation of the relationship between the independent and dependent (outcome) variables to assess linearity (Maxim, 1999). Further, p-values for simple regressions on each outcome variable were calculated for every individual-level covariate as a preliminary indicator of which variables would ultimately emerge as significant in the multivariable models.

Following the simple regression analyses, all variables found to be statistically significant ($p < 0.05$) were included in a full multivariate regression model, which was properly weighted to the clinical weighting variable available with the CHHS data (PWGTC). Multivariate regression is a popular statistical method in the social sciences for studying relationships between multiple independent variables and a singular outcome variable (Maxim, 1999). The multivariate model with *n* independent variables can be described by equation (1):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon \qquad (1)$$

Where Y is the outcome variable, β_0 is the intercept, β_i is the slope coefficient for the independent variable X_i, and ε represents the vector of errors terms for each observation.

In total, three full models were constructed for each outcome: a combined model including all cases, and sex-stratified models for males and females exclusively. Men and women were analysed separately to accommodate for any differences in the determinants of BMI and WC (King et al., 2006).

Missing cases in the individual-level independent variables were apparent in two variables, EDUCATION, and INCOME. In order to include more cases in the final analyses, two separate approaches were adopted. Firstly, values were interpolated using a hot-deck imputation approach (Law, Wilson, Eyles et al., 2005; Maxim, 1999). This technique stratifies the sample based on age, sex, and employment status, and for each missing value, one case with the same characteristics is chosen randomly and acts as a donor value for substitution. Only six missing values were imputed for EDUCATION, while 451 missing cases were imputed for INCOME. The second approach to these missing cases still used the hot-deck procedure to substitute values for EDUCATION, however, since the proportion of missing cases was so high for the INCOME variable (17.77%), the missing cases were also categorized and analysed separately to explore any discernible trends. The results of this analysis can be found in the following chapter of this thesis.

An all-subsets method based upon the adjusted R^2 statistic was used to select an optimal subset of variables from the full model for further investigation (CRAN, 2006). A backwards stepwise selection method (based on a maximum likelihood estimator; the Akaike Information Criterion (AIC)) was then used to confirm these results. Following the subset selection from each of the six full models, a Type II Analysis of variance (ANOVA) test was used to test the significance of each variable to the overall fit of the model[11] (Fox, In Press). All variables found to be statistically significant after the Type II ANOVA test ($p < 0.05$) were selected for inclusion in the final regression models.

After computing a multivariable regression, it is important to apply several regression diagnostics to ensure that the assumptions of the OLS linear model have been met, and to investigate any potential influential observations (Fox, In Press). Outliers and observations with a high level of influence on the regression

[11] Also at this stage in the analysis, variables found to be consistently significant elsewhere in the obesity literature were forced into the model, and subsequently left in the model, or removed based on the results of the Type II ANOVA test

surface were examined using an outlier test and an influence plot, respectively (CRAN, 2006). No cases were found to have a large enough influence on the regression to warrant removal from the analyses.

In terms of the regression surfaces, a plot of the studentized residuals of the models was computed first to assess the distribution of the errors. All models were found to have normally distributed errors. Secondly, a plot of the studentized residuals against the fitted values for the model was used to assess the pattern of the error variance. No systematic pattern was discernible; that is, it was clear that the error variance was relatively constant around the mean studentized residual ($\mu = 0$). Finally, the generalized variance inflation factor for each variable was computed to identify any mutlicollinearity in the regression. No collinearity was present for any of the six models. To summarize, the models satisfied the three main assumptions of the multivariate linear model; normally distributed errors, constant error variance, and no apparent collinearity. Thus, the six multivariate regression models computed as described above accurately represented the trends in the data.

3.3.3 Multilevel Modeling

Multilevel modeling was the final stage of analysis employed in this thesis, and serves as the central method for addressing the second and third objectives outlined previously in this chapter. Analysis of hierarchically structured data has long been of interest to social scientists and statisticians alike. These are data collected from a random sample of micro-units (individuals) heterogeneous within macro-units (contexts) at a higher level, upon which data may also be collected (Goldstein, 1991).

Many populations have naturally occurring hierarchical structures, the most discernible structure being the focus of this research: individuals clustered in geographical areas (Juhn et al., 2005; Boslaugh et al., 2004; Pampalon et al., 1999). Whether they are social or geographical, it is possible that individual characteristics are influenced by the contexts in which they are clustered, so-called *contextual effects*. Likewise, *compositional effects* may also exist, whereby the individuals composing a particular group influence the properties of that group (Kreft, 1998). As a result of these effects, responses (e.g. health outcomes) from individuals may not be independent, since individuals within the same groups may share influencing characteristics. It has become increasingly apparent in recent years that it is necessary to employ a method able to separate compositional and contextual effects (Duncan et al., 1998). Multilevel modeling uses information from all levels and considers this information simultaneously. Such techniques provide one with a means of assessing the variation in a particular response that can be attributed to each level (Goldstein, 1991). Multilevel modeling represents a movement in the field of health geography towards more contextualized research, and provides a means of capturing and quantifying *place effects* (Kearns & Moon, 2002).

3.3.3.1 Why Multilevel Modeling?

Traditional methods of analyzing hierarchical data forced a decision between one of two mutually exclusive choices; aggregation or disaggregation (Garson, 2007). However, a number of substantial methodological issues arise in each of these cases (Duncan et al., 1998). Aggregation forces individual-level data to be aggregated to the higher contextual-level, and subsequent analysis is performed on the averages for each contextual unit. In addition to clearly preventing any cross-level interaction analysis, another frequently occurring problem in using this method is referred to as the *ecological fallacy* (Snijders & Bosker, 2000; Duncan et al., 1998). The ecological fallacy states that inferences made at the contextual-level may not necessarily reflect the relationships at the individual-level (Robinson, 1950). One hypothetical example of this might be as follows: if it is found that high rates of obesity are found to be associated with low levels of education at the neighbourhood level, it may in fact be that individuals in that particular area that are obese are those individuals with higher levels of education, and not necessarily the apparent relationship produced through ecological analyses.

Similar issues arise if contextual-level variables are disaggregated to the individual level. Using this method, contextual effects on the individuals are disregarded, and what is known as the *atomistic fallacy* may be committed (Duncan et al., 1998). Disaggregation results in a multiplication of the number of units to be considered. For example, if 5 individuals are sampled from each of 10 neighbourhoods, disaggregating the neighbourhood-level variables to the individual level ignores the fact that some individuals are from the same neighbourhood, and possibly influenced by the characteristics of that area. This method then assumes that there are 50 independent observations, when in fact there are only 10 independent observations; the 10 neighbourhoods (adapted from an example in Snijders & Bosker, 2000). This single-level model would traditionally be analysed using multiple regression techniques, which assume that the error terms of individual observations are not correlated, when in fact they could be related due to living in the same neighbourhood (Duncan et al., 1998). As a result of breaking this assumption, any analysis between neighbourhoods would result in a higher frequency of Type I errors; finding relationships where none exist (Kreft & Leeuw, 1998). Conversely, when examining within-context relationships, the probability of committing a Type I error would be too low (Snijders & Bosker, 2000). It is clear that when examining clustered data, especially when a health outcome is the outcome if interest, it is necessary to use a method that leads to correct inferences about relationships within a particular sample.

3.3.3.2 The Multilevel Model

As an alternative method to these traditional techniques, multilevel modeling (synonymous with hierarchical linear modeling, mixed linear models, variance component models) uses maximum likelihood estimation (MLE) to compute estimates for a single dependent variable at the base, or individual-level (Garson, 2007). Additional independent variables at the individual-level may be added much like in the OLS multivariate regression equation (1). Equation (2) represents the individual-level equation in a multilevel model.

$$Y_{ij} = \beta_{0j} + \beta_{1j}X_{1ij} + \beta_{2j}X_{2ij} + \ldots + \beta_{nj}X_{nij} + \varepsilon_{ij} \qquad (2)$$

In the OLS model, it is assumed that all regression coefficients are fixed in each context. That is, in equation (2) neighbourhood membership is ignored, and the slope coefficients ($\beta_{1j}, \ldots, \beta_{nj}$) and intercept ($\beta_{0j}$) are equal for each individual 'i' in each group 'j' (Kreft & Leeuw, 1998). However, in a multilevel model, the regression of the individual-level variables on the individual-level outcome variable is performed for each group. Further, so-called *moderator* variables at the neighbourhood level can be added to the model to determine if any characteristics of neighbourhood moderate the relationships between variables at the individual-level (Snijders & Bosker, 2000; Goldstein, 1995). That is, each slope coefficient (or intercept) can be written as a linear combination of a group level intercept, *m* group level variables, and a group level error term as in equation (3).

$$\beta_{0j} = \gamma_{00} + \gamma_{10}Z_1 + \ldots. + \gamma_{m0}Z_m + R_{0j} \qquad (3)$$

Where γ_{00} represents the average intercept for context 'j', and R_{0j} represents the contextual-level error term. The neighbourhood-level variables ($Z_1, \ldots, Z_m$) are included to try to explain variability in the random slopes and intercepts at the individual-level. Analysing the data in this manner allows slope coefficients and intercepts to vary between neighbourhoods (contexts) (Garson, 2007).

Assessing the proportion of total variation attributed to contextual effects is a relatively important tool, and central to completing the third objective of this thesis. The variation due to each level in the model can be calculated as a proportion of the total variation (Goldstein, 1995). For example, the intraclass correlation coefficient is defined as the degree of resemblance among individuals within the same contexts (Snijders & Bosker, 2000). This measure defines the proportion of the total variation that can be attributed to the neighbourhood-level. The presence of a significant intraclass correlation in a model strengthens the adoption of multilevel modeling as an alternative to traditional regression methods, as it confirms the presence of statistically significant variation at the area level (Garson, 2007).

Finally, multilevel model fit is assessed using a deviance statistic, which is defined as minus two times the log likelihood produced by the MLE (Kreft & Leeuw, 1998). The deviance statistic produced for one individual model is difficult to evaluate, however, the difference between deviances for two models on the same data set can be used to measure improvement of model fit (Snijders & Bosker, 2000). A chi-square test can be performed on the difference between deviances to see if one model is significantly different from the previous model. If it is not, then typically the model with fewer variables is selected (Garson, 2007). The following section discusses the steps followed when building the multilevel models analysed throughout this research.

3.3.3.3 Building the Multilevel Models

The steps followed to construct the multilevel models of interest in this thesis are based upon the procedure outlined by Hox (1995). Firstly, the deviance statistic was computed for the null model which includes only the intercept, to test for significant area-level variation. Secondly, the deviance was computed for the model that included individual-level independent variables, as selected by the multivariable regression procedure. The random variance components of the slope coefficients were constrained to zero, creating a random intercept model, whereby the intercept is allowed to vary between neighbourhoods. A chi-square difference test was conducted to see if the random intercept model had a better fit than the intercept only model, and non-significant individual-level variables ($p > 0.05$) were excluded from the model.
Next, the slope coefficients for the continuous variables were allowed to vary by neighbourhood. Deviance statistics were computed at each stage, and non-significant slopes were constrained back to zero. These steps constructed the individual-level basis for the multilevel model.

Next, neighbourhood level modifier variables were included in the model individually, and again the deviance statistic was used to determine which variables improved model fit. Those that were not significant were removed from the model. Finally, Hox (1995) suggests that cross-level interactions between neighbourhood level variables and variables that have slope variance be assessed at this point. However, since no variables had significant slope variance, this step was not necessary. Following these steps resulted in the construction of six random intercept models for final evaluation.

3.4 Summary

This chapter reviewed the quantitative methodologies used to meet the objectives of this thesis, as well as information regarding data collection and data linkage. The final linked data built upon the OHHS data, as well as data from the 1991 Canadian census which was linked to the individual-level data at the neighbourhood level. Theory and preliminary statistical analyses were used to inform the construction of the multivariate regression models as well as the final multilevel models. Finally, statistics based upon the multilevel models were used to identify individual- and contextual-level covariates of overweight and obesity. Further, the intraclass correlation coefficient was used to determine the relative contributions of individual- and neighbourhood-level factors to the development of these conditions. The following chapter will present the results of the multivariate regression analyses.

CHAPTER FOUR INDIVIDUAL-LEVEL RISK FACTORS FOR OVERWEIGHT AND OBESITY

This chapter presents the results of the preliminary descriptive and multivariate regression analyses carried out to address the first research objective:

> 1) To investigate the relationships between specific individual-level determinants of health and weight status.

As mentioned in the previous chapter, six multivariate regressions were calculated: a male-only model, a female-only model, and a combined model for each of the outcome variables: BMI and WC. These models then served as the individual-level base upon which the multilevel models presented in the following chapter were built.

4.1 Preliminary Analyses

4.1.1 Sample Characteristics

Table 4-1 presents a demographic and socioeconomic profile of the sample from the OHHS. As indicated by the table, there was a relatively even distribution of males and females, and the majority of participants had completed their secondary school education. In terms of income, the category with the most responses suggests that the majority of participants earned $50,000 or greater in the previous year. However, a substantial number of participants refused to provide information for this variable, a point that will be revisited later in this chapter. Finally, the majority of the participants were married or living common law (65%). Although it is important to recognize the composition of this sample, for the purposes of this thesis, the sample will be weighted to the age-sex categories of the population of Ontario, circa 1991 (approximately 7 093 000 (CHHDBC, 1997)).

Table 4-1: Descriptive Statistics

	Count	*Percent*
Age		
18-24	351	13.83 %
25-34	891	35.11 %
35-44	397	15.64 %
45-54	217	8.55 %
55-64	175	6.90 %
65-74	507	19.98 %
Total	**2538**	**100%**

Sex		
Male	1259	49.61 %
Female	1279	50.39 %
Total	**2538**	**100%**
Education		
HS Complete	650	25.61 %
HS Not Completed	1882	74.15 %
N.A.	6	0.24 %
Total	**2538**	**100%**
Income		
Under $12000	158	6.23 %
$12000 – 24999	298	11.74 %
$25000 – 49999	675	26.60 %
$50000 and over	956	37.67 %
N.A.	451	17.77 %
Total	**2538**	**100%**
Marital Status		
Partner	1650	65.01 %
No Partner	888	34.99 %
Total	**2538**	**100%**

4.1.2 Prevalence of Overweight/Obesity Outcomes

It is important to explore the prevalence of the two overweight outcomes of interest within the sample. Table 4-2 presents the frequency of BMI categories, as well as the two risk categories for WC identified in Chapter 2. Specifically, the categories of interest for BMI are *normal weight*, defined as 24.9 kg/m^2 or less; *overweight* (25.0 – 29.9 kg/m^2); *obese* (30 – 34.9 kg/m^2); and *superobese*, which is defined as ≥ 35.0 kg/m^2 (Janssen et al., 2004; Health Canada, 2003; WHO, 2000). In terms of WC, there are two specific risk categories identified by the WHO (2006a), and others (e.g. Health Canada, 2003; Dobbelsteyn et al., 2001). *Increased risk* is defined as having a WC greater than 90 centimetres for males, and greater than 80 centimetres for females. *Substantially increased risk* indicates that the WC exceeds cut points of 102 centimetres, and 88 centimetres for males and females respectively.

From Table 4-2, we can see that approximately 37% of the total OHHS sample can be classified as overweight. Based on only the participants who had their BMIs measured (n=1 985), this number climbs to almost 48%. The classifications of participants whom were overweight, obese, and superobese make up 26.9%, 7.5%, and 2.88% of the sample respectively. Percentages based only on those respondents who had their BMIs measured increase to 34.4%, 9.6%, and 3.7% respectively. In general, males had much higher rates of overweight (42.9%) than females (25.69%), while the rates of obesity were reversed, (although comparable) between the sexes (12.6% for males, and 13.9 % for females). Since the prevalence of overweight and obesity were so substantial, it was reasonable to assume that this data set would be an appropriate platform for the quantitative analyses proposed in the previous chapter of this thesis.

Table 4-2: BMI outcome distribution

BMI Category (kg/m^2)	*Count*	*Percent*	*Valid Percentage*
≤ 24.9	1040	40.97 %	52.39 %
25 – 29.9	682	26.87 %	34.36 %
30 – 34.9	190	7.49 %	9.57 %
≥ 35.0	73	2.88 %	3.68 %
N.A.	553	21.79 %	
Male BMI Categories			
≤ 24.9	445	35.35 %	44.50 %
25 – 29.9	429	34.07 %	42.90 %
30 – 34.9	105	8.33 %	10.50 %
≥ 35.0	21	1.67 %	2.10 %
N.A.	259	20.57 %	
Female BMI Categories			
≤ 24.9	595	46.52 %	60.41 %
25 – 29.9	253	19.78 %	25.69 %
30 – 34.9	85	6.65 %	8.63 %
≥ 35.0	52	4.07 %	5.28 %
N.A.	294	22.99 %	

In terms of WC (Table 4-3), approximately 44% of males were classified as being in the first risk category, while 15% of males were classified as being at a substantially increased risk. Based on those males who had their WCs measured (n=1 012), these percentages increase to 54%, and 18% respectively. Examining the female WC categories indicates that approximately 31% of female respondents fall into the first risk category, with 18% being at a substantially increased risk. Further, based on only those female participants who had their WCs measured (n=994), these rates increase substantially to 40% and 23% respectively. The preliminary analysis of BMI and WC suggest that overweight and obesity are quite prevalent in the OHHS sample, making this particular sample an ideal candidate for the proposed analysis as outlined in Chapter 3.

Table 4-3: Waist Circumference outcome distribution

Waist Category (cm)	*Count*	*Percent*	*Valid Percentage*
Risk Category 1			
Males ≥ 90	551	43.76 %	54.45 %
Males < 90	461	36.62 %	45.55 %
N.A.	247	19.62 %	
Risk Category 2			
Males ≥ 102	185	14.69 %	18.28 %
Males < 102	827	65.59 %	81.72 %
N.A.	247	19.62 %	
Risk Category 1			
Females ≥ 80	399	31.20 %	40.14 %
Females < 80	595	46.52 %	59.86 %
N.A.	285	22.28 %	
Risk Category 2			
Females ≥ 88	232	18.14 %	23.34 %
Females < 88	762	59.58 %	76.66 %
N.A.	285	22.28 %	

4.1.3 Income Analysis

Before proceeding with the presentation of the multivariate regression results, it is important to acknowledge the demographic characteristics of respondents whom did not report their income category. Income has been found to be an important socioeconomic indicator of health outcomes and behaviours, including cardiovascular disease risk factors (Diez-Roux, 2000; Kaplan & Keil, 1993), and obesity (Sundquist et al., 1999; Ellaway et al., 1997). Since the non-response for the income variable was high (n=451, 17.7%), an analysis of the participants whom did not report income is a useful exercise.

A frequency analysis of income stratified the variable by sex, age, and education, the results of which are presented in Table 4-4. There was a higher probability of non-report in females, older persons, and those individuals that had not completed a secondary school education. More specifically, of the total 451 missing cases, 20.6% of females (n=259), 21.1% of older persons (n=107), and 23.4% of those not having completed high school (n=152) did not report their income.

Table 4-4: INCOME stratified by age, sex and education

	Non-Reports	*Total*	*Percent*
SEX			
Males	192	1279	15.0%
Females	**259**	**1259**	**20.6%**
AGE			
18-34	222	1242	17.9%
35-64	122	789	15.5%
66-74	**107**	**507**	**21.1%**
EDUCATION			
<High School	**152**	**650**	**23.4%**
High School Complete	219	1240	17.7%
University/College	77	642	12.0%

These results are consistent with other findings in the health literature regarding non-disclosure of income information (e.g. Law et al., 2005). The missing values were handled in two different ways in terms of the regression analyses (see Chapter 3); hot-decking and categorization. In both cases, income was not found to be statistically significant in bivariate or multivariate regression analyses, nor did it emerge as significant in the multilevel analyses with either outcome variable. This finding is quite interesting, as income is frequently found to be a statistically significant predictor of overall health status, and specific health outcomes including obesity (e.g. Brown, Guy & Broad, 2005; Chaix & Chauvin, 2003; Cubbin, LeClere & Smith, 2000; Cairney & Wade, 1998). Results discussed further in this chapter will present evidence that an alternative socioeconomic variable acts as a more important indicator of overweight and obesity in this research.

4.2 Multivariate Regression Results

To allow for the calculation of population estimates, all multivariate regressions were weighted to the age-sex categories of the 1991 Ontario population using the clinical weighting variable PWGTC (see Chapter 3). Throughout these analyses, the outcome variables were treated as continuous variables, allowing for accurate estimates of the relationships between BMI and the individual-level independent variables. Further, although all individual-level variables of interest (Table 3-1) were entered into the multivariate models, only those that emerged as statistically significant have been included in the final models presented here. The regression results are presented as β estimates, and may be interpreted as the absolute change in BMI or WC associated with a one unit increase in the independent variable, when controlling for all other covariates present in the model (Maxim, 1999).

4.2.1 Body Mass Index

To allow for simple comparisons between the male, female, and combined models, only the estimates are presented in the tables below. For a more detailed presentation of the results, refer to Appendix E, which includes information regarding the standard errors, p-values, and 95% confidence intervals for each covariate. The ordinary least squares (OLS) regression on body mass index (BMI) for each of the combined, male, and female cases is displayed in Table 4-5.

Due to missing data, the combined model was based on approximately 78.1% of the 2 538 cases (n=1 981). The independent variables that were significant in the final combined BMI model include: age in years, sex, education, partner (married or common law), and behavioural variables capturing smoking status, and physical activity. The value of the intercept for this model indicates that while controlling for various other individual-level variables, the average body mass index across all participants in all areas was 21.578 kg/m^2 (95% CI: [20.91, 22.25]). The adjusted R^2 for this model was 0.09687, which indicates that approximately 9.7% of the total variation in BMI was captured by the regression on these six variables.

The regression coefficient of age indicates that an increase in a participant's age by one year was significantly associated with a corresponding increase in BMI of approximately 0.057 kg/m^2 (95% CI: [0.043, 0.071]), while holding all other variables constant. This first finding represents the typical positive relationship between age and BMI (CHHSRG, 1997). A number of dichotomous categorical variables were also found to be associated with higher levels of BMI. Being male, not having completed a secondary school education, having a partner, and living a sedentary lifestyle were each found to have a significant positive relationship with BMI.
Specifically, males displayed a BMI that was 0.657 kg/m^2 (95% CI: [0.285, 1.029]) higher than females on average. Similarly, those participants with less than a secondary school education had BMIs that were significantly higher (0.985 kg/m^2, 95% CI: [0.520, 1.450]) than those who had completed at least their high school education. Being married or living common law predicted a higher BMI by 0.666 kg/m^2 (95% CI: [0.266, 1.066]), as did living a sedentary lifestyle during the past month; predicting a BMI that was 1.097 kg/m^2 (95% CI: [0.713, 1.481]) higher than relatively more active participants on average. In addition to these variables that predicted a higher BMI, self-reported regular smoking was also

found to be significant, however, this particular behaviour predicted a lower BMI by 0.480 kg/m^2 (95% CI: [-0.950, -0.009]).

Due to missing data, the male BMI model was based upon 79.3% of the total 1259 male participants (n=998). The value of the intercept for this model, 23.838 kg/m^2 (95% CI: [22.852, 24.824]) represents the average BMI across all males from all areas, while holding all other variables present in the model to a constant value. This value was larger than the average across all respondents by 2.26 kg/m^2. The adjusted R^2 statistic for the regression on male BMI was 0.1003, indicating that approximately 10% of the total variation in male BMI was captured by the regression on these five variables.

Table 4-5: BMI multivariate regression analyses

	Combined BMI	*Male BMI*	*Female BMI*
(Intercept)	21.578 ***	23.838 ***	21.249 ***
Age (years)	0.057 ***	0.040 ***	0.068 ***
Sex			
Male	0.657 ***	---	---
Female	---	---	---
Education			
HS Not Complete	0.985 ***	0.557 *	1.312 ***
HS Completed	---	---	---
Marital Status			
Partner	0.666 **	0.994 ***	N/S
No Partner	---	---	---
Jobtype			
Full-Time	---	---	---
Other	N/S	-0.709 **	N/S
Household	N/S	-0.229 **	N/S
Smoking Status			
Regular Smoker	-0.480 *	N/S	N/S
Non-Smoker	---	---	---
Physical Activity			
Sedentary	1.097 ***	0.907 ***	1.234 ***
Physically Active	---	---	---

Diabetic Status			
Diabetic	N/S	N/S	1.650 *
Not Diabetic	---	---	---
Model Adjusted R^2	0.0969	0.1003	0.0990

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05; 'N/S' Not Significant

Four variables that were significant in the full data model were found to have statistically significant effects on male BMI: age, education, marital status, and physical activity levels. Specifically, for each increase of one year in age, the average male BMI increased by 0.040 kg/m^2 (95% CI: [0.020, 0.060]), although this relationship was not quite as strong as the relationship presented in the combined model. Similarly, not having completed a secondary school education, and living a sedentary lifestyle for the past 30 days were also significantly associated with a higher BMI by 0.557 kg/m^2 (95% CI: [0.038, 1.076]), and 0.907 kg/m^2 (95% CI: [0.454, 1.360]) respectively.

Being married/common law married had a stronger relationship with BMI in the male only model. That is, males that reported having partners were associated with having a BMI approximately 0.994 kg/m^2 larger than male participants without partners (95% CI: [0.433, 1.555]). In addition to these four variables that were also represented in the full data model, two new variables emerged as having statistically significant effects on male BMI. The variable household represents the number of persons living in a participant's home. The regression coefficient for household in the BMI model indicates that when controlling for all other variables in the model, an increase of one additional person living in the participant's home, was associated with a decrease in BMI by 0.229 kg/m^2 (95% CI: [-0.383, -0.075]). Further, male respondents whom worked full-time were associated with a BMI that was, on average, 0.709 kg/m^2 (95% CI: [0.213, 1.205]) higher than respondents with other types of employment.

Finally, Table 4-5 also displays the final regression model for female BMI, based upon 76.9% of the 1 279 cases from the CHHS Ontario data (n=983). The intercept value for this model indicates that the average BMI for all female participants across all areas was 21.25 kg/m^2 (95% CI: [20.302, 22.196]) when controlling for age, education, physical activity levels and diabetic status. The adjusted R^2 statistic for this model was 0.099, indicating that 9.9% of the variation in female BMI across all individuals was captured by the regression on four individual-level variables.

As expected, age was positively associated with the BMI variable at a statistically significant level. Specifically, each increase in one year of age in a female participant was associated with an average increase of 0.068 kg/m^2 (95% CI: [0.046, 0.090]). Further, this variable was more strongly associated (by 0.028 kg/m^2) with a larger BMI than the relationship observed in the male only BMI model, a preliminary indicator that age may have more impact on weight status in females than in males.

Level of education remained as the only significant socioeconomic indicator in this model, suggesting that females whom had not completed their secondary school education had a BMI which was, on average, 1.312 kg/m^2 larger than those whom had completed their high school education (95% CI: [0.557, 2.067]). Living a sedentary lifestyle for the past month was the only statistically significant behavioural variable in the female only model. In particular, the model suggests that sedentary females had BMIs which were approximately 1.234 kg/m^2 (95% CI: [0.60, 1.861]) larger than relatively more active females.

Finally, self-reported diabetic status was found to be positively associated with BMI, which was not apparent in either the full data or male only BMI regressions. Females whom reported having clinically diagnosed diabetes were found to have larger BMIs in general, by approximately 1.65 kg/m^2 (95% CI: [0.019, 3.28]). This relationship was significant at the 0.05 level, after controlling for age, education and physical activity.

4.2.2 *Waist Circumference*

Table 4-6 presents the combined (male/female), male, and female OLS multivariate regression models on the dependent waist circumference (WC) variable. Due to missing data, the combined model was based upon approximately 79% of the 2538 total participants (n=2 002). The intercept coefficient for this model indicates that while controlling for age, sex, education, behavioural variables, and diabetic status, the average WC across all areas was 65.07 centimetres (cm) (95% CI: [62.634, 67.498]). The adjusted R^2 statistic for this model was 0.3606, which indicates that approximately

Table 4-6: WC multivariate regression analyses

	Combined WC	*Male WC*	*Female WC*
(Intercept)	65.066 ***	71.713 ***	68.329 ***
Age (years)	0.259 ***	0.310 ***	0.217 ***
Sex			
Male	11.524 ***	---	---
Female	---	---	---
Education			
HS Not Complete	2.237 ***	N/S	3.323 ***
HS Completed	---	---	---
Household	N/S	-0.582 **	N/S
Smoking Status			
Regular Smoker	-1.853 **	N/S	-1.893

Non-Smoker	---	---	---
Physical Activity			
Sedentary	4.025 ***	3.310 ***	4.975 ***
Physically Active	---	---	---
Diabetic Status			
Diabetic	5.949 ***	3.223 *	8.315 ***
Not Diabetic	---	---	---
Alcohol			
Drinker	2.288 *	7.552 **	N/S
Non-Drinker	---	---	---
Model Adjusted R^2	0.3606	0.2295	0.1896

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05; 'N/S' Not Significant

36% of the total variation in waist circumference was captured by the regression on age, sex, education, diabetic status, smoking status, physical activity, and alcohol consumption.

Much like the full BMI model, the demographic variables were associated with WC in the expected direction. The regression coefficient for age indicates that with every increase of one year, WC increased by approximately 0.26 cm (95% CI: [0.224, 0.294]). Additionally, it is clear that males had a larger WC than female participants by 11.524 cm, on average (95% CI: [10.591, 12.457]). The difference in WC between males and females reported here supports the definition of sex-specific cut-points for WC risk categories adopted by the World Health Organization (90 cm for males, and 80 cm for females) (2006a).

When examining the effects of the socioeconomic variables at the individual level, education was the primary indicator of weight status as measured WC. In particular, those respondents whom had not completed their secondary school education exhibited a WC that was 2.237 cm (95% CI: [1.084, 3.389]) larger than those respondents with at least a high school education. It is important to note that, as in the BMI model, income did not emerge as a significant variable.

In terms of the biological variables available in the CHHS, self-reported diagnosed diabetes was the only variable that exhibited a significant effect on WC. The regression coefficient indicates that, when controlling for all other variables in the model, being diabetic was associated with a larger average WC of 5.949 cm (95% CI: [3.632, 8.266]) in comparison to non-diabetics. However, since the CHHS are of cross-sectional design, the direction of this relationship cannot be determined. Hence, the variable was included as a control variable, with no speculation as to the causality.

Finally, three behavioural variables were found to have a significant impact on individual waist circumference. Two of these, living a sedentary lifestyle for the past month and being a current drinker, were associated with larger WCs. In particular, sedentary individuals had larger WCs by 4.025 cm (95% CI: [3.074, 4.976]), while drinkers had larger recorded WCs by an average of 2.288 cm (95% CI: [0.185, 4.391]), although the statistical strength of the latter association was not as strong as some other variables in the model. The third behavioural variable that emerged as significant was self-reported smoking status. Similar to the BMI model, being a current smoker was associated with a smaller WC in general, by 1.853 cm (95% CI: [-3.035, -0.671]).

In addition to the combined models, males and females were also analysed separately in an effort to capture any differences in the determinants of increased WC between sexes. The male WC model was based upon data from 1 012 of the 1 259 male respondents (80.4%). The intercept value for the male model indicates the average waist circumference in centimetres across all males from all areas was 71.713 cm (95% CI: [66.397, 77.029]) after controlling for all other variables present in the model. This value is approximately 6.65 cm larger than the intercept value for the full data model, which can be expected since male waist circumference is typically found to be larger for males than females (Janssen & Katzmarzyk, 2004). The adjusted R^2 statistic for this model indicates that approximately 23% of the variation in male WC was captured by the regression.

As expected, age was positively associated with male WC and the estimate indicated a stronger relationship than was represented in the combined model. Specifically, each increase in age of one year corresponded to an average increase in WC of 0.31 cm (95% CI: [0.265, 0.355]). Self-reported diagnosed diabetes emerged as having a significant effect on male WC, as it did in the full data model, although the relationship was less strong (see Appendix E). Being a diabetic male was associated with an increased WC of 3.223 cm (95% CI: [0.408, 6.038]).

Two behavioural variables found to be significant to the full data model remained statistically significant in the male only regression. Living a sedentary lifestyle was very strongly associated with a larger male WC by 3.310 cm (95% CI: [2.087, 4.533]), as was being a drinker (7.552 cm, 95% CI: [2.922, 12.182]). Finally, similar to the male only BMI model, number of people living in the household was found to be negatively associated with male waist circumference. With each additional person living in the participant's household, WC decreased by 0.582 cm (95% CI: [0.189, 0.998]) on average.

The female WC regression model was based upon 992 of the 1279 female respondents (77.6%). The intercept value for this model indicates that the average WC across all females from all areas was 68.329 cm (95% CI: [66.081, 70.577]) after controlling for the five individual-level variables including age, education, behavioural variables and diabetic status. The adjusted R^2 for this particular regression was 0.1896, which indicates that approximately 19% of the individual-level variation in female WC was captured by its regression on the five individual-level covariates.

Age was positively associated with female WC at a highly significant level. In particular, each increase of one year corresponded to an increase in WC of 0.217 cm (95% CI: [0.164, 0.270]), when holding all other variables constant. This relationship was not as strong as the association found in the male only model (see Appendix E). This result was the opposite of the differences in the age-outcome relationships found for sex-stratified regressions on BMI.

Contrary to the results presented in the male only WC model, the estimates displayed for the female only model indicate that education was very strongly associated with WC. Specifically, females whom had not completed their secondary school education had, on average, WCs that were 3.323 cm (95% CI: [1.575, 5.071]) larger than those who were at least high school educated. This relationship was also much stronger (by 1.086 cm) than the relationship found in the full data WC model.

Two behavioural variables were found to have a statistically significant impact on female WC. First, being a self-reported regular smoker was associated with having a smaller WC. Females whom reported being a smoker had, on average, WCs that were 1.893 cm smaller (95% CI: [-3.661, -0.0125]) than former smokers, or non-smoking females. Secondly, living a sedentary lifestyle for the past month was associated with a larger WC after controlling for all other variables in the model. In particular, being sedentary predicted a larger WC by approximately 4.975 cm (95% CI: [3.523, 6.427]).
Finally, diabetic status was found to be associated with a larger WC at a statistically significant level, as it was in both the full data and male only models. Specifically, having diabetes was associated with a larger WC of, on average, 8.315 cm (95% CI: [4.436, 12.194]).

4.3 Discussion

In general, the associations between demographic variables and the outcome measures echo the findings of other studies throughout the obesity literature. For example, male BMI and WC were found to be significantly higher than female values by 0.657 kg/m^2, and 11.52 cm respectively, after controlling for all other significantly associated variables in the combined models. This is a common result found throughout the obesity literature, and is the central reasoning underlying different cut-points for male and female WC (CIHI, 2004). Across all six models, age was positively associated with weight status as measured by BMI and WC. In terms of BMI, the relationship between an increase in one year of age and BMI was more strongly represented for females (0.068 kg/m^2) than males (0.040 kg/m^2). However, the opposite was true for the WC outcome. Each increase of one year of age was associated with an increase in WC of 0.22 cm for females, and 0.31 cm for males. Due to their strong association with overweight and obesity, age and sex are typically included as control variables in the majority of quantitative obesity research (McTigue, Larson, Valoski et al., 2006; Trakas et al., 1999; Cairney & Wade, 1998; Ledoux et al., 1997b; Macdonald et al., 1997).

Education emerged as statistically significant in all models with one exception, the male only WC regression. Completion of a secondary school education has been linked to economic and social advancement within the context of developed countries, and thus provides an accurate indicator of individual socioeconomic status (Isaacs & Schroder, 2004). Typically, individuals with lower levels of education have higher BMI values (Zhang & Wang, 2004; Macdonald et al., 1997). Similar relationships were present in the full data (0.985 kg/m^2 larger), male only (0.557 kg/m^2 larger) and female only (1.312 kg/m^2 larger) results found in this research. Additionally, not having completed a high school education was associated with a larger WC in both the combined and female only regressions, by 2.237 cm and 3.323 cm respectively.

In terms of socioeconomic variables, this research also explored the relationships between BMI/WC and income, income adequacy, marital status, number of individuals living in the home, and occupation type. As mentioned previously, neither income, nor income adequacy were found to be significant at any level in any of the six models. Having a partner was associated with an increased BMI in both the full data and male only models by an average of 0.666 kg/m^2 and 0.994 kg/m^2 respectively. This finding is similar to the results reported by Cairney and Wade (1998) that individuals with partners were at an increased risk of being obese compared to single individuals (Odds Ratio [OR] = 1.21, 95% CI: [1.03, 1.41]). Although from the results presented above, it appears that this effect is stronger for males than females, as marital status did not emerge as significant in the female only BMI regression. Similarly, number of people living in the home had a statistically significant inverse relationship with both male specific outcomes. The regression coefficients suggest that for each additional person living in the home, male BMI and WC is lower by 0.582 kg/m^2 and 0.229 cm respectively. Finally, occupation type was found to be significant to male BMI only (Table 4-5). Specifically, having a full-time occupation was associated with a higher BMI by approximately 0.709 kg/m^2 in comparison to males with other employment tenures. These results agree with other findings in the literature, although in this research the relationship was limited specifically to males (e.g. Robert & Reither, 2004; Chaix & Chauvin, 2003).

It is interesting to note that throughout these regressions, education emerged as a more significant predictor of weight status than income. There is much support in the obesity literature for the presence of an inverse association between income and obesity (e.g. Janssen et al., 2006; Robert & Reither, 2004), including a recent study by Statistics Canada on the health of Canadians which reported that adults in the lowest income quintile were 40% more likely to be obese than those in the highest income quintile (Statistics Canada, 2005). The majority of research concerned with the SES-obesity relationship, however, has been conducted in the United States (U.S.) and Europe. In a comparative study of the relationship between income and mortality between the U.S. and Canada by

Ross and colleagues (2000), it is argued that education may be a more accurate indicator of health status than income or income inequality in a Canadian context. The results of this study support this finding, as education rather than income was found to have a substantial impact as a risk factor for overweight and obesity. Although unlikely, this finding may also be a result of the large number of missing cases for the income variable (17.7%) and the treatment of these missing cases as discussed previously (Chapter 3).

Typically the three behaviours most strongly associated with obesity have been physical activity, diet and smoking (Sundquist & Johansson, 1998). There was limited information on diet in the CHHS, which is one of the main limitations of this data. However, the results presented in this chapter specific to the behavioural covariates provide further evidence that relationships with individual behaviours are important. Firstly, smoking was found to have substantial impact in both the full data BMI and WC models. Specifically, smoking was related with a decreased BMI by 0.480 kg/m^2 and a smaller WC by 1.853 cm. Although smoking has often been found to be associated with lower levels of physical activity and an increased risk of being overweight (e.g. Gruber et al., 2006), there is some evidence that smoking is linked to lower BMI due to the appetite suppression mechanism of smoking itself (Trakas et al., 1999). Further, the discrepancy between current smokers and others may in part be due to the inclusion of former smokers in the reference category of this variable. It is currently understood that former smokers have larger BMI values, and WCs than current, or non-smokers (Glasgow, Strycker, Eakin et al., 1999).

Living a sedentary lifestyle was an important predictor of BMI and WC, as it was statistically significant at a high level across all six models. The relationships indicate that individuals whom had not been physically active during the past month had BMIs approximately 1.097 kg/m^2 higher than relatively more physically active respondents, and WCs 4.025 cm larger. Similar relationships remained in the male only and female only regressions. These findings are consistent with results produced elsewhere in the obesity literature (e.g. Health Canada, 2005; Katzmarzyk, 2002; Rabkin et al., 1997). Although, due to the liberal definition of sedentary in the CHH surveys,[12] it is likely that these results underestimate the actual relationship between physical activity and risk of overweight. This particular relationship provides further evidence that physical activity levels, or energy expenditure, have significant impact on the chronic energy imbalance which defines the condition of overweight and obesity (Katzmarzyk, 2002).

Finally, alcohol consumption was positively associated with WC in both the male and full data regression models. In particular, being a drinker was associated with larger WCs by 2.288 cm in the full data model and 7.552 cm in the male only model. The magnitude of the regression coefficient in the male

[12] Sedentary individuals were individuals whom had not participated in at least one half-hour of physical activity in the past 30 days during their leisure time (Appendix C)

only model suggests that this determinant is much stronger for males than females. This result coincides with the findings by Cairney and Wade (1998), who reported current drinkers as being 1.22 times as likely as non-drinkers (95% CI: [1.03, 1.47]) to be obese.

The final variable that was found to be significant in these models was the only biological variable included in the analyses. Diabetic status was statistically significant in all three WC regressions, as well as the female BMI regression. In each model, reporting clinically diagnosed diabetes was associated with an increasing weight outcome. Overweight and obesity have been well-established as risk factors for type II diabetes (Kim et al., 2006; Pickett et al., 2005; Wannamethee et al., 2005; Trakas et al., 1999). Conversely, overweight and obesity have been identified as co-morbidities of diabetes. Since the CHHS are cross-sectional, it makes the direction of this relationship impossible to discern. Thus, this variable was included in these models as a control variable.

4.4 Summary

The results suggest a number of statistically significant individual-level risk factors for overweight and obesity, as indicated by BMI and WC that are consistent with the known literature. These models also served as the basis for the individual-levels in the multilevel models presented in the following chapter (Chapter 5). Demographic variables age and sex were found to be significant in each of the six models presented and will be used as control variables in the multilevel analyses at the individual-level. The typical inverse relationship between socioeconomic status and overweight/obesity has been demonstrated in each model; however, as measured by education, marital status, and occupation type rather than income or income adequacy. Further, a number of behavioural variables emerged as significant, including smoking status, alcohol consumption, and physical activity levels. Finally, being a diabetic was included in several of the regressions as a control variable.

As discussed in the previous chapter, these multivariate regressions assume that each observation is independent, and thus that the error terms associated with each observation are not correlated. However, since it is known that these observations are clustered within geographical areas, it is necessary to use multilevel modeling to analyse the data in order to remove the possibility that the relationships presented here exist only as a result of being clustered in the same areas. Further, in even the most robust regression, the adjusted R^2 indicated that only 36% of the variation in either outcome was captured by an individual-level regression. The following chapter will use the multivariate regression models as the individual-level basis for the main multilevel analyses, which will be used to capture and quantify any further variation in the outcomes that may be occurring as a result of differences between areas.

CHAPTER FIVE MULTILEVEL ANALYSIS OF OVERWEIGHT AND OBESITY

This chapter presents the results of the multilevel regression analyses used to address the second and third objectives of this research: to explore the range of contextual-level variables mediating the individual relationships captured in the multivariate regression, and to determine the relative contributions of individual- and contextual-level factors to the conditions of overweight and obesity. The multilevel regression results are presented as β estimates, which can be interpreted as an absolute change in kg/m^2 (BMI models), or centimetres (WC models) between the reference category and the specified category for categorical variables (e.g. sex). For continuous variables (e.g. age), these estimates can be interpreted as the absolute change in the outcome variable associated with a one unit increase (e.g. one year) in the continuous independent variable.

These data were analysed in MLwiN version 2.0, using iterative generalized least squares (IGLS) random intercept regression (Rasbash, Steele, Browne et al., 2004). A 5% significance level cut-off was used and 95% confidence intervals (CIs) are reported with all estimates. If the 95% CI for a particular β estimate does not contain zero, it follows that the p-value for that estimate is less than 0.05 (Maxim, 1999). The deviance statistic reported in the following tables represents a measure of model fit for the multilevel models. Standing alone, this measure does not hold much meaning; however, the difference between deviances from two models can be compared to a chi-squared (χ^2) distribution to determine a p-value for the goodness-of-fit of the larger model (Rasbash et al., 2004). This p-value is reported in each table presented in this chapter, and was the main statistic used to determine model fit, as suggested by Hox (1995).

Also reported in these tables are the level two and level one variance, which represent the variation in the outcome variable between areas, and between individuals within those areas respectively. The intraclass correlation coefficient (ICC) measures the extent to which the outcome values of individuals in the same group resemble each other in contrast to individuals in different groups. This may also be interpreted as the proportion of variation in the outcome variable that is due to the differences between groups (Rasbash et al., 2004). This statistic is calculated by dividing the area level variance by the total variance (King et al., 2006; Rasbash et al., 2004).

5.1 Body Mass Index

5.1.1 Combined Data, BMI

Table 5-1 presents the multilevel full data model for BMI, and the five models leading to the construction of the final model. The model statistics for Model 1 indicated a significant area level variance in BMI (1.705, Standard Error (SE) = 0.407, 95% CI: [0.252, 2.503]). This statistical significance remained when adjusted for demographic characteristics age and sex, although the variance was reduced (1.532, SE = 0.425, 95% CI: [0.699, 2.365]). The variance was further reduced when adjusted for individual-level education (1.307, SE = 0.392, 95% CI: [0.539, 2.075]). Finally, after adjusting for age, sex, education, and behavioural variables representing respondent smoking status and physical activity levels (Table 5-1: Model 4), the area level variation remained statistically significant at 1.362 (SE = 0.388, 95% CI: [0.602, 2.122]). The reported ICC (0.0664) indicated that 6.64% of the variation in BMI was due to the differences between areas after controlling for these individual-level variables.

Marital status (partner vs. no partner) was the only variable included in the multivariate regression for BMI (Table 4-5) that was not found to be significant in the final multilevel model (Model 5). This most likely occurs here because the multilevel accounts for the hierarchical structure of the data. This may result in smaller standard errors than produced by regular multiple regressions, as explained in Chapter 3 (Goldstein, 1995). The intercept value for the final model indicated that the average BMI across all individuals from all areas was 21.170 kg/m^2, and the level 2 variance suggests that the average for each group varies around this value by 0.897 kg/m^2. The β coefficient for age indicated a similar positive relationship as reported in the multivariate regression, although the magnitude of the estimate was smaller. Specifically, this relationship suggests that each increase of one year of age corresponded to an increase in BMI of 0.053 kg/m^2 (95% CI: [0.037, 0.069]).

Males were found to have higher BMI values than females by approximately 0.944 kg/m^2 (95% CI: [0.474, 1.414]) which was much larger than the estimate reported in the multivariate regression. The relationship between BMI and education emerged as the strongest individual-level association in the model. Individuals whom had not completed their secondary school education were associated with an increased BMI by 1.230 kg/m^2 (95% CI: [0.624, 1.836]) in contrast to individuals whom had completed high school. As in the multivariate regressions, even after forcing income and income adequacy into the multilevel models, it appears that education is a more sensitive indicator of socioeconomic status in this particular research.

Two behavioural variables were found to be significant to this model, as they were in the multivariate regression. Smoking was found to be preventive of overweight and obesity, as regular smokers were associated with a lower BMI by approximately 0.822 kg/m^2 (95% CI: [-1.490, -0.154]). This relationship was much stronger in the multilevel model than in the regular multivariate regression by 0.342 kg/m^2. Physical activity during the last month was also associated with BMI; however, the relationship was in the opposite direction. Living a sedentary lifestyle was associated with an increased BMI of 0.985 kg/m^2 (95% CI: [0.422,

Table 5-1: Full data multilevel model, BMI

	Model 1(CI)	*Model 2 (CI)*	*Model 3 (CI)*	*Model 4 (CI)*	*Model 5 (CI)*
Level 1 Variables					
(Intercept)	25.411 (25.095, 25.727)	21.877 (21.160, 22.594)	22.152 (21.438, 22.865)	22.150 (21.386, 22.914)	21.170 (20.347, 21.993)
Age (years)		0.071 (0.055, 0.087)	0.057 (0.043, 0.071)	0.053 (0.037, 0.069)	0.053 (0.037, 0.069)
Sex					
Females		---	---	---	---
Males		1.016 (0.532, 1.500)	0.990 (0.506, 1.474)	0.971 (0.499, 1.534)	0.944 (0.474, 1.414)
Education					
HS Completed			---	---	---
HS Not Complete			1.287 (0.724, 1.850)	1.341 (0.739, 1.943)	1.230 (0.624, 1.836)
Smoking					
Non-Smoker				---	---
Regular Smoker				-0.758 (-1.426, -0.090)	-0.822 (-1.490, -0.154)
Physical Activity					
Physically Active				---	---
Sedentary				0.931 (0.368, 1.494)	0.985 (0.422, 1.548)
Level 2 Variables					
Avg. Dwelling Value					
Low					1.930 (1.085, 2.775)
Middle					1.282 (0.704, 1.860)
High					---
Model Statistics					
Level 1 Variance (SE)	20.784 (1.258)	19.589 (1.228)	19.435 (1.211)	19.146 (1.169)	19.133 (1.169)
Level 2 Variance (SE)	1.705 (0.407)	1.532 (0.425)	1.307 (0.392)	1.362 (0.388)	0.897 (0.290)
Intraclass Correlation	7.58%	7.28%	6.30%	6.64%	4.45%
Deviance Statistic	11674.410	11573.100	11557.000	11537.320	11508.170
χ^2	24.2	101.31	16.1	19.68	29.15
P-value	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***

Model 1 = null model; Model 2 = Model 1 + age + sex; Model 3 = Model 2 + education; Model 4 = Model 3 + smoking + physical activity; Model 5 = Model 4 + average dwelling value

1.548]), although due to the poor definition of this variable in the CHHS, it is thought that the relationships reported here may be conservative estimates of the actual relationships.

Only one area-level modifier variable was found to significantly improve the model fit (Model 5). Average dwelling values (categorized as low, middle, and high) reduced the level 2 variance to 0.897 (SE = 0.290), although the variance did remain significant (95% CI: [0.329, 1.465]). Inclusion of this area level variable improved the deviance statistic from 11537.32 to 11508.17, which can be compared to a chi-squared value of 29.15 on 2 degrees of freedom ($p < 0.001$). The coefficients associated with average dwelling value suggested an inverse gradient with BMI that existed after adjustment for age, sex, education, and behavioural variables at the individual-level. Specifically, the difference in average BMI for individuals living in a neighbourhood with middle average dwelling value versus the highest average dwelling value was 1.282 kg/m^2 (95% CI: [0.704, 1.860]). The difference in average BMI for individuals living in a neighbourhood with low average dwelling value versus the highest was 1.930 kg/m^2 (95% CI: [1.085, 2.775]). This relationship is typical of the ubiquitous inverse gradient between neighbourhood socioeconomic status and a broad range of health outcomes reported in numerous studies throughout the ecological and epidemiological literature (Evans & Kantrowitz, 2002).

5.1.2 Male Data, BMI

Table 5-2 displays the results of the male only multilevel model with BMI as the outcome variable. Model 2 in this table indicates that after controlling for age, the area level variance in BMI remained significant (1.283, 95% CI: [0.585, 1.987]). Further, after adjusting for marital status and physical activity levels (Model 4), area level variance remained significant, although it decreased (1.033, 95% CI: [0.423, 1.643]). Type of occupation, and number of persons living in the household were not found to be significant in the multilevel models as they were in the multivariate regressions. The ICC calculated for the final model indicates that approximately 7.68% of the variation in BMI was due to area level differences after controlling for these individual-level variables. However, no area level modifier variables emerged as significant in the male only BMI model. Thus, although substantial area-level variation remained in male BMI, the census variables of interest to this research did not capture any of this variation at a statistically significant level.

The value of the intercept indicates that the average male BMI for all individuals from all areas was 23.427 kg/m^2, and the level 2 variance indicates that the average for each group varied around this value by 1.033 kg/m^2. The intercept for the male only model was larger than in the combined model by 2.257 kg/m^2 which is consistent with the assertion that males have higher BMI values than females on average (CIHI, 2004). The coefficient for age was in the expected direction, although the estimate was smaller than in the male only

Table 5-2: Male only multilevel model, BMI

	Model 1 (CI)	*Model 2 (CI)*	*Model 3 (CI)*	*Model 4 (CI)*
Level 1 Variables				
(Intercept)	25.908 (25.587, 25.940)	23.689 (22.956, 24.422)	23.667 (22.890, 24.465)	23.427 (22.663, 24.191)
Age (years)		0.052 (0.036, 0.068)	0.031 (0.011, 0.051)	0.030 (0.010, 0.050)
Education				
HS Completed			---	---
HS Not Complete			1.003 (0.229, 1.777)	0.897 (0.131, 1.663)
Marital Status				
No Partner			---	---
Partner			0.970 (0.364, 1.576)	0.962 (0.372, 1.552)
Physical Activity				
Physically Active				---
Sedentary				0.886 (0.306, 1.466)
Model Statistics				
Level 1 Variance (SE)	13.285 (0.781)	12.771 (0.800)	12.588 (0.753)	12.420 (0.728)
Level 2 Variance (SE)	1.397 (0.361)	1.283 (0.359)	1.043 (0.315)	1.033 (0.311)
Intraclass Correlation	9.52%	9.13%	7.65%	7.68%
Deviance Statistic	5558.309	5516.068	5491.522	5482.068
χ^2	8.08	42.26	24.55	9.45
P-value	<0.0045**	<0.001***	<0.001***	0.0021**

Model 1 = null model
Model 2 = Model 1 + age
Model 3 = Model 2 + education + marital status
Model 4 = Model 3 + physical activity

regression on BMI (Table 4-5). The multilevel relationship suggested that an increase in one year of age was associated with an increased BMI in males by 0.030 kg/m^2 (95% CI: [0.010, 0.050]).

The relationships observed between male BMI and each of education, marital status, and physical activity were similar to each other in terms of magnitude and direction. Specifically, not having completed a secondary school education was associated with a higher BMI by 0.897 kg/m^2 (95% CI: [0.131, 1.663]). This relationship was stronger than the relationship reported in the male only multivariate regression. Having a partner was associated with a larger BMI by 0.962 kg/m^2 (95% CI: [0.372, 1.552]), and emerged as the strongest predictor of male overweight and obesity as measured by BMI. Finally, living a sedentary lifestyle was associated with a larger BMI by 0.886 kg/m^2 (95% CI: [0.306, 1.466]).

5.1.3 Female Data, BMI

The multilevel model for female BMI is presented in Table 5-3. The model statistics for Model 1 indicate a significant area level variance in female BMI (2.392, SE = 0.859, 95% CI: [0.708, 4.076]). After controlling for age (Model 2), this significance remained, and was only decreased slightly (2.388, 95% CI: [0.763, 4.013]). The variance was further reduced when the model was adjusted for education levels, to 1.983, although the significance held (95% CI: [0.497, 3.469]). The ICC for Model 3 indicates that approximately 7.35% of the variation in female BMI was due to area level differences after controlling for age and education.

Model 5 represents the final multilevel model for female BMI. The intercept in the final model suggested that the average BMI across all females from all areas is 20.322 kg/m^2, which was lower than the intercepts reported in the combined and male only models, as expected. The strength of the age-outcome relationship was very similar to the association reported in the multivariate regression. In particular, an increase of one year of age was associated with a larger BMI by 0.069 kg/m^2 (95% CI: [0.049, 0.089]). Level of education emerged as the strongest individual-level predictor of female BMI. Not having completed a secondary school education predicted a larger BMI by 1.520 kg/m^2 (95% CI: [0.469, 2.571]). This relationship was much stronger for female BMI than the relationship reported for male BMI. Both physical activity levels, and diabetic status were significant in the female BMI regression (Table 4-5), however, neither of these emerged as significant in the multilevel model.

One area level modifier variable significantly improved the model fit in this case. Average dwelling value at the area level significantly improved the deviance statistic from 5974.39 to 5947.68. This reduction can be compared to a chi-squared value of 26.70 on 2 degrees of freedom ($p<0.001$). Adjusting the model for area level average dwelling value also significantly reduced the area level variance to 1.050, although the variance remained significant ($p<0.05$).

Table 5-3: Female only multilevel model, BMI

	Model 1 (CI)	*Model 2 (CI)*	*Model 3 (CI)*	*Model 4 (CI)*
Level 1 Variables				
(Intercept)	24.918 (24.469, 25.367)	25.216 (20.144, 22.190)	21.555 (20.602, 22.508)	20.322 (19.213, 21.431)
Age (years)		0.087 (0.063, 0.111)	0.068 (0.046, 0.090)	0.069 (0.049, 0.089)
Education				
HS Completed			---	---
HS Not Complete			1.731 (0.677, 2.684)	1.520 (0.469, 2.571)
Level 2 Variables				
Avg. Dwelling Value				
Low				2.728 (1.640, 3.816)
Middle				1.355 (0.526, 2.184)
High				---
Model Statistics				
Level 1 Variance (SE)	26.913 (2.213)	25.216 (2.053)	24.985 (2.030)	25.037 (2.051)
Level 2 Variance (SE)	2.392 (0.859)	2.388 (0.829)	1.983 (0.758)	1.050 (0.591)
Intraclass Correlation	8.16%	8.65%	7.35%	4.02%
Deviance Statistic	6026.407	5983.411	5974.386	5947.684
χ^2	9.80	43.00	9.03	26.70
P-value	0.017*	<0.001***	0.0027**	<0.001***

Model 1 = null model
Model 2 = Model 1 + age
Model 3 = Model 2 + education
Model 4 = Model 3 + average dwelling value

Additionally, the ICC decreased from 7.35% to 4.02% indicating that the inclusion of average dwelling value in this model explained approximately 45% of the total variation in female BMI at the area level, after adjusting for age and education at the individual level.

The coefficients associated with average dwelling value indicated a similar inverse gradient with BMI observed in the combined data model. In particular, the difference in average BMI for females living in an area with middle average dwelling values versus the highest average dwelling values was 1.355 kg/m^2 (95% CI: [0.526, 2.184]) after controlling for age and education levels. Similarly, the difference in average BMI for females living in low average dwelling value neighbourhoods in comparison to the highest average dwelling value neighbourhoods was 2.728 kg/m^2 (95% CI: [1.640, 3.816]). This relationship is very similar to the inverse gradient observed in the combined data model, although the magnitudes of the coefficients suggest a stronger effect in the female only model.

5.2 Waist Circumference

5.2.1 Combined Data, WC

Table 5-4 presents the results of the multilevel waist circumference model for the combined male and female data. Model statistics from Model 1 indicate a significant area level variance in average WC (10.926, SE = 2.390, 95% CI: [6.242, 15.610]) without adjustment for any individual level covariates. This statistical significance remained when adjusted for demographic characteristics age and sex in Model 2, although the variance was reduced to 8.188 (95% CI: [4.883, 11.493]). The variance was further reduced after controlling for individual-level education (Model 3) to 6.827 (95% CI: [3.803, 9.851]). After including physical activity into the model, the area level variance remained significant, and increased to 7.015 (95% CI: [4.001, 10.029]). The reported ICC for Model 4 indicates that after controlling for these four individual-level variables, that 5.68% of the variation in waist circumference was due to differences between areas. In comparison to the multivariate regression for the (combined data) WC model, diabetic status, smoking status, and alcohol consumption were all found to be non-significant in the multilevel model. Again, this is most likely because the multilevel model is incorporating the hierarchical structure of these data into the analysis.

The intercept value for the final model (Model 5) suggests that the average WC across all individuals from all areas was 63.504 cm (95% CI: [61.597, 65.411]), and the level 2 variance indicates that the average WC for each group varied around this value by 4.502 cm. The age coefficient represents a positive relationship between age and WC, as observed in the multivariate regression. Specifically, an increase of one year in age was associated with an increase in WC by 0.260 cm (95% CI: [0.223, 0.297]). Males were found to have larger WCs

Table 5-4: Full data multilevel model, WC

	Model 1 (CI)	*Model 2 (CI)*	*Model 3 (CI)*	*Model 4 (CI)*	*Model 5 (CI)*
(Intercept)	85.840 (84.987, 86.693)	66.870 (65.112, 68.628)	67.497 (65.721, 69.273)	66.539 (64.795, 68.283)	63.504 (61.597, 65.411)
Age (years)		0.291 (0.258, 0.324)	0.260 (0.223, 0.297)	0.257 (0.220, 0.294)	0.260 (0.223, 0.297)
Sex					
Females		---	---	---	---
Males		12.990 (11.747, 14.233)	12.940 (11.699, 14.181)	12.876 (11.665, 14.087)	12.766 (11.563, 13.969)
Education					
HS Completed			---	---	---
HS Not Complete			3.092 (1.771, 4.413)	2.825 (1.471, 4.179)	2.381 (0.976, 3.786)
Physical Activity					
Physically Active				---	---
Sedentary				3.255 (1. 959, 4.179)	3.331 (2.026, 4.636)
Level 2 Variables					
Avg. Dwelling Value					
Low					1.930 (-0.157, 4.017)
Middle					2.526 (1.038, 4.014)
High					---
% HS Educated					
Low					3.344 (1.351, 5.337)
Middle					1.350 (-0.163, 2.863)
High					---
Model Statistics					
Level 1 Variance (SE)	176.578 (6.855)	119.885 (6.443)	119.043 (6.409)	116.593 (6.201)	116.395 (6.196)
Level 2 Variance (SE)	10.926 (2.390)	8.188 (1.686)	6.827 (1.543)	7.015 (1.538)	4.502 (1.352)
Intraclass Correlation	5.83%	6.39%	5.42%	5.68%	3.72%
Deviance Statistic	16137.620	15342.880	15326.210	15296.680	15271.900
χ^2	6.98	794.76	16.67	29.553	24.78
P-value	0.0082**	<0.001***	<0.001***	<0.001***	<0.001***

Model 1 = null model; Model 2 = Model 1 + age + sex; Model 3 = Model 2 + education; Model 4 = Model 3 + physical activity; Model 5 = Model 4 + area-level variables than females, by an average of 12.766 cm (95% CI: [11.563, 13.969]). The relationship between education and WC remained as an inverse relationship. Not having completed a secondary school education was associated with a larger WC by 2.381 cm (95% CI: [0.976, 3.786]) in contrast to individuals whom had graduated from high school. Similarly, living a physically inactive lifestyle was associated with a larger WC by 3.331 cm (95% CI: [2.026, 4.636]).

Two area level modifier variables were found to significantly improve model fit. Average dwelling values, and percentage of individuals in the neighbourhood whom had completed a secondary school education were categorized each as low, middle and high, as discussed in Chapter 3. Inclusion of these two variables decreased the level 2 variance by 35% to 4.502, although this variance remained significant (95% CI: [1.852, 7.152]). The coefficients for average dwelling value did not represent an inverse gradient as presented in previous models (Tables 5-1, 5-3). However, the difference in average WC for individuals living in low and middle average dwelling value neighbourhoods versus the highest average dwelling value neighbourhoods was 1.930 cm (95% CI: [-0.157, 4.017]) and 2.526 cm (95% CI: [1.038, 4.014]) respectively. This indicates that individuals in the highest average dwelling value neighbourhoods have lower WCs on average, than other individuals, after controlling for age, sex, education and physical activity levels.

The coefficients for neighbourhood education levels did exhibit an inverse gradient relationship with the outcome variable. The average difference in WC between individuals living in the middle educated neighbourhoods versus the highest educated neighbourhoods was 1.350 (95% CI: [-0.163, 2.863]). Further, the average WC for individuals living in the least educated neighbourhoods was found to be 3.344 cm (95% CI: [1.351, 5.337]) larger than individuals living in the most educated neighbourhoods. Inclusion of these two area level modifier variables decreased the ICC for the model by almost 2%. This suggests that of the 5.68% of the variation in WC due to differences between neighbourhoods after controlling for individual-level covariates, 35% of that variation was captured by including neighbourhood dwelling value and area education levels to the regression.

5.2.2 Male Data, WC

Table 5-5 presents the results of the multilevel regression on WC for male participants only. The variance statistics in Model 1 indicate that without controlling for any individual-level covariates, there was significant variation in WC at the area level (13.033, SE = 3.452, 95% CI: [6.267, 19.799]). This variance remained significant after controlling for age in Model 2, although there was a substantial decrease to 9.945 (95% CI: [4.200, 15.690]). After adjusting for socioeconomic variables education, and marital status in Model 3, the variance decreased further to 8.982 and remained significant (95% CI: [3.813, 14.151]). Finally, after controlling for age, education, marital status, and physical activity,

Table 5-5: Male only multilevel model, WC

	Model 1 (CI)	*Model 2 (CI)*	*Model 3 (CI)*	*Model 4 (CI)*
Level 1 Variables				
(Intercept)	92.167 (91.203, 93.131)	79.695 (77.619, 81.771)	79.774 (77.469, 82.079)	78.866 (76.614, 81.118)
Age (years)		0.294 (0.247, 0.341)	0.246 (0.185, 0.307)	0.243 (0.182, 0.304)
Education				
HS Completed			---	---
HS Not Complete			2.682 (0.473, 4.891)	2.274 (0.118, 4.430)
Marital Status				
No Partner			---	---
Partner			1.945 (0.138, 3.752)	1.859 (0.099, 3.619)
Physical Activity				
Physically Active				---
Sedentary				3.228 (1.535, 4.921)
Model Statistics				
Level 1 Variance (SE)	117.749 (8.162)	101.188 (7.796)	99.927 (7.463)	97.600 (6.832)
Level 2 Variance (SE)	13.033 (3.452)	9.945 (2.931)	8.982 (2.637)	9.054 (2.519)
Intraclass Correlation	9.97%	8.95%	8.25%	8.49%
Deviance Statistic	7855.311	7660.231	7646.179	7625.438
χ^2	5.80	195.09	14.05	20.74
P-value	0.016*	<0.001***	<0.001***	<0.001***

Model 1 = null model
Model 2 = Model 1 + age
Model 3 = Model 2 + education + marital status
Model 4 = Model 3 + physical activity

the area level variance converged to 9.054 (95% CI: [4.117, 13.991]). In comparison to the multivariate regression presented previously for male only WC, the statistically significant individual-level covariates are quite different. Number of people living in the household, alcohol consumption and diabetic status, were not significant in the regression and were replaced with variables related to participant education and marital status. The same four individual level variables were found to be significant in the male only BMI model, presented previously in this chapter (Table 5-2).

The intercept value indicates that the average WC across all males from all areas was 78.866 cm (95% CI: [76.614, 81.118]). The level 2 variance in Model 4 suggests that the averages of each area vary around this value by 9.054 cm. The coefficient for age decreased in contrast to the multivariate regression, and indicates that an increase in one year of age for males corresponded to an increase in WC by 0.243 cm (95% CI: [0.182, 0.304]). Education, a variable that was absent from the multivariate regression, emerged as a strong indicator of WC in the multilevel model. In particular, not having completed a secondary school education was associated with a larger WC by 2.274 cm (95% CI: [0.118, 4.430]). Marital status was positively associated with male WC, similar to the BMI model. Specifically, having a partner (married or common law) predicted a larger WC by approximately 1.859 cm (95% CI: 0.099, 3.619). Finally, living a sedentary lifestyle over the past month was strongly associated with a larger WC by 3.228 cm (95% CI: [1.535, 4.921]).

The ICC for this model indicates that 8.49% of the variation in male WC could be attributed to differences at the area level. Although substantial variation existed at the area level, none of the area level variables of interest from the Canadian census significantly captured any of this variation. This finding is very similar to the results presented previously specific to the male only BMI model. Further research would be necessary to identify the area level characteristics that can capture the variation in male BMI and WC, and this issue will be discussed in detail in Chapter 6.

5.2.3 Female Data, WC

Table 5-6 presents the multilevel regression on female WC from the CHHS. From the model statistics of Model 1, it is clear that there is statistically significant variation in female WC at the area level (12.148, SE = 3.477, 95% CI: [5.333, 18.963]). This variation was reduced substantially after adjusting for age (Model 2), although the variation remained significant (9.880, 95% CI: [4.122, 15.638]). The area level variance was further reduced after controlling for education (8.163, 95% CI: [2.822, 13.504]) and physical activity levels (7.838, 95% CI: [2.818, 12.858]). In comparison to the multivariate regression model for female WC (Table 4-6), the multilevel regression did not find smoking status or diabetic status to be significant. Age, education and physical activity remained in the model as the only influential individual-level covariates.

Table 5-6: Female only multilevel model, WC

	Model 1 (CI)	*Model 2 (CI)*	*Model 3 (CI)*	*Model 4 (CI)*	*Model 5 (CI)*
Level 1 Variables					
(Intercept)	79.331 (78.298, 80.364)	66.968 (64.538, 69.398)	67.801 (65.488, 70.114)	67.000 (64.668, 69.332)	63.513 (60.904, 66.122)
Age (years)		0.287 (0.232, 0.342)	0.245 (0.194, 0.296)	0.243 (0.192, 0.294)	0.251 (0.198, 0.304)
Education					
HS Completed			---	---	---
HS Not Complete			4.033 (1.708, 6.358)	3.925 (1.600, 6.250)	3.098 (0.728, 5.468)
Physical Activity					
Physically Active				---	---
Sedentary				2.611 (0.592, 4.630)	2.844 (0.792, 4.896)
Level 2 Variables					
Avg. Dwelling Value					
Low					2.946 (0.292, 5.600)
Middle					2.233 (0.294, 4.171)
High					---
% HS Educated					
Low					3.807 (1.263, 6.351)
Middle					1.554 (-0.457, 3.565)
High					---
Model Statistics					
Level 1 Variance (SE)	150.752 (9.964)	133.082 (8.180)	131.604 (7.992)	130.317 (8.108)	129.874 (8.108)
Level 2 Variance (SE)	12.148 (3.477)	9.880 (2.938)	8.163 (2.725)	7.838 (2.561)	4.491 (2.069)
Intraclass Correlation	7.46%	6.91%	5.84%	5.67%	3.34%
Deviance Statistic	7797.488	7677.652	7665.398	7655.962	7633.241
χ^2	5.130	119.837	12.25	9.436	22.72
P-value	0.024*	<0.001***	<0.001***	0.0021**	<0.001***

Model 1 = null; Model 2 = Model 1 + age; Model 3 = Model 2 + education; Model 4 = Model 3 + physical activity; Model 5 = Model 4 + average dwelling value + area-level high school education

The intercept value for the final model (Model 5) suggests that the average WC for all women across all areas was 63.513 cm (95% CI: [60.904, 66.122]) after controlling for age, education and physical activity. The level 2 variance indicates that the average WCs for different areas varied about this value by 4.491 cm. This value is much smaller than the average value found in the male only model (Table 5-5), as females typically have much smaller WCs than males (CIHI, 2004). The regression coefficient for age was in the expected direction, and indicated that an increase of one year of age corresponded to an increase in female WC by 0.251 cm (95% CI: [0.198, 0.304]). Education emerged as a very strong predictor of female WC, and the coefficient suggests that not having completed a secondary school education was associated with a larger WC by 3.098 cm (95% CI: [0.728, 5.468]). Finally, at the individual-level, physical activity levels again exhibited a strong relationship with WC. Specifically, living a sedentary lifestyle during the past month corresponded to a larger WC by 2.844 cm (95% CI: [0.792, 4.896]).

Two neighbourhood level variables were found to significantly improve the model fit (Model 5). Similar to the combined WC model, average dwelling value and area-level education (categorized as low, middle and high) both emerged as statistically significant. Inclusion of these two variables improved the deviance statistic from 7655.96 to 7633.24, which can be compared to a chi-squared value of 22.72 based on 4 degrees of freedom ($p<0.001$). Both area level variables exhibited the typical inverse gradient association with WC. In particular, the difference in WC between females living in the middle dwelling value neighbourhoods in comparison to the highest dwelling value areas was 2.233 cm (95% CI: [0.294, 4.171]). The difference in average WC between females living in the lowest dwelling value areas versus the highest was 2.946 cm (95% CI: [0.292, 5.600]). Further, the difference in average female WC between the middle educated neighbourhoods and the most educated neighbourhoods was 1.554 cm (95% CI: [-0.457, 3.565]), while the difference between the least educated and most educated areas was 3.807 cm (95% CI: [1.263, 6.351]). The relationships observed between both area-level variables and WC suggest that as the socioeconomic status of the neighbourhood decreased, female WC increased on average. This relationship existed after controlling for age, education and physical activity levels at the individual level.

5.3 Discussion

5.3.1 Individual-level covariates

The individual-level covariates of BMI and WC presented in this chapter serve to address the first objective of this research: to investigate the relationships between specific individual-level determinants of health and obesity status. As expected, age and sex were found to be highly statistically significant in any model in which they were included. In general, it was found that age was positively associated with both outcome variables BMI and WC. However, the strength of this relationship tended to be slightly stronger for females than for males. For example, an increase in one year of age corresponded to a larger average BMI value by 0.039 kg/m^2 and a larger WC by 0.008 cm in comparison to the increases observed for males. This particular result has been found elsewhere in the literature (King et al., 2006), however, only in select studies in the overweight and obesity literature have males and females been analysed separately in multilevel analyses. Thus, although the difference in the impact of age on males and females is usually not reported, an overall positive relationship with age is certainly apparent (McTigue et al., 2006; Trakas et al., 1999; Cairney & Wade, 1998).

Additionally, the relationships found between sex and the outcome variables were consistently highly significant in each of the six models presented previously in this chapter. In particular, males were found to have larger average BMIs than females by 0.944 kg/m^2 (see Table 5-1), and larger average WCs by 12.766 cm (Table 5-4). This relationship existed after controlling for other individual-level covariates such as age, education, physical activity levels, and in the BMI model, smoking status. The direction and magnitude of these relationships coincide with conclusions from the majority of obesity research throughout the literature (e.g. King et al., 2006; McTigue et al., 2006; CIHI, 2004; Trakas et al., 1999; CHHSRG, 1997). Even after incorporating the hierarchical structure of the data in this thesis, these two variables remain highly statistically significant to the prediction of both outcome variables.

Contrary to the multivariate regression models presented in Chapter 4, each of the six multilevel models presented in the current chapter indicate that individual-level education was the most important socioeconomic covariate of overweight and obesity. Further, this inverse relationship appears to be important for both males and females. As discussed in Chapter 2, this result is quite typical in the literature as education is often found to be a strong predictor of many health outcomes (Siapush et al., 2005; Isaacs & Schröder, 2004). For example, in a multilevel analysis of neighbourhoods in Sweden, Sundquist and colleagues (1999) found that educational attainment significantly predicted an increased likelihood of being a daily smoker, being physically inactive, and being obese. Specific to the combined models in this research, not having completed a secondary school education predicted a larger BMI by 1.230 kg/m^2, and a larger WC by 2.381 cm.

The contributions made by these results with respect to education are twofold. Firstly, as discussed in the multivariate analysis chapter previously, education is an important indicator of socioeconomic status within developed countries such as Canada (Isaacs & Schroder, 2004). In this research, education emerged as the most significant socioeconomic variable, and as expected, individuals within the lowest socioeconomic group (those whom had not completed a secondary school education) were more likely to be overweight or obese. This relationship is unlike many studies throughout the obesity literature that have frequently included a measure of wealth and/or income into multivariate regressions and multilevel analyses as a proxy for individual socioeconomic status (e.g. Janssen et al., 2006; Robert & Reither, 2004; Isaacs & Schroder, 2004; Zhang & Wang, 2004; Willms et al., 2003).

This result supports the preliminary findings from the multivariate regression analyses, that education may be a more important indicator of overweight and obesity in the Canadian population than income. However, since the relationship between obesity and income is reported so frequently in the literature, it is possible that the data in the CHHS have failed to accurately represent individual income. Firstly, there were many missing cases in the income variable due to non-report. Even though these missing cases were handled in two different ways (see Chapter 3 for explanation of hot-decking and categorization), it is possible that these methods did not effectively capture the income distribution. Additionally, the categorization of the income variable was quite crude -Under \$12,000, \$12,000 - \$24,999, \$25,000 - \$50,000, over \$50,000 – and the definition of these four categories may have a resolution which is too broad to accurately represent the distribution of income within the sample.

A second contribution of these results is the indication that the effect of education on the weight status of the female population is stronger than in the male population. When the models were stratified by sex, the regression coefficients suggest that this effect was stronger for females than for males. In contrast to increases in male BMI (0.897 kg/m^2), not having completed a secondary school education was associated with an additional increase of 0.623 kg/m^2 in the female participants. Likewise, although education was inversely related to male WC (2.274 cm), female WC was predicted to be even larger (3.098 cm). This sex difference in the relationship between obesity and education has been found elsewhere in the obesity literature. In particular, a study of sex differences in the association of socioeconomic indicators and obesity conducted in the United Kingdom by Wardle, Waller and Jarvis (2002) found that females whom had left their education at 14 years old or younger were 2.63 times as likely to be obese (as measured by BMI) in comparison to females whom were at least 19 years old. In contrast, under the same conditions, males were found to only be 2.07 times as likely to be obese if they had left their education at 14 years old or younger. Similarly, in a Spanish study conducted between 1987 and 1997, Gutiérrez-Fisac and colleagues (2002) found that the prevalence of obesity in males and females in the lowest education category was 24.5% and 47.9% respectively. These results suggest that education may be a more important predictor of female overweight and obesity in contrast to their male counterparts.

Occupational attainment and marital status, as alternative measures of socioeconomic status, have each been found to have significant effects on overweight and obesity (Robert & Reither, 2004; Chaix & Chauvin, 2003; Cairney & Wade, 1998). While type of employment was not found to be statistically significant in this research, being married/common law married was found to have an important positive relationship with male BMI and WC (see

Tables 5-2, 5-5). Specifically, having such a partner was associated with a larger BMI value by 0.962 kg/m^2, and a larger WC by 1.859 cm on average. Typically, combined male and female regressions found in the literature report no statistically significant differences between marital status and weight outcomes (Cairney & Wade, 1998). However, research that had stratified their models by sex reported corroborating evidence for the results presented here. In particular, Wardle and colleagues (2002) found that single males were almost half as likely to be obese in comparison to married/cohabiting males, as did Ball et al. (2002) in their cross-sectional study of Australian adults. Additionally, in a 2002 release by the Centres for Disease Control (CDC), it was reported that American married men were the most likely demographic group to be overweight or obese.

Individual-level behavioural characteristics have been well established in the literature as important risk factors for overweight and obesity (e.g. Gruber & Frakes, 2006; Janssen et al., 2006; Chaix & Chauvin, 2003). As discussed previously (Chapter 2) diet, smoking status, and physical activity levels are three of the most influential of these behaviours. The variables related to diet in the CHHS are very crudely defined, and therefore were not included in the analyses presented in this thesis. This is one of the main limitations of these data, and this research. However, variables that represented individual physical activity and smoking status were both included in the multilevel regression models.

Self-reported smoking status was found to be significant in only one of the six multilevel models (Table 5-1), and was found to be inversely associated with BMI. Specifically, being a smoker predicted a lower BMI by 0.822 kg/m^2, on average, after controlling for age, sex, education, and physical activity. In comparison to the multivariate regressions, this variable is no longer significant to the WC outcome variable. Further, the magnitude of the regression coefficient is substantially smaller than in the multivariate regression, indicating that the effect of smoking on overweight is actually less strong than originally presented in Chapter 4.

Living a sedentary lifestyle was a very important predictor of BMI and WC in both the combined and sex-stratified models. This variable emerged as statistically significant in all models except the female only BMI model, and performed in the expected way in each model. Again, it should be noted that due to the poor definition of this variable; exercising less than once per week during leisure time in the past month; the estimates are most likely underestimated. In the combined BMI model (Table 5-1), living a sedentary lifestyle predicted a larger BMI by 0.985 kg/m^2 after controlling for age, sex, education, and smoking status. This effect was slightly decreased in the male only model (Table 5-2), to 0.886 kg/m^2, yet remained significant. In terms of the WC models, physical activity emerged as significant in each of the three models. In the combined model (Table 5-4), physical inactivity was associated with an increase in WC by 3.331 cm. The magnitude of this estimate decreased slightly in the male only model (3.228 cm, Table 5-5), and decreased even more in the female only model (2.844 cm, Table 5-6). Although diet does indeed play a role in the chronic energy imbalance that defines obesity, it is also well known that physical activity levels play a similar role in the development of this chronic condition (Katzmarzyk, 2002). Much is known about the inverse relationship between physical activity and overweight/obesity, and this is reflected in the literature (e.g. Janssen et al., 2006; Health Canada, 2005; Rabkin et al., 1997; Green et al., 1997). The results of this thesis with respect to sedentary living and overweight presented in this chapter are consistent with results produced elsewhere.

The multilevel analysis results suggest some alternative results compared to those produced by the multilevel regressions presented in the previous chapter. In particular, in the combined models, neither diabetic status nor alcohol consumption emerged as significant. In addition to these variables, number of people living in the household, and occupation type are absent from the male only models. Finally, diabetic status was absent from the female only models, while the behavioural variables were not found to be significant to the female only WC model. As discussed in the methods chapter, the multilevel models have incorporated the hierarchical structure of these data into the analysis. By using information from both the individual and area levels simultaneously, both the β estimates and the standard errors of these estimates differ in contrast to the multivariate regression (Kreft & Leeuw, 1998; Goldstein, 1995). Thus, variables that were found to be significant in the regular regression have been excluded in the multilevel analyses. Exploring the data using this methodology provides a more accurate representation of the actual relationships at work (Duncan, Jones & Moon, 1996).

5.3.2 Area-level covariates & variation

A comprehensive list of contextual-level variables investigated in the multilevel analyses was presented in Table 3-2 of this thesis. The majority of these variables were selected in an effort to capture aspects of the local social environment, due to data limitations regarding the measures of the physical environment in the 1991 Canadian census. Although all variables listed in Table 3-2 were forced into the multilevel models, and tested for statistical significance, only two area-level measures emerged as significant in the models after controlling for individual-level covariates. Specifically, in the combined BMI model (Table 5-1), the inclusion of average dwelling value into the model at the area level produced an inverse gradient relationship. Individuals living in the mid-disadvantaged neighbourhoods had larger BMIs on average by 1.282 kg/m^2 in comparison to those in the least disadvantaged areas, while individuals living in the most disadvantaged neighbourhoods had larger BMIs by 1.930 kg/m^2. A similar relationship was evident in the female only model (Table 5-3), however, the estimates indicated a much stronger gradient as they increased to 1.355 kg/m^2 and 2.728 kg/m^2 respectively. These relationships existed after controlling for individual-level covariates present in the multilevel analyses. No significant area-level modifier variables that emerged as significant in the male BMI model (Table 5-2).

The combined data WC model (Table 5-4) indicated two significantly associated variables at the area level. Average dwelling value again substantially improved model fit, based on the deviance statistic. As in the BMI model, the β estimates for this variable suggested that individuals living in areas with the highest average dwelling values had the smallest WCs, after controlling for age, sex, education and physical activity at the individual-level. Specifically, those living in areas with middle average dwelling values had WCs that were larger by 2.526 cm, on average, while those living in areas with the lowest average dwelling values had larger WCs by 1.930 cm. The stepwise inverse gradient observed in the BMI model was not apparent in this model; however, after stratifying for sex the gradient was re-established. Additionally, inclusion of a variable measuring the proportion of individuals living in the area whom had completed their high school education further improved model fit. This variable did exhibit the inverse stepwise relationship. In particular, living in areas with the lowest percentage of people with their secondary school education predicted a larger WC by 3.344 cm. Individuals in areas with the middle percentage had WCs that were 1.350 cm larger than those living in the most educated neighbourhoods.

In the female only WC model (Table 5-6), the same variables emerged as significant at the area level. In this model, both variables were associated with female WC in the expected manner. The difference in WC for females living in the middle average dwelling value neighbourhoods in contrast to the highest average dwelling value neighbourhoods was 2.233 cm. Living in areas with the lowest average dwelling values predicted a larger WC by 2.946cm. Additionally, living in the mid- and lowest-educated neighbourhoods corresponded to larger WC values by 1.554 cm and 3.807 cm respectively in comparison to areas with the highest proportion of high school educated individuals. Again, no area-level variables were found to be significant in the male only model (Table 5-5). This may partially explain why a stepwise inverse relationship was not apparent in the combined data model (Table 5-4). After stratifying for sex, this relationship was very discernible in the female only model.

In a Canadian context, this thesis is some of the first research to explore neighbourhood-level differences in BMI and WC, and the role played by the area-level socioeconomic status as a predictor of adult overweight and obesity. The inverse stepwise relationships observed here coincide with the majority of research throughout the literature concerned with examining the relationship between neighbourhood-level socioeconomic status (SES) and overweight or obesity (e.g. Janssen et al., 2006; Robert & Reither, 2004; Sundquist et al., 1999; Ellaway et al., 1997). Currently, there is no consensus on a single best indicator of neighbourhood SES, and typically area-level SES is measured by income levels, or income inequality (Pickett et al., 2005; Stafford & Marmot, 2003). However, some studies have used dwelling value as an important indicator of neighbourhood-level wealth, and thus, neighbourhood SES (Cozier et al., 2007; Veugelers et al., 2001).

Neighbourhood-level education is another well-established indicator of neighbourhood SES (Veugelers et al., 2001). Neighbourhood level education has been linked inversely to numerous adverse health outcomes including mortality (Næss, Leyland, Davey Smith et al., 2005; Veugelers et al., 2001), physical inactivity, smoking, and self-reported health (CIHI, 2006; Pickett & Pearl, 2001). It is clear that for the purposes of this study, neighbourhood-level SES is well represented by the combination of area average dwelling value and neighbourhood education levels; particularly for females. Further, it follows from the literature that both of these measures are appropriate indicators of neighbourhood SES.

In terms of area-level variation, each of the six models had statistically significant variation in the intercept-only models (Model 1s). Further, after controlling for the important individual-level covariates, significant variation remained. Firstly, in the combined BMI model (Table 5-1); the ICC reported for Model 4 indicates that 6.64% of the total variation in BMI was occurring at the area level. After including the average dwelling value, this statistic decreased to 4.45%. This suggests that average dwelling value explained almost 33% of the variation that existed at the area level in this particular model. Similarly, in Table 5-3 inclusion of average dwelling value decreased the ICC from 7.35% to 4.02%, indicating that this variable explained approximately 45% of the area-level variation in female BMI, after controlling for age and individual-level education. In terms of the male only model (Table 5-2), after adjustment for all statistically significant individual-level covariates, the area-level variation remained significant, and the ICC suggests that 7.68% of the variation in male BMI was occurring at the area level. Since no contextual-level variables were found to be significant, this highlights an area for further research, which will be discussed in the following chapter.

In the combined WC model (Table 5-4); inclusion of average dwelling value and area-level high school education reduced the ICC from 5.68% to 3.72%. This indicates that these two area-level measures of SES have explained almost 35% of the area-level variation in WC that existed after controlling for individual-level covariates. Similarly, inclusion of these variables in the female WC model explained approximately 40% of the area-level variation. As in the male BMI model, no significant area-level variables were found in the male WC model.

To address the third objective, the intraclass correlation coefficient was used to determine the relative contributions of individual- and contextual-level factors to the development of overweight and obesity as defined by WC and BMI. Specifically, the variation occurring at the area-level ranged from 5.67% in the female WC model, to 8.49% in the male WC model. WC tended to have larger variation at both the individual- and area-levels, possibly due to the resolution of the scale at which this measurement was recorded (tenths of centimetres). These results indicate that there is substantial variation in both measures of overweight/obesity at the area level, for males and females alike. As discussed in Chapter 2, while the most important variation in health is typically thought to be a mechanism of individual behaviours, characteristics, and genetics, it is currently understood that the various contexts in which one is situated certainly contribute to health status (Pickett & Pearl, 2001). The results presented here provide further support for this claim.

5.4 Summary

This chapter presented and discussed the results of the multilevel analysis of adult overweight and obesity in a representative sample of adults living in Ontario, Canada. These analyses were employed to address the three objectives of this thesis, as outlined previously. Two variables capturing the socioeconomic status of each neighbourhood were included in the analysis. In particular, average dwelling value was found to be an important contextual-level variable to the combined, and female BMI models. In addition to average dwelling value, proportion of people in the area with their high school education was found to have a substantial impact on individual-level WC, particularly in the female model. No area-level variables were found to be significant to the male only models, which may explain the difference in magnitude between the regression coefficients reported in the combined data, and female models. The final chapter of this thesis will discuss the impact and relevance of these results, as well as the limitations of this study, future directions, and policy implications of this research.

CHAPTER SIX DISCUSSION AND CONCLUSION

The goal of this thesis was to gain a better understanding of the determinants of the emerging epidemic of overweight and obesity in Canada. Over the past twenty-five years, adult obesity rates have doubled, and recent data indicate that approximately 36% of the adult population in Canada can be classified as overweight (CCHS, 2004). Both conditions have been identified as important predictors of various adverse health outcomes, including type II diabetes mellitus, some cancers, and cardiovascular disease (currently the leading cause of mortality in Canada) (Kim et al., 2006). Further, obesity has become an important public health challenge in Canada in and of itself; linked to increased hospital/doctor visits, higher rates of injury/disability, and adverse psychosocial outcomes such as guilt, low self-esteem, and depression (Katzmarzyk et al., 2004).

To address this critical public health issue, this research explored the individual- and contextual-level determinants of overweight and obesity in a representative sample of the adult population of Ontario. In so doing, integrated data from the Canadian Heart Health Surveys, and the 1991 Canadian census (2 536 individuals clustered in 163 areas) were analysed. The objectives of this thesis fell under the umbrella of one of the specific aims of the CHHS follow-up study research programme: to investigate the influence of social and environmental determinants of health on the relationship between obesity and other concurrent chronic disease risk factors (Katzmarzyk, 2004). The specific objectives of this thesis were to:

1) investigate the relationships between specific individual-level determinants of health and weight status;

2) explore the range of contextual-level variables mediating relationships at the individual-level; and

3) determine the relative contributions of individual- and contextual-level factors to the development of overweight and obesity.

This final chapter presents a summary of key findings, as well as contributions and policy implications of this research. Study limitations, and directions for future research are also addressed.

6.1 Summary of Key findings

Both health outcomes (i.e. BMI and WC) used in this analysis are understood to be accurate indicators of overweight and obesity, especially when used in conjunction (Dobbelsteyn et al., 2001). The independent variables were selected for analysis based on the known literature, and the determinants of health as outlined by the population health perspective (Table 3-1). As expected, demographic variables such as age and sex were found to be highly significant to each of the multivariate regression models. These findings have been repeatedly reproduced throughout the obesity literature (e.g. King et al., 2006; McTigue et al., 2006; Sundquist et al., 1999; Trakas et al., 1999; Cairney & Wade, 1998; CHHSRG, 1997), and the estimates reported in this thesis provide further support for the inclusion of these factors as controls in any regression using obesity outcomes (Zhang & Wang, 2004).

Several important individual-level socioeconomic status (SES) variables were also identified at this stage of analysis. Firstly, completion of a high school education emerged in each model except the male only WC model. As discussed previously, in developed countries such as Canada, completion of a secondary school education has been linked to social and economic advancement, and is therefore a useful indicator of individual-level SES (Isaacs & Schroder, 2004). Traditionally, income is reported as the most important measure of SES when predicting adverse health outcomes (e.g. King et al., 2006; Diez-Roux et al., 2000; Sundquist et al., 1999; Cairney & Wade, 1998; Waitzman & Smith, 1998), albeit the relationship with education is not absent from the body of knowledge (McTigue et al., 2006; Robert & Reither, 2004; Willms et al., 2003). Since income did not arise as significant at any level in these analyses, it appears that education may act as a more sensitive predictor of individual-level overweight and obesity in this Canadian context, a point that is revisited further in this chapter.

In addition to high school education, other SES variables including having a partner (married/common law) and full-time employment both predicted higher BMI values for males. Similar relationships have been reported in adult populations in Australia (Robert & Reither, 2004), France (Chaix & Chauvin, 2003), and elsewhere in Canada (Cairney & Wade, 1998). In general, however, these relationships are not as strong as those found between health outcomes and education or income (Chaix & Chauvin, 2003). This was evident in the multilevel models, as other SES variables fell out of the regressions after incorporating the hierarchical structure of the data.

Finally, behavioural variables (i.e. smoking, physical activity) were found to consistently be significant to these models, although physical activity exhibited a stronger, more consistent relationship with the outcomes than smoking (Tables 4-5, 4-6; Appendix E). The results specific to physical activity confirm results reported by numerous other studies in the obesity literature (Janssen et al., 2006; Health Canada, 2005; Chaix & Chauvin, 2003; Katzmarzyk, 2002; Sundquist &

Johansson, 1998; CHHSRG, 1997). It should be noted that due to the poor definition of this variable (less than 30 minutes of physical activity at least once during leisure time in the past month), the regression estimates reported likely underestimate the magnitude of this relationship.

The results of the multivariate analyses (Tables 4-5, 4-6; Appendix E) indicate that compositional (individual-level) variables have a strong influence on adult overweight and obesity. However, examining the adjusted R^2 statistics for these models suggests that only a proportion (up to 36%) of the variation in BMI or WC can be explained by their regression on individual-level covariates (Tables 4-5, 4-6). This result parallels results reported in a study of CVD conducted in Ontario by Jaglal and colleagues (1999), who found that after controlling for demographic and behavioural variables approximately 30 percent of the variation in CVD related mortality could be captured by regression techniques. The current consensus within health geography is that variation in health outcomes may be due to contextual effects which place individuals at a higher or lower risk for ill health (Shaw et al., 2002). This argument serves as the basis of the context versus composition framework that informed this research.

Multilevel regression techniques were used to assess potential contextual effects. Models were constructed using a procedure outlined by Hox (1995), and were informed by the literature as well as the multivariate regression analyses. The individual-level results produced by the multivariate analyses differed from those reported by the multilevel analysis, however the stronger relationships held (e.g. age, sex, education and physical activity - Sections 5.1, 5.2; Tables 5-1 to 5-6). Any individual-level variables that significantly improved the fit of the multilevel models were included as controls.

Three key results emerged from the inclusion of area-level variables into the multilevel models. Firstly, average dwelling value emerged as the strongest area-level predictor of individual-level BMI and WC. Secondly, proportion of individuals living in the area whom had completed their secondary school education significantly predicted individual WC. Finally, after stratifying the data by sex, no area-level variables were significantly associated with male weight status.

The results specific to average dwelling value and weight status have not been reproduced elsewhere in the literature, however, in most studies at least one area-level indicator of SES is included in multilevel analyses, typically as measured by income or income inequality (Pickett et al., 2005). Average dwelling value was selected for analysis for this particular research because it represents a measure of neighbourhood-level wealth, and thus provides a strong measure of the socioeconomic status of a particular area (Cozier et al., 2007). Inclusion of this variable accounted for 33% and 45% of the variation occurring at the area level in the combined and female only BMI models, respectively.

Neighbourhood-level education has not been specifically linked to overweight or obesity in the literature, although in related studies it has been inversely associated with physical activity levels (CIHI, 2006; Pickett & Pearl, 2001). Further, neighbourhood-level education level has been linked to various health outcomes including mortality and self-reported health, and has been identified as an alternative indicator of area-level SES (Næss et al., 2005; Veugelers et al., 2001). Inclusion of the two significant area-level covariates accounted for 35% and 41% of the area-level variation in the combined and female only WC models, respectively. Both the combined and female only models (Tables 5-4, 5-6) exhibited the expected inverse stepwise relationship with the outcome variable, after controlling for individual-level covariates.

The final main result that emerged from the multilevel analyses was apparent following the stratification of the models by sex. Specifically, no area-level modifier variables were found to be significant in either of the male only models (Tables 5-2, 5-5). However, significant area-level variation remained in each outcome, after controlling for age, education, marital status, and physical activity. These results suggest that although there was substantial variation in male WC and male BMI occurring at the area-level, the census variables of interest (Table 3-2) in this research were not able to significantly capture any of this variation. By analysing the male and female data separately, it becomes clear that the determinants of overweight and obesity differ for males and females at the individual and area level. The difference in area-level influences could potentially be due to differences in the social constructs of gender (Diamond, 2000). For example, often higher levels of social support and social cohesion are present in higher SES areas (Cohen et al., 2006). It is possible that females rely on social networking and social support within their communities for healthy living (physical activity, healthy eating) more so than their male counterparts. Further, as discussed later in this chapter, low SES areas are more likely to be perceived as unsafe, which has in turn has been linked to lower physical activity levels (e.g. Boslaugh et al., 2004). Perhaps females are more cognizant of feelings of safety, and thus less likely than males to participate in physical activity on their own in an environment that they perceive as unsafe. Regardless of the mechanism at work, this research provides evidence that it is necessary to stratify regression models by sex in order to effectively capture potential differences in the determinants of health between males and females (King et al., 2006; Robert & Reither, 2004; Ball et al., 2002; Wardle et al., 2002).

Overall, these findings are consistent with current understanding in health geography, that characteristics of place have an independent influence on individual health outcomes (Evans & Kantrowitz, 2002; Duncan et al., 1999). Since there is no current consensus on a single measure of area-level SES (Pickett et al., 2005), the results of this analysis suggest that average dwelling value, and neighbourhood-level education are useful indicators of area-level SES. These variables have been used elsewhere in the health geography literature as proxies for SES (e.g. Cozier et al., 2007; Veugelers et al., 2001), and displayed the expected inverse stepwise relationship with the outcome variables WC and BMI in this research.

The intraclass correlation coefficients (ICC) from the multilevel models were used to quantify the amount of variation in BMI and WC resulting from differences between areas. Each of the six models (Tables 5-1, to 5-6) exhibited significant area-level variation. In general, these statistics indicated that a substantial proportion of adult BMI (7 - 8%) and WC (6 - 9%) was occurring at the area level (Tables 5-1 to 5-6). As discussed previously, individual-level behaviours and characteristics captured approximately 10% of the variations in BMI (Table 4-4), and 20 - 35% of the variation in WC (Table 4-5). This implies that environmental influences may indeed be playing an important role in the obesity epidemic, knowledge that could prove valuable to improving the weight status of the entire population.

6.2 Contributions & Policy Implications

6.2.1 Theoretical Contributions

Theoretically, this research was informed by the population health perspective (PHAC, 2006), and the context versus composition framework (Duncan et al., 1999). Adopting a population health approach requires embracing a broad definition of the possible determinants of health, including individual behaviours, demographics and socioeconomic status, human biology, and aspects of the local social and physical environments (PHAC, 2006). By addressing each of these broad categories, this research has strengthened the existing knowledge of the determinants of health as defined by the population health perspective. Additionally, these results highlight the suitability of the population health perspective and the advantages of applying this framework to questions of interest to health geographers.

Secondly, under the umbrella of the context versus composition framework, a distinct emphasis was placed on addressing the independent impact of the social and physical environments on the development of overweight and obesity. Focus on the contextual influence on health contributes to the strength of the determinants of health as outlined by the population health perspective. Further, a focus on the role of place in the shaping of overweight and obesity contributes to the increased focus on contextualized research observable in the health geography literature over the past two decades (Kearns & Moon, 2002), as well as the focus on the built environment in the cardiovascular disease research community (e.g. Mobley, Root, Finkelstein et al., 2006).

6.2.2 Methodological Contributions

Methodologically, this research employed multilevel statistical techniques to explore the extent of association between environmental aspects and individual health outcomes. Until recently, these techniques have been used sparingly in the field of health geography, despite the clear hierarchical structure typically present in geographical data (Pampalon et al., 1999). By employing these techniques in an environment and health setting, this research provides evidence necessary to account for both individual- and contextual-level determinants of disease or ill health. Further, this research has also expanded the relatively small class of multilevel studies concerned with health outcomes conducted in a Canadian context. A volume of literature which currently features important research by Janssen and colleagues (2006) on contextual influences on adolescent obesity; Ross, Tremblay and Graham (2004) whom investigated neighbourhood influences on self-reported health in Montreal; Veugelers, Yip and Kephart (2001) who examined the socioeconomic determinants of mortality in Nova Scotia; and a multilevel study of health perception in Québec by Pampalon, Duncan, Subramanian and Jones (1999).

Secondly, this research presented all regression estimates as β estimates as opposed to odds ratios or relative risks which tend to be reported in the majority of obesity research throughout the literature. This choice was made deliberately, so that regression results could be interpreted as an absolute change in BMI or WC associated with any given independent variable. The goal of this thesis was to investigate the determinants of overweight and obesity, as substantial co-morbidities associated with each outcome contribute to the overall social and economic burden. Further, overweight and obesity are developmental by nature, with varying degrees of intensity in terms of their adverse health effects. Knowing the average increase in BMI or WC related to a particular risk factor provides information as to the severity of potential health implications associated with exhibiting that risk factor.

A third methodological contribution of this thesis lies in the indicators used as outcome variables for overweight and obesity. Typically, studies examine either BMI or WC (also, hip circumference, or waist-to-hip ratio), and indeed risk of cardiovascular disease (CVD) has been linked to both outcome measures (WHO, 2000; Ledoux et al., 1997b). While BMI tends to be the most prevalent, there is substantial evidence that suggests that WC is a more appropriate measure for indicating obesity and CVD risk. Additionally, Dobbelsteyn and colleagues (2001) argue that analysing these outcomes in combination may provide the most useful information. Nevertheless, there is a lack of studies that examine both outcomes, and a particular lack of epidemiological data using WC as a health outcome in a Canadian context (Health Canada, 2005). By analysing both indicators in combination, this research contributes to both gaps in the literature.

Finally, the stratification of all ordinary regression, and multilevel regression models by sex was an important contribution of this research. Sex-stratification was only found in one other multilevel obesity study, conducted on an adult population in Australia (King et al., 2006). Separating the sample by sex allows for different determinants of overweight and obesity between male and female participants. Although some strong relationships existed across female and male models (age, education, physical activity), this technique proved very useful in this research. It became quite clear that certain variables were important for males only (e.g. marital status), while two contextual-level variables (average dwelling value, area-level high school education) emerged as significant only in the female specific models (Tables 5-1 to 5-6). As exemplified by the results presented in this thesis, failure to analyse males and females separately could increase the risk of overlooking pertinent information.

6.2.3 Substantive Contributions

Substantively, some demographic relationships (e.g. age, sex) reported in this thesis have been reproduced elsewhere in numerous contexts. Similarly, the association between individual physical activity levels and both BMI and WC has been exhibited in numerous studies throughout the literature (Janssen et al., 2006; Health Canada, 2005; Katzmarzyk, 2002; CHHSRG, 1997). However, the findings with respect to individual-level socioeconomic status indicate some novel relationships. Firstly, marital status as a measure of SES was found to be significant in the male only models (Tables 5-2, 5-5). While this result has been found in other male specific regression models (Ball et al., 2002; CDC, 2002; Wardle et al., 2002), this research is the first to report similar relationships in a multilevel analysis. Secondly, income, wealth, or some relative measure of these has been found to be significantly associated with overweight and obesity in the majority of studies in the literature (for example, Janssen et al., 2006; Isaacs & Schroder, 2004; Zhang & Wang, 2004; Willms et al., 2003; Chaix & Chauvin, 2003). In this research, however, education has emerged as a more significant predictor of overweight and obesity while no measures of income were included in any of the regression or multilevel models. This finding is noteworthy, and suggests that education at the individual- and area-levels are accurate indicators of individual SES in a Canadian context, and thus more sensitive indicators of health outcomes (Ross et al., 2000).

Other substantive contributions surfaced through the multilevel analyses, with respect to the area-level covariates of overweight and obesity. In the female only and combined multilevel regressions average dwelling value emerged as significant in both the BMI and WC models, while area-level high school education was important in the WC model only. Inclusion of these variables explained up to 45% of the existing variation that was occurring at the area-level, indicating the importance of these two variables. The result specific to average dwelling value is of particular importance to the contributions made by this thesis, as these results have not been exhibited in any other known obesity study, and the variable emerged most consistently across four of the six multilevel regressions.

There is an emerging consensus in the housing and health inequalities literature that housing characteristics such as dwelling values are a manifestation of socioeconomic status (Dunn, 2002). As discussed previously, the lowest SES groups tend to be at a substantially increased risk for ill-health, regardless of individual-level income, education, and occupation (Isaacs & Schroder, 2004). Typically, area-level SES is captured in multilevel models by income, or some relative measure of income such as income inequality (e.g. Robert & Reither, 2004). However, an inverse stepwise relationship between BMI/WC and average dwelling value was produced by the analyses in this thesis, thus, it is reasonable to assume that average dwelling value is behaving as a measure of area-level SES for this particular sample.

Since average dwelling value is a known indicator of area-level wealth (Dunn, 2002; Dunn & Hayes, 2000), the relationships with BMI and WC could possibly be representing some other mediating variable.. For example, average dwelling value has been linked positively to dwelling satisfaction and more broadly, to neighbourhood satisfaction (Dunn & Hayes, 2000). Poor feelings about material and social circumstances, and the social meanings people attach to their material possessions are very important to the development of health inequalities as they directly relate to "physiological stress responses across the lifecourse" (Dunn, 2002, p. 671). Yet another mediating mechanism could be perception of neighbourhood safety. Low SES neighbourhoods are often viewed by their residents as unsafe, or aesthetically unpleasant. This negative perception has been shown to be linked to substantially lower physical activity levels (Boslaugh et al., 2004; Ross, 2000) as well as an increased risk of being overweight or obese (Cohen et al., 2006). Further research would be necessary to uncover these mediating variables, and fully understand the relationship between area-level dwelling values, and individual overweight/obesity.

As an alternative explanation to the emergence of average dwelling value in these models, it is possible that this variable represents the difference between rural and urban areas. In a continuing effort to characterise the urban and rural areas of Canada, the Canadian Rural Partnership has found that for the majority of the Canadian provinces, the most rural areas correspond with areas with the lowest average dwelling value (Government of Canada [GC], 2007). For example, in most provinces, living in urban areas corresponded to dwelling values that were up to twice as high as rural areas (GC, 2007)[13]. Further, an assessment of the health of rural Canadians found that rural Canadians were at a higher risk for all-cause mortality and injury, although these particular statistics may directly result from the agricultural lifestyle (CIHI, 2006). Rural individuals were also more likely to smoke cigarettes, practise poor eating habits, and be overweight. Compounding these statistics, rural individuals have more limited health care resources, indicated by the 14.9% of physicians working in Ontario rural areas in 1991 compared to the 29.2% of the total population (Laurent, 2002). These facts are relevant to this research, because it is possible that average dwelling value is representing the differences between rural and urban areas.

While qualitative study would be necessary in these areas to tease out the actual mechanism driving the gradient in obesity it is clear from the results of this research that these areas are fostering obesogenic environments in some manner. This is the main contribution of this research, in that it has uncovered important

[13] At the time of publication of this thesis, the Ontario report had not yet been released

indicators of these high risk areas. In order to appropriately address the problem of obesity in Ontario, changes must be made in these areas to make it easier for individuals to attain and maintain a healthy weight. In so doing, the overall health of the entire population could make substantial advances, and the overall burden of obesity could be curtailed.

6.2.4 Policy Implications

From each of the multilevel models (Tables 5-1 to 5-6), it was clear that substantial variation in BMI and WC was occurring at the area-level, capturing as much as 8.49% of the total variation in these outcomes. Numbers of this magnitude strongly suggest that a substantial amount of the differences in weight status were a result of neighbourhood level characteristics. Although, as expected, the majority of the variation in BMI and WC was occurring at the individual level. Secondly, with respect to the findings in the female specific BMI and WC models (Tables 5-3, 5-6), it was clear that neighbourhood-level SES (as measured by average dwelling value and education levels) played a large role in the development of female overweight and obesity.

The results of this thesis can help guide policy interventions targeting overweight and obesity in Canada by providing further evidence that the local social environment can influence individual health outcomes, above and beyond the effects of individual behaviours and characteristics (Ross, 2000). Previous individual-centred interventions focused on behaviour modification have proven relatively ineffective in addressing health issues such as smoking (Community Intervention Trial for Smoking Cessation [COMMIT], 1995), as well as overweight and obesity (Nestle & Jacobson, 2000). The results of this thesis suggest that in order to effectively shift the distribution of these conditions towards zero, it would prove useful to implement overweight and obesity intervention at both the individual- and contextual-levels. Additionally, action should be implemented in a number of settings, including the workplace, schools, communities (low SES communities in particular), health care settings, and the home.

Although overweight and obesity are important public health issues in Canada, the increasing rates of these conditions are preventable and reversible (WHO, 2003). Results presented here provide evidence that to begin a reversal of this trend, a multisectoral approach involving various levels of government, private sectors, society, and individuals will be necessary. Since the relationship with education (individual- and area-level) was statistically represented so strongly, this particular finding could provoke government and ministries to address adult education levels. For example, implementing public awareness campaigns, or offering appropriate incentives for adults to complete high school equivalency courses could prove to be useful in fighting increasing prevalence rates. Additionally, the media could play an important role in education by providing current, up to date information related to these conditions, and maintaining public awareness of the problems of overweight and obesity in a Canadian society.

Providing information and an opportunity for education could indeed play an important role in solving the obesity problem in Canada, and increased awareness has certainly been recommended as a required policy action elsewhere (e.g. Nestle & Jacobson, 2000). However, the onus cannot be placed completely on an individual to synthesize information and appropriately adjust their behaviours, particularly in obesogenic environments that obstruct opportunities for healthy eating and physical activity (Cohen et al., 2006). It is clear from the results presented here that priority should be placed on low SES neighbourhoods (particularly as indicated by average dwelling value). Specifically, a focus on the development of community-level policies that limit energy intake, and increase energy expenditure could be very promising.

Residents of low SES areas may face limited access to affordable healthy foods, resources for physical activity, or access to adequate health care (Robert & Reither, 2004). Environmental planning that promotes walking, cycling, or other physical activity in low SES neighbourhoods should be strongly encouraged in an attempt to increase energy expenditure at the individual level. As suggested by Cohen and colleagues (2006), Ross (2000), and others, residents of neighbourhoods that are not aesthetically pleasing, or perceived as unsafe, are also limited in their physical activity levels. Actions to regenerate the aesthetics of priority neighbourhoods could increase the desire of these residents to engage in outdoor physical activity. These efforts need not be limited to the physical neighbourhood environment. Since the population of interest in this thesis was an adult population, a tax incentive for employers to encourage their employees to maintain or achieve a healthy weight through work-based programs could be an appropriate alternative or complementary policy action. Likewise, action should be taken to limit energy intake through food consumption by, for example, implementation and monitoring of national and provincial food labelling guidelines. Further, the private sector could adopt an increased responsibility by providing adequate, useful nutritional information with each of their products, and limiting the advertisement of energy-dense foods; particularly for residents of low SES areas.

6.3 Limitations

While the strength of this research lies in the methodologies employed for analysis, there were three marked limitations of this study, one of which stemming from the study design, and two of which are related to data availability and quality. Firstly, the CHHS are a cross-sectional group of surveys. Overweight and obesity are developmental conditions, and the relationships implicit in developmental conditions may change in direction and magnitude over time. However, cross-sectional studies capture a single moment in time, thus are limited in determining the direction of relationships and detecting differences in magnitude that may be time related (Orfila, Ferrer, Lamarca et al., 2000). Although many of the relationships discovered throughout this thesis are well-established in the literature, and the direction of the relationships are well known, a longitudinal study design may have provided further insight into the complex relationships at work. It should be noted that by linking these CHHS surveys to the Canadian Mortality Database, one of the goals of the CHHS follow-up study is to partially address this limitation (Katzmarzyk, 2004).

Within the CHHS there were two main limitations to the data collected in 1992: sufficient measures of diet and physical activity. Obesity has been defined as a "chronic energy imbalance, whereby intake exceeds expenditure" (Katzmarzyk, 2002, p. 1039). This fact makes explicit the importance of diet (energy intake) and physical activity (energy expenditure) to the development of this disease. Limited information on diet, coupled with the poor definition of sedentary individuals (see previous discussion, Chapter 4), likely limited the proportion of explained variation in both outcome variables at the individual-level. Secondly, as the contextual basis for this research, the 1991 Canadian census proved to be limited with respect to measures of the local physical environment, and measures of neighbourhood social cohesion/networks. Both of these environmental aspects have been shown to significantly predict many individual health outcomes, including obesity (Macintyre et al., 2002).

6.4 Future Directions

Throughout the research process, a number of areas have been identified where further investigation would prove useful. First, overweight and obesity are not static conditions; rather, these are chronic conditions that develop over time, with varying degrees of severity. Thus, it would prove useful to conduct a longitudinal study of overweight, obesity and CVD outcomes to determine the direction (cause-effect) of the relationships exhibited in this research, as well as any change in the magnitude of relationships over time.

Secondly, a deeper exploration of the contextual-level determinants of health would be important to fully understand the contribution of area level characteristics to the development of these conditions. While this research has examined a number of indicators of the social environment, more attention should be paid the physical environment, and measures of social cohesion, or social support. Macintyre and colleagues (2002) suggest that in addition to compositional (e.g. characteristics of the individual) and contextual factors (e.g. aspects of the local social and physical environment), it is also important to consider collective factors. This dimension draws attention to the socio-cultural and historical features of place, and for example, could examine the relationship between health and measures of social cohesion and neighbourhood perception (Macintyre et al., 2002). Broadening the scope of the second level variables to include more contextual and collective factors could provide important information that may contribute to a more comprehensive explanation.

Finally, this research has focused on one level of geography as the appropriate geographical unit of analysis[14]. It could be useful to explore other geographical units, provided they satisfy the assumptions of the multilevel. For example, using a smaller definition of neighbourhood would change the resolution of the hierarchical structure of the data. This may prove to be more, or less, sensitive to area-level changes, and may provide a deeper understanding of the relationship between overweight, obesity, and area-level characteristics. Additionally, it could also be useful to incorporate higher levels of geography into the multilevel models, in order to assess higher level variation in the outcome variables (e.g. inter-provincial disparities).

Ultimately, this research has contributed to a better understanding of the emerging obesity epidemic observed in Ontario over the past several decades, within a population health framework. It is clear that targeting high-risk individuals will only address a portion of the problem, and that it is also important to address places that compel individuals to make unhealthy choices. This research provides further evidence to support Gatrell's landmark statement that "our 'health' and our 'geographies' are inextricably linked" (2002, p. 3). To move forward and challenge the problem of obesity, it will be necessary for policy makers to acknowledge this.

[14] Defined previously as Forward Sortation Area

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Appendix A

Obesity in Canada: A growing trend

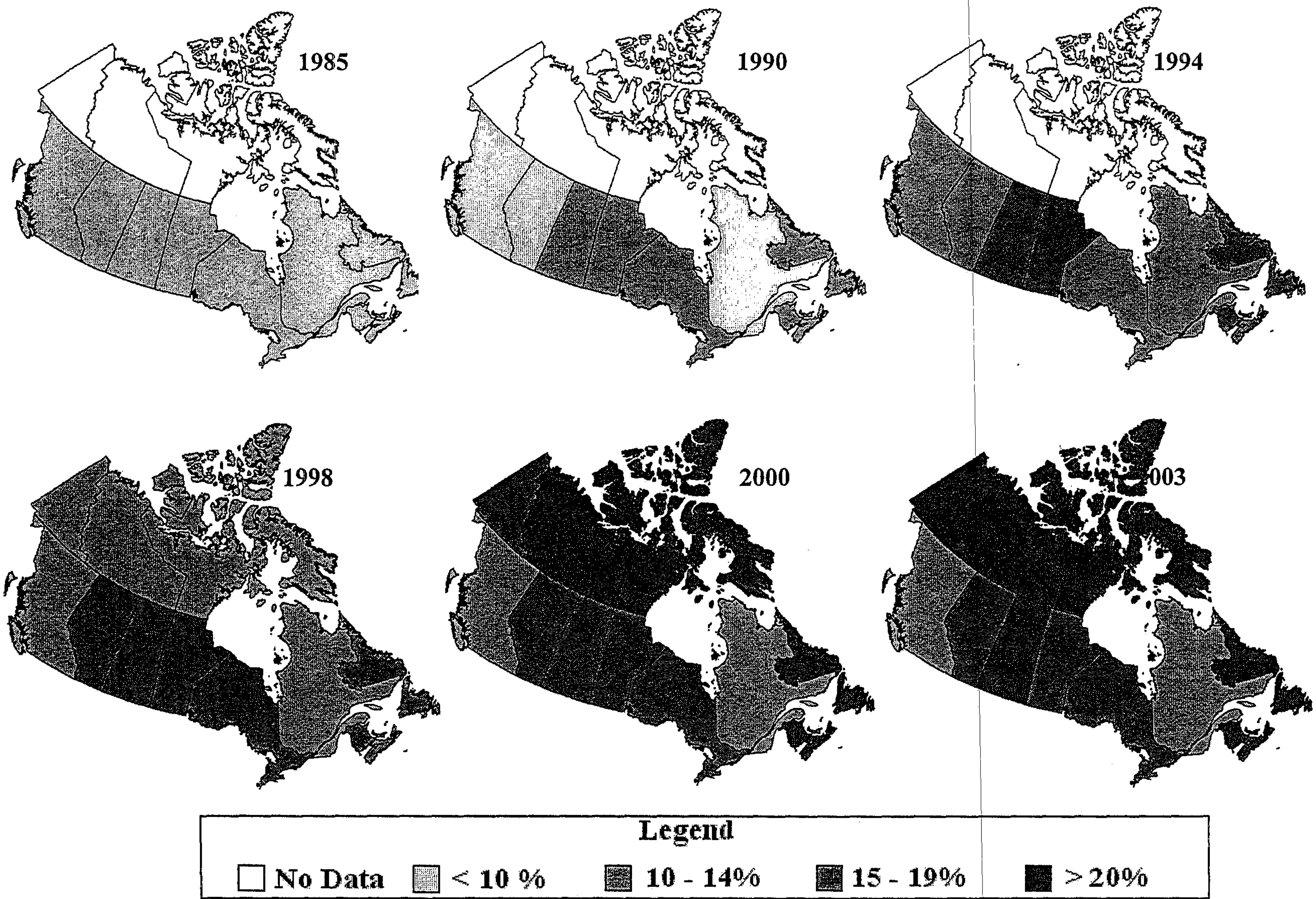


Figure A-1: Prevalence of adult obesity by province (Adapted from Katzmarzyk, 2000)

Appendix B

Ethics Approval Certificate

McMaster University Research Ethics Board (MREB)

c/o Office of Research Services, MREB Secretariat, GH-305, e-mail: ethicsoffice@mcmaster.ca

CERTIFICATE OF ETHICS CLEARANCE TO INVOLVE HUMAN PARTICIPANTS IN RESEARCH

Application Status: New ☒ **Addendum** ☐ **Renewal** ☐ **Project Number** 2006 098

TITLE OF RESEARCH PROJECT:

Understanding the prevalence of overweight and obesity in Ontario: a multilevel approach

Name(s)	Dept./Address	Phone	E-Mail
Faculty Investigator(s)/ Supervisor(s)			
S. Elliott	Geography	23139	elliotts@mcmaster.ca
Student Investigator(s)			
D. Harrington	Geography	42815	harrindw@mcmaster.ca

The application in support of the above research project has been reviewed by the MREB to ensure compliance with the Tri-Council Policy Statement and the McMaster University Policies and Guidelines for Research Involving Human Participants. The following ethics certification is provided by the MREB:

☒ The application protocol is approved as presented without questions or requests for modification.

☐ The application protocol is approved as revised without questions or requests for modification.

☐ The application protocol is approved subject to clarification and/or modification as appended or identified below:

COMMENTS AND CONDITIONS:

Reporting Frequency: **Annual:** **Other:**

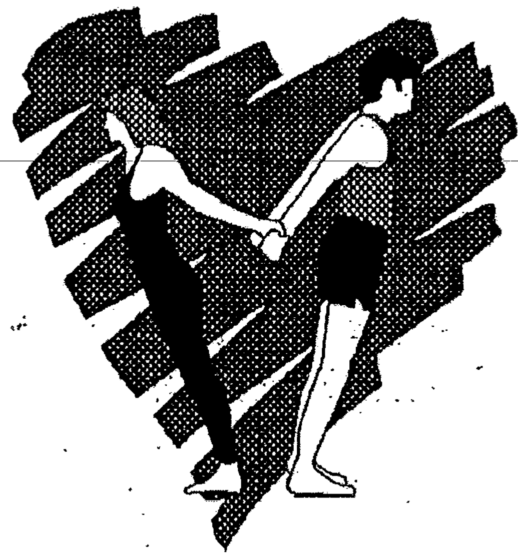
Date: July 11, 2006 **Dr. D. Maurer, Chair, MREB:** VICE-CHAIR

Figure B-1: Ethics Approval Certificate

Appendix C

Ontario Heart Health Survey – 1992

ONTARIO HEART HEALTH SURVEY
Questionnaire



Confidential When Completed

FIRST BLOOD PRESSURE READING

_______/_______

systolic diastolic

First, I would like to ask you a few general questions about heart disease.

1. Can you tell me the major causes of heart disease or heart problems? *Circle all that apply. DO NOT READ LIST.*

   01 POOR DIET
   02 OVERWEIGHT
   03 EXCESS FATS
   04 EXCESS SALTS
   05 HIGH BLOOD CHOLESTEROL
   06 FOODS WITH HIGH CHOLESTEROL
   07 EXCESS STRESS, WORRY OR TENSION
   08 OVERWORK OR FATIGUE
   09 LACK OF EXERCISE
   10 SMOKING
   11 HEREDITY
   12 HIGH BLOOD PRESSURE/ HYPERTENSION
   13 ARTERIOSCLEROSIS OR HARDENING OF THE ARTERIES
   14 DON'T KNOW
   15 OTHER (specify)__________

2. Based upon what you have heard or read, do you believe that heart disease can be prevented?

   1 YES
   2 NO
   8 DON'T KNOW

BLOOD PRESSURE

3. Before this interview, have you ever had your blood pressure checked?

   1 YES
   2 NO —▸ go to #8

4. How long ago did you last have your blood pressure checked?

   1 LESS THAN 6 MONTHS
   2 6-12 MONTHS
   3 OVER A YEAR
   8 DON'T KNOW

5. Who checked your blood pressure at that time?

   1 DOCTOR
   2 NURSE
   3 FAMILY MEMBER OR FRIEND
   4 COIN OPERATED MACHINE
   5 CHECK SELF
   6 OTHER (specify) _______
   8 DON'T KNOW

6. Which of the following describes the information you were given? Was it:

   1 DESCRIBED IN NUMBERS
   2 DESCRIBED IN NUMBERS AND IN WORDS LIKE HIGH, LOW, NORMAL
   3 DESCRIBED IN WORDS ONLY —▸ go to #8
   4 NOT DESCRIBED —▸ go to #8
   5 DON'T KNOW —▸ go to #8

On tario Heart Health Survey *2*

7. What was your blood pressure reading in numbers when it was last taken?

   ______/______
   systolic diastolic

   998 DON'T REMEMBER

8. Were you ever told by a doctor, nurse, or some other health professional that you had high blood pressure?

   1 YES
   2 NO → *go to #15*
   8 DON'T KNOW → *go to#15*

9. Was any treatment or program prescribed for your high blood pressure?

   1 YES
   2 NO ---> go to #15
   8 DON'T KNOW → go to #15

10. What were you told to do? **Circle all that apply.** ***DO NOT READ LIST.***

    01 TAKE MEDICINE ONLY
    02 TAKE. MEDICINE AND SOME OTHER TREATMENT.
    03 GO ON A SALT FREE DIET
    04 WATCH WEIGHT
    05 AVOID STRESS, SLOW DOWN AND RELAX
    06 CUT DOWN OR STOP SMOKING
    07 CUT DOWN ALCOHOL INTAKE
    08 START EXERCISE PROGRAM
    09 USE BIOFEEDBACK
    10 OTHER TREATMENT (specify)

    ____

11. Are you still following that program or are you doing something different?

    1 DIFFERENT PROGRAM NOW
    2 SAME PROGRAM → go to #13
    3 NO PROGRAM NOW → go to #13
    8 DON'T KNOW → go to #13

12. What program are you now following? ***Circle all that apply. DO NOT READ LIST.***

    01 TAKE MEDICINE ONLY
    02 TAKE MEDICINE AND SOME OTHER TREATMENT
    03 GO ON A SALT FREE DIET
    04 WATCH WEIGHT
    05 AVOID STRESS, SLOW DOWN AND RELAX
    06 CUT DOWN OR STOP SMOKING
    07 CUT DOWN ALCOHOL INTAKE
    08 START EXERCISE PROGRAM
    09 USE BIOFEEDBACK
    10 OTHER TREATMENT (specify)

    ____

13. Are you now-taking medication for your high blood pressure?

    1 YES → go to #15
    2 NO
    8 DON'T KNOW

14. Have you ever taken medication for your high blood pressure?

    1 YES
    2 NO
    8 DON'T KNOW

15. As far as you know, is your blood pressure normal now?
    1 YES
    2 NO
    8 DON'T KNOW

16. Do you think that high blood pressure can affect a person's health?
    1 YES
    2 NO → go to #18
    8 DON'T KNOW → go to #18

17. How do you think that blood pressure can affect your health? *Record up to 3 answers. (PROBE)*

    ____
    ____
    ____

18. Do you know what things can give you high blood pressure. *Record up to 3 answers.. (PROBE)*

    ____
    ____
    ____

If respondant answers "Food" or "Beverages" to Question 18, go to Question 20.

19. Have you heard anything about high blood pressure being related to things people eat or drink?
    1 YES
    2 NO → *go to "DIABETES"*

20. What things that people eat or drink, do you think are related to high blood pressure. ***Circle all that apply. DO NOT READ LIST.***
    01 SALT/SALTY FOODS
    02 SODIUM
    03 ALCOHOL
    04 FATS
    05 SATURATED FATS
    06 CHOLESTEROL
    07 CALORIES/EATING TOO MUCH
    08 ADDITIVES/PRESERVATIVES /FOOD COLOURING
    09 CAFFEINE/COFFEE
    10 SUGAR/SWEET FOODS
    11 STARCH/STARCHY FOODS
    12 PORK
    13 SPECIFIC MEAT OTHER THAN PORK
    14 MEATS GENERALLY
    15 FRIED/GREASY/OILY FOODS
    16 CALCIUM
    17 DON'T KNOW
    18 OTHER (specify)

    ____

DIABETES

Next, I would like to ask you some questions about diabetes.

21. Have you ever been told by a doctor that you have diabetes?
    1 YES
    2 NO → *go to "ALCOHOL"*

22. How old were you when you were first told you had diabetes?
    [ ] YEARS OLD
    98 CAN'T REMEMBER

23. Are you now on any treatment for your diabetes?
    1 NO CURRENT TREATMENT
    2 INSULIN
    3 PILLS TO CONTROL BLOOD SUGAR
    4 DIET
    5 WEIGHT LOSS
    6 OTHER (specify) ____________

ALCOHOL

The following questions are about your alcohol consumption:

When a question refers to a drink it means...

- *1 bottle of beer 112 oz. or 360 mL)*
- *1 glass of wine (4-5 oz. or 120-150 mL)*
- *1 small shot of liquor or spirits with or without mix (1- 1 1/2 oz.)*

24. Have you ever taken a drink of beer, wine, liquor or other alcoholic beverage?
    1 YES
    2 NO → go to "WEIGHT"
    9 REFUSED → go to "WEIGHT"

25. Not counting small sips, at what age did you start drinking alcoholic beverages?
    [ ] AGE

26. In the past 12 months, have you taken a drink of beer, wine, liquor or other alcoholic beverage?
    1 YES
    2 NO → go to "WEIGHT"
    9 REFUSED → go to "WEIGHT'

27a How often, on the average, did you have an alcoholic beverage in the past 12 months?
    ____ number of times per week
    OR
    ____ number of times per month
    95 LESS THAN ONCE A MONTH
    99 REFUSED

27b On the days that you drink, how many drinks do you have per day on the average?
    ____ number of drinks
    99 REFUSED

28. Beginning with yesterday, how many drinks did you have on each of the last 7 days?
    [ ] MONDAY
    [ ] TUESDAY
    [ ] WEDNESDAY
    [ ] THURSDAY
    [ ] FRIDAY
    [ ] SATURDAY
    [ ] SUNDAY

29. In the past 12 months, how many times did you drink 10 or more drinks on one occasion?
    [ ] TIMES
    88 NEVER

30. In the past 12 months, how many times did you drink 5 or more drinks on one occasion?

[ ] TIMES

88 NEVER

WEIGHT AND HEIGHT

I would also like to ask you some questions about your height and weight.

31. Have you ever tried to lose weight?

1 YES

2 NO

32. Are you presently trying to lose weight, gain weight or neither?

1 LOSE WEIGHT

2 GAIN WEIGHT → go to #35

3 NEITHER → go to #35

33. Which of the following are you doing to lose weight? *Circle all that apply. READ LIST FROM 1 TO 5.*

1 DIETING

2 EXERCISING

3 SKIPPING MEALS

4 TAKING DIET PILLS

5 ATTENDING WEIGHT CONTROL PROGRAMS

6 OTHER (specify) ____________

34. Why would you like to lose weight? *Circle all that apply. DO NOT READ LIST.*

1 TO BECOME MORE ATTRACTIVE

CONTINUED IN NEXT COLUMN

2 TO IMPROVE GENERAL HEALTH

3 TO DECREASE THE RISK OF HEART ATTACK

4 TO MAINTAIN AN ACCEPTABLE LEVEL OF BLOOD PRESSURE

5 TO MAINTAIN AN ACCEPTABLE LEVEL OF BLOOD CHOLESTEROL

6 TO SLOW DOWN THE HARDENING OF THE ARTERIES

7 TO DECREASE THE RISK OF GETTING DIABETES

8 OTHER (specify) ____________

35. How much do you weigh?

[ ] pounds or [ ] kgs

36. How much would you like to weigh?

[ ] pounds or [ ] kgs

37. How tall are you without your shoes?

[ ] ft [ ] inch or [ ] cent.

EATING HABITS

Now I would like to ask you some questions about your eating habits.

38. How often would you say salt is added to your food during cooking?

1 OFTEN/ALWAYS

2 SOMETIMES

3 OCCASIONALLY

4 ALMOST NEVER/NEVER

8 DON'T KNOW

39. How often would you say salt is added to your food at the table?
    1 OFTEN/ALWAYS
    2 SOMETIMES
    3 OCCASIONALLY
    4 ALMOST NEVER/NEVER

40. Do you think the amount of salt people eat can affect their health?
    1 YES
    2 NO → *go to "FATS"*
    3 DON'T KNOW → *go to "FATS"*

41. How do you think your health would be affected if you ate too much salt? ***Circle all that apply. DO NOT READ LIST.***
    01 BLOOD PRESSURE WOULD INCREASE
    02 WEIGHT WOULD INCREASE
    03 ANKLES MAY BECOME SWOLLEN
    04 INCREASE THE RISK OF HEART ATTACK
    05 INCREASE THE RISK OF STROKE
    06 INCREASE THE RISK OF KIDNEY PROBLEMS
    07 NEED TO TAKE BLOOD PRESSURE PILLS/MEDICATION
    08 SPEEDS UP THE HARDENING OF THE ARTERIES
    09 DON'T KNOW
    10 OTHER **(specify)**________________

FATS

I would like to ask you some questions about fats.

42. Another thing found in many foods is fat. Do you think the amount of fat a person eats can affect their health?
    1 YES
    2 NO → *go to "CHOLESTEROL"*

43. What health problems do you think might be related to the amount of fat a person eats? ***Circle all that apply. DO NOT READ LIST.***
    1 OVERWEIGHT/OBESITY
    2 HEART DISEASE/CORONARY DISEASE/HEART PROBLEMS/HEART ATTACK
    3 HIGH BLOOD CHOLESTEROL
    4 HIGH BLOOD PRESSURE
    5 ARTERIOSCLEROSIS/ HARDENING OF THE ARTERIES/FAT BUILD-UP
    6 DON'T KNOW
    7 OTHER **(specify)**________________

CHOLESTEROL

The next set of questions are about cholesterol.

44. Have you heard about cholesterol?
    1 YES
    2 NO → *go to "SMOKING"*

45. What have you heard-about cholesterol?
Record up to 3 answers. (PROBE)

____

____

____

46. Do you think that cholesterol is found in foods?

1	YES	
2	NO	→ *go to #49*
8	DON'T KNOW	→ *go to #49*

47. Which foods do you think contain cholesterol? *Circle all that apply. DO NOT READ LIST.*

01	EGGS/EGG YOLK
02	POULTRY
03	BEEF/RED MEATS
04	PORK/HAM/BACON
05	SEAFOODS
06	MILK (specify) ________
07	CHEESE (specify) ________
08	BUTTER
09	FAST FOOD (specify) ________
10	DON'T KNOW
11	OTHER (specify) ________

48. Do you think that cholesterol in the foods people eat can affect their health?

1	YES
2	NO
8	DON'T KNOW

49. Do you think that cholesterol is found in people's blood?

1	YES	
2	NO	→ *go to #51*
8	DON'T KNOW	→ *go to #51*

50. Do you think that too much cholesterol in people's blood can affect their health?

1	YES
2	NO
8	DON'T KNOW

51. How do you think cholesterol can affect people's health? *Circle all that apply. DO NOT READ LIST.*

1	HARDENING OR CLOGGING OF ARTERIES
2	INCREASE BLOOD PRESSURE
3	HEART ATTACK
4	STROKE
5	ANGINA (PAIN IN THE CHEST)
6	OTHER (specify) ________
8	DON'T KNOW

52. Have you ever had your blood cholesterol measured?

1	YES	
2	NO	→ *go to #54*
8	DON'T KNOW	→ *go to #54*

53. Were you told what your blood cholesterol level was?

1	YES
2	NO
8	CAN'T REMEMBER

54. Were you ever told by a doctor, nurse or other health professional that your blood cholesterol was high?

1 YES
2 NO —> go to #57
3 CAN'T REMEMBER —> go to #57

55. Did the doctor, nurse or other health professional prescribe any treatment or tell you what to do to lower your blood cholesterol?

1 YES
2 NO
3 CAN'T REMEMBER

56. Are you presently on a special diet, which was recommended by a doctor, nurse or other health professional, to lower your blood cholesterol?

1 YES
2 NO

57. Can you tell me what a person can do to lower his or her blood cholesterol level? ***Circle all that apply. DO NOT READ LIST.***

01 EXERCISE REGULARLY
02 CONTROL STRESS AND FATIGUE
03 TAKE PRESCRIBED MEDICATION
04 EAT FOOD WITH LESS CHOLESTEROL
05 EAT LESS FATTY FOOD
06 LOSE WEIGHT
07 USE SKIM MILK OR LOW FAT DAIRY PRODUCTS
08 NOTHING

CONTINUED IN NEXT COLUMN

09 DON'T KNOW
10 OTHER (specify) ____________

SMOKING

I would like to ask you some questions about smoking

58. At the present time do you smoke cigarettes daily, occasionally or not at all?

1 DAILY
2 OCCASIONALLY —> go to #61
3 NOT AT ALL —> go to #61

59. At what age did you begin to smoke daily?

[ ] AGE

60. How many cigarettes do you smoke each day now?

[ ] Number of cigarettes —> go to #65

61. Have you ever smoked cigarettes daily?

1 YES
2 NO —> go to #65

62. At what age did you begin to smoke daily?

[ ] AGE

63. At what age did you stop smoking daily?

[ ] AGE

64. How many cigarettes a day did you usually smoke?

[ ] Number of cigarettes

65. Do you smoke pipes, cigars, or cigarillos daily, occasionally or not at all?
    1 DAILY
    2 OCCASIONALLY
    3 NOT AT ALL

EXERCISE

The next few questions are about current physical activity or exercise.

66. Do you regularly engage in physical activity during your leisure time? By regularly we mean at least once a week during the past month.
    1 YES
    How many times a week?
    [ ]
    2 NO → *go to #69*
    8 CAN'T REMEMBER → *go to #69*

67. How much of this physical activity is strenuous enough to cause sweating or breathing heavily?
    1 MOST OF IT
    2 SOME OF IT
    3 NONE OF IT

68. How long do you usually exercise? *READ THIS LIST.*
    1 LESS THAN 15 MINUTES
    2 15 TO 30 MINUTES
    3 31 TO 60 MINUTES
    4 MORE THAN 60 MINUTES
    8 DON'T KNOW

69. Does your work require strenuous physical activity?
    1 YES
    2 NO
    3 NOT APPLICABLE
    8 CAN'T REMEMBER

HEART DISEASE

Now I would like to ask you a few questions about your health.

70. Have you ever had a heart attack? *(If necessary explain what a heart attack is).*
    1 YES
    2 NO
    8 DON'T KNOW

71. Have you ever had a stroke? *(If necessary explain what a stroke is).*
    1 YES
    2 NO
    8 DON'T KNOW

72. Based upon what you have heard or read, do you believe that strokes can be prevented?
    1 YES
    2 NO
    8 DON'T KNOW

73. Do you suffer from any kind of heart disease that you have not yet told me about?
    1 YES, What is it?
    ____
    2 NO

74. Are you presently taking any medicine for your heart prescribed by a doctor?
    - 1 YES
    - 2 NO

75. **ASK WOMEN ONLY:**
    Are you presently taking.....
    - 1 ORAL CONTRACEPTIVES?
    - 2 HORMONAL PILLS?
    - 3 NEITHER

FAMILY HISTORY

Now I would like to ask you some questions about your family's health

76. Is your father alive?
    - 1 YES → *go to #78*
    - 2 NO
    - 8 DON'T KNOW → *go to #78*

77. What was the cause of death?
    - 1 AN ACCIDENT
    - 2 CANCER
    - 3 STROKE
    - 4 HEART ATTACK
    - 5 OTHER
    - 8 DON'T KNOW

78. How old is your father? or How old was your father when he died?
    [ ]
    998 DON'T KNOW

79. Has (Did) your father had (have) a heart attack or angina?
    - 1 YES
    - 2 NO → *go to #81*
    - 8 DON'T KNOW → *go to #81*

80. Did this occur before he was 60?
    - 1 YES
    - 2 NO
    - 8 DON'T KNOW

81. Has (Did) your father had (have) strokes or cerebral vascular disease?
    - 1 YES
    - 2 NO → *go to #83*
    - 8 DON'T KNOW → *go to #83*

82. Did this occur before he was 60?
    - 1 YES
    - 2 NO
    - 8 DON'T KNOW

83. Has (Did) your father had (have) high blood pressure or hypertension?
    - 1 YES
    - 2 NO
    - 8 DON'T KNOW

84. Has (Did) your father had (have) high cholesterol or high blood fats?
    1 YES
    2 NO
    8 DON'T KNOW

85. Is your mother alive?
    1 YES → go to #87
    2 NO
    8 DON'T KNOW → go to #87

86. What was the cause of death?
    1 AN ACCIDENT
    2 CANCER
    3 STROKE
    4 HEART ATTACK
    5 OTHER
    8 DON'T KNOW

87. How old is your mother? or How old was your mother when she died?
    [ ]
    998 DON'T KNOW

88. Has (Did) your mother had (have) a heart attack or angina?
    1 YES
    2 NO → *go to #90*
    3 DON'T KNOW → go to #90

89. Did this occur before she was 60?
    1 YES
    2 NO
    8 DON'T KNOW

90. Has (Did) your mother had (have) strokes or cerebral vascular disease?
    1 YES
    2 NO → go to #92
    8 DON'T KNOW → go to #92

91. Did this occur before she was 60?
    1 YES
    2 NO
    8 DON'T KNOW

92. Has (Did) your mother had (have) high blood pressure or hypertension?
    1 YES
    2 NO
    3 DON'T KNOW

93. Has (Did) your mother had (have) high cholesterol or high blood fats?
    1 YES
    2 NO
    3 DON'T KNOW

94. What is the total number of brothers, sisters, half-brothers and half-sisters you have had?
    [ ] NUMBER
    98 DON'T KNOW

95. Of these, how many are living?
    [ ] NUMBER
    98 DON'T KNOW

96. How many of your brothers, sisters, half-brothers and half-sisters, whether living or not, have had the following disorders? ***Do not include UNCERTAIN or UNKNOWN responses.***

[ ] Heart attack or angina before age 60

[ ] High blood pressure or hypertension

[ ] Strokes or cerebral vascular disease

[ ] High cholesterol or high blood fats

DEMOGRAPHIC INFORMATION

The next few questions let us look at health factors by different groups.

97. CIRCLE RESPONDENT'S SEX:

1 MALE

2 FEMALE

98. What is your date of birth?

____

DAY/MONTH/YEAR

999999 REFUSED

99. What is your current employment status? ***READ THIS LIST.***

1 FULL TIME (35 hours or more a week)

2 PART TIME (less than 35 hours a week)

3 UNEMPLOYED

4 LAID OFF

5 RETIRED

6 OTHER (specify) ____________

CONTINUED IN NEXT COLUMN

7 HOMEMAKER → go to #101

8 STUDENT ---> go to #101

100. What is your occupation? ***Circle most appropriate. DO NOT READ LIST.***

1 PROFESSIONAL

2 CLERICAL WORKER

3 SKILLED/FOREMAN

4 MANAGER, OFFICIAL PROPRIETOR

5 SALES WORKER

6 NON-SKILLED

7 OTHER (specify) ____________

____

101. What is your current marital status? ***READ LIST FROM 1 TO 5.***

1 NEVER MARRIED

2 DIVORCED

3 MARRIED/COMMON LAW

4 WIDOWED/WIDOWER

5 SEPARATED

9 REFUSED TO ANSWER

102. What is the highest grade or year of school you have completed?

[ ] GRADE (elementary, secondary)

[ ] YEARS (college, university)

98 DON'T KNOW

If there is some doubt, record the response.

____

____

____

103. What language did you first speak in childhood?

1 ENGLISH

2 FRENCH

3 OTHER (specify) ____________

104. What language do you speak most often at home?

1 ENGLISH

2 FRENCH

3 OTHER (specify) ____________

105. How many people live in this household?

[ ]

106. What was your approximate total household income for the year 1991 before income tax deduction?

01 NO INCOME

02 LESS THAN $6,000

03 $6,660 - $11,999

04 $12,000 - $19,999

05 $20,000 - $24,999

06 $25,000 - $29,999

07 $30,000 - $39,999

08 $40,000 - $49,999

09 $50,000 - $59,999

10 $60,000 - $69,999

11 $70,000 - $79,999

12 $80,000 AND MORE

13 DON'T KNOW

14 REFUSED

107. To which ethnic or cultural group(s) do you or did your ancestors belong? *Circle all that apply. DO NOT READ LIST.*

01 FRENCH

02 ENGLISH

03 GERMAN

04 SCOTTISH

05 IRISH

06 ITALIAN

07 UKRANIAN

08 DUTCH

09 CHINESE

10 JEWISH

11 POLISH

12 PORTUGUESE

13 NORTH AMERICAN INDIAN

14 METIS

15 INUIT

16 CANADIAN

17 OTHER (specify)

____

SECOND BLOOD PRESSURE READING

____

systolic diastolic

Ontario Heart Health Survey

Blood Collection and Physical Measurements

Reference Number: *(affix label)*

Interviewer 1: _____

Interviewer 2: _____

Home Visit or First Visit	
First Blood Pressure Readings	1A. ________/________ (systolic / diastolic) 1B. ________/________ (systolic / diastolic)
Clinic or Second Visit	
Date of Clinic Visit	1 REFUSED 2 NO SHOW ____/____/____ (day month year) ________ (time)
Second Blood Pressure Readings	2A. ________/________ (systolic / diastolic) 2B. ________/________ (systolic / diastolic)
Blood Sample	Sample Status: 1 TAKEN 2 REFUSED Time sample taken: _____ a.m. Hours since last meal: _____ hrs.
Physical Measurements	Height: ______ cm. Waist: ______ cm. Weight: ____.__ kg. Hip: ______ cm.
Quality Control Measurements	
Blood Taken	1 YES Blood Specimen #: __________ 2 NO
Physical Measurements	Height: ______ cm. Waist: ______ cm. Weight: ____.__ kg. Hip: ______ cm.
Blood Pressure Readings	3A. ________/________ 3B. ________/________

Appendix D

Map of Sampled Forward Sortation Areas
(Toronto Insert)

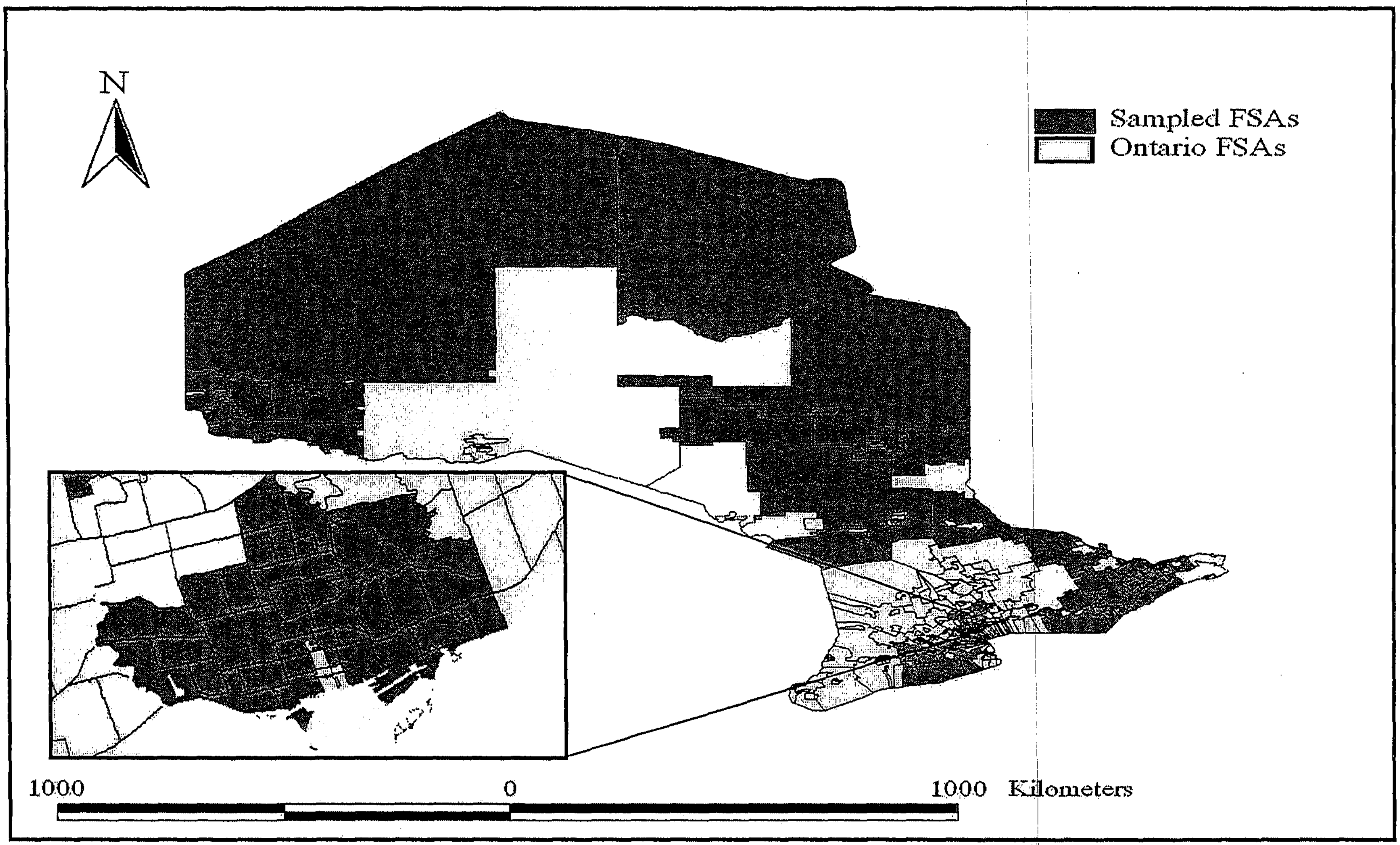


Figure D-1: FSA coverage of Ontario (Toronto insert)

Appendix E

Detailed Multivariate Regression Tables

Table E-1: Multivariate regression, full data, BMI

	Estimate	*Std. Error*	*p-value*	*95% CI*	*Significance*
(Intercept)	21.578	0.342	<2e-16	(20.91, 22.25)	***
Age	0.057	0.007	3.47e-15	(0.043, 0.071)	***
Males	0.657	0.190	5.68e-4	(0.285, 1.029)	***
<High School	0.985	0.237	3.45e-5	(0.520, 1.450)	***
Partner	0.666	0.204	0.0011	(0.266, 1.066)	**
Regular Smoker	-0.480	0.240	0.0459	(-0.950, -0.009)	*
Sedentary	1.097	0.196	2.53e-8	(0.713, 1.481)	***

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05
Adjusted R^2: 0.09687

Table E-2: Multivariate regression, full data, WC

	Estimate	*Std. Error*	*p-value*	*95% CI*	*Significance*
(Intercept)	65.066	1.241	<2e-16	(62.634, 67.498)	***
Age	0.259	0.018	<2e-16	(0.224, 0.294)	***
Males	11.524	0.476	<2e-16	(10.591, 12.457)	***
<High School	2.237	0.588	0.000147	(1.084, 3.389)	***
Diabetes	5.949	1.182	5.26e-7	(3.632, 8.266)	***
Regular Smoker	-1.853	0.603	0.00215	(-3.035, -0.671)	**
Sedentary	4.025	0.485	<2e-16	(3.074, 4.976)	***
Alcohol	2.288	1.073	0.0331	(0.185, 4.391)	*

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05
Adjusted R^2: 0.3606

Table E-3: Multivariate regression, male data, BMI

	Estimate	*Std. Error*	*p-value*	*95% CI*	*Significance*
(Intercept)	23.838	0.503	<2e-16	(22.852, 24.824)	***
Age	0.040	0.0104	0.00010	(0.020, 0.060)	***
< High School	0.557	0.265	0.0361	(0.038, 1.076)	*
Partner	0.994	0.286	0.00054	(0.433, 1.555)	***
Household	-0.229	0.0787	0.0037	(-0.383, -0.075)	**
Jobtype – Other	-0.709	0.253	0.0052	(-1.205, -0.213)	**
Sedentary	0.907	0.231	8.9e-05	(0.454, 1.360)	***

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05
Adjusted R^2: 0.1003

Table E-4: Multivariate regression, male data, WC

	Estimate	*Std. Error*	*p-value*	*95% CI*	*Significance*
(Intercept)	71.713	2.712	<2e-16	(66.397, 77.029)	***
Age	0.310	0.023	<2e-16	(0.265, 0.355)	***
Household	-0.582	0.207	0.0051	(-0.988, -0.189)	**
Alcohol	7.552	2.362	0.0014	(2.922, 12.182)	**
Diabetes	3.223	1.436	0.0250	(0.408, 6.038)	*
Sedentary	3.310	0.624	1.40e-7	(2.087, 4.533)	***

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05
Adjusted R^2: 0.2295

Table E-5: Multivariate regression, female data, BMI

	Estimate	*Std. Error*	*p-value*	*95% CI*	*Significance*
(Intercept)	21.249	0.483	<2e-16	(20.302, 22.196)	***
Age	0.068	0.011	1.07e-9	(0.046, 0.090)	***
< High School	1.312	0.385	0.00069	(0.557, 2.067)	***
Sedentary	1.234	0.320	0.00013	(0.607, 1.861)	***
Diabetes	1.650	0.832	0.0475	(0.019, 3.28)	*

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05
Adjusted R^2: 0.099

Table E-6: Multivariate regression, female data, WC

	Estimate	*Std. Error*	*p-value*	*95% CI*	*Significance*
(Intercept)	68.329	1.147	<2e-16	(66.081, 70.577)	***
Age	0.217	0.027	<2e-16	(0.164, 0.270)	***
< High School	3.323	0.892	0.00021	(1.575, 5.071)	***
Regular Smoker	-1.893	0.902	0.0361	(-3.661, -0.125)	*
Diabetes	8.315	1.979	2.89e-5	(4.436, 12.194)	***
Sedentary	4.975	0.741	3.20e-11	(3.523, 6.427)	***

Significance Codes: '***' <0.001; '**' <0.01; '*' <0.05
Adjusted R^2: 0.1896

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