Geographical Epidemiology of Health and Deprivation: a Population-Based, Spatio-Temporal Analysis of Health and Social Inequality in Nova Scotia, Canada

by

Mikiko Terashima

Submitted in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

at

Dalhousie University
Halifax, Nova Scotia
April 2011

DALHOUSIE UNIVERSITY

INTERDISCIPLINARY PH.D. PROGRAM

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Geographical Epidemiology of Health and Deprivation: a Population-Based, Spatio-Temporal Analysis of Health and Social Inequality in Nova Scotia, Canada" by Mikiko Terashima in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Dated: April 4, 2011

External Examiner: _______________________

Research Supervisor: _______________________

Examining Committee: _______________________

____

____

Departmental Representative: _______________________

DALHOUSIE UNIVERSITY

DATE: April 4, 2011

AUTHOR: Mikiko Terashima

TITLE: Geographical Epidemiology of Health and Deprivation: a Population-Based, Spatio-Temporal Analysis of Health and Social Inequality in Nova Scotia, Canada

DEPARTMENT OR SCHOOL: Interdisciplinary Ph.D. Program

DEGREE: PhD CONVOCATION: October YEAR: 2011

____

Signature of Author

To Jason

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF ABBREVIATIONS USED

AIC	Akaike Information Criterion
CIDR	Comparative Illness and Disability Ratio
DA	Census Dissemination Area
DIC	Deviance Information Criterion
DIHWPQ	Deprivation Index for Health and Welfare Planning in Quebec
GIS	Geographic Information Systems
GHQ	General Health Questionnaire
GSA	General Services Area
IMD	Index (Indices) of Multiple Deprivation
LLTI	Limiting Long Term Illnesses
LE	Life Expectancy (at Birth)
PCA	Principal Component Analysis
SERI	Socioeconomic Risk Indicator
UPA	Underprivileged Area
VANDIX	Vancouver Area Neighbourhood Deprivation Index
YPLL	Years of Potential Life Lost

ABSTRACT

Narrowing the gap in health inequality is vital not only from an equity point of view but also from an economic cost point of view. Small-area level investigations of health inequalities can play an important role in this effort. This research is an attempt to produce evidence of within-province social and health inequality. This cross-sectional, ecological study examines the geographical distribution of life expectancy at birth (LE) and its relationships with two domains of deprivation—material and social—at two time periods (1995-1999 and 2003-2007) across 182 'communities.' The deprivation measures were derived from a set of indices now widely used in Quebec. Five community types assigned to the communities represented relative levels of rurality. A general pattern was observed that material deprivation became more prominent as 'rurality' increased. The pattern of social deprivation by rurality was more 'flat' where other levels of rurality than the most urban type had similar deprivation scores and rankings. LE was patterned by a relative degree of deprivation but not by rurality *per se*, though high socioeconomic deprivation tends to be observed in 'rural areas.' The gaps in LEs between the most and least deprived were wider for males than for females. Inequalities in LE by material deprivation of the communities appear to have widened over time. The regression models indicated the presence of an interaction effect—material and social deprivation together exacerbate the risk of low LE. The study also observed some regional clustering of unaccounted factors, which requires further investigation to determine what potential regional phenomena account for this effect. Lastly, the deprivation scores left more variations in LE in rural communities unexplained than variations in urban communities, leading us to suspect that the indices employed might be less sensitive for health inequalities in rural communities than in urban communities. Further research efforts are necessary to tackle many questions this research could not address, which would more fully inform policy related to the reduction of health and social inequality in Nova Scotia and elsewhere.

ACKNOWLEDGEMENTS

The guidance and support of Dr. Judith Read Guernsey, Director of the Atlantic RURAL Centre and my thesis supervisor, has been tremendous throughout this marathon learning process. I am also deeply indebted to the generous guidance of the committee members: Dr. Pantelis Andreou, Dr. Robert Maher, and Dr. Victor Thiessen. Given the multidisciplinary nature of this research, one of the largest challenges was the conception of the research idea and research framework itself. All the professors' insights from their respective fields of expertise have helped find the voice asking the very questions I wanted to ask but had difficulty in articulating. Furthermore, I could not have done without the passionate curiosity and infinite patience of Dr. Andreou in helping me understand Bayesian statistics and spatial models through countless meetings throughout my Ph.D. program. The friendship we have built over the years is also invaluable.

My sincere appreciation goes to the generous funding support provided by and the Atlantic RURAL Centre at Dalhousie University, Canadian Institute of Health Research (CIHR) Strategic Training Program, Public Health and Agricultural Rural Ecosystems (PHARE) and the Killam Pre-doctoral fellowship program. Especially, the support from the Atlantic RURAL Centre goes far beyond financial. The Centre has given me opportunities to conduct some interesting research on rural health of the region, inspiring research questions and ideas that I have pursued and will pursue in my future research career.

My thanks also go to Mr. Junaid Kapra, Research and Statistical Officer at Nova Scotia Vital Statistics Office, who patiently worked with me on the process of geocoding over 100,000 birth and death records and assigning communities. Likewise, Nova Scotia Community Counts' former Director, Mr. Dennis Pilkey is owed much thanks for his guidance in initial development of the data supporting the deprivation indices and understanding how community units were designed. I would also like to thank my friend and great English teacher Jon Pickup who patiently proofread my thesis, which must not have been a picnic. Lastly, I would like to send my warm thanks to friends and family who provided encouragement and support throughout the process not only of my research career development but also of my personal growth.

Chapter 1. INTRODUCTION

1.1. Health and Social Inequality (with)in Nova Scotia

The province of Nova Scotia, Canada, has a population of just under 1 million people, and population growth has been slow compared with provinces in western and central Canada over the last two decades (Nova Scotia Community Counts, 2010). Nova Scotia was reported to have the highest rates of death from cardiovascular and respiratory diseases, and the second highest rates of circulatory death and diabetes in the country (Nova Scotia Office of Health Promotion, 2005). While being at the lowest end of such inter-provincial health inequality is disquieting, there are also likely variations among sub-populations within the province that may be important to address. For example, Read Guernsey and colleagues (Read Guernsey, Dewar, & Weerasinghe, et al., 2000) found that Sydney, the largest municipality in Cape Breton County, had overall cancer incidence rates that were 50% higher than the Nova Scotia average. A more recent study (Pong, DesMeules, & Heng, et al., 2010) also found that rates of physician visits and hospitalization for some diseases such as respiratory diseases, injury, mental disorders varied in Nova Scotia and a few other provinces, depending on the type of rurality defined by the area's proportion of commuters to the urban areas (Metropolitan Influence Zone). Narrowing the gap in health inequality is important both from an economic cost point of view (LaVeist, Gaskin, & Richard, 2009; Mackenbach, Meerding, & Kunst, 2007), and an equity point of view (Braveman, 2006; Sen, 2002). It is possible that the provincial average health status hides worse conditions of some sub-groups, while others might enjoy health status similar to or higher than the Canadian standard. Yet the patterns and distributions of health status and social conditions across sub-populations in Nova Scotia—particularly across small areas of the province—are not clearly known.

An attempt to improve the average health status of Nova Scotia residents from behavioural perspectives—i.e., reducing smoking, promoting healthy diet and physical activities in individuals—can be effective in improving the health status of a population. However, it may also lead to an unexpected consequence where the programs and policies will unintentionally leave out those who tend to be socioeconomically disadvantaged and lack access to education and information (Woodward & Kawachi, 2000). In order to reach all sectors of the population, both 'population as a whole' and 'vulnerable population focused' approaches to health intervention strategies are necessary (Frohlich & Potvin, 2008). Doing so requires, as part of their strategies, identification of the sub-populations within the province who live in areas vulnerable to risks of producing lower level health. It is of interest to the province, particularly to government authorities mandated to improve the health and social conditions of all Nova Scotians and attract more people to live in the province, as it could lead to a sustainable population and economic growth.

1.2. Geographical Epidemiology of Health and Deprivation—What Does It Mean?

Small-area spatial analyses of health and social inequalities have been increasingly popular, as our understanding of, and interest in, the importance of one's immediate surrounding environment—in which one lives, works, and raises family—has grown (Kawachi & Berkman, 2003). However, such small-area studies often face challenges such as data availability and the conceptualization of area units where the 'effect' of interest occurs (Frohlich et al., 2006: O'Campo, 2003; also see Pong, Pitblado, & Irvine et al., 1999 for discussion on some data challenges in developing rural health indicators). There are additional challenges when the investigation includes rural areas where the population is sparse and the location information such as postal codes does not necessarily point to the actual geographical location. Certainly, these challenges have been considerable in research work investigating small-area level inequality in health and social conditions in Nova Scotia, which encompasses both urban and rural populations, though it is certainly not only limited to Nova Scotia.

This research is an attempt to 'do the best' with available data and resources to produce evidence of intra-province social and health inequality in Nova Scotia. I employ geographical epidemiology as a research framework and investigate the relationships between the geographical/spatial distribution of health and some social determinants at the ecological level at two different time periods (1995-1999 and 2003-2007). For the ecological level social determinants, I examine two 'domains' of deprivation. These two domains of deprivation measures represent: 1) relative socioeconomic position; and 2) relative levels of social isolation in the communities. They were constructed following the indices of 'material' and 'social' deprivation developed in Quebec (Pampalon and Raymond, 2000). Specifically, this study examines: 1) the distribution patterns of health inequalities (measured by life expectancy at birth) and social inequalities (measured by two domains of deprivation); 2) the associations between health and deprivation; 3) time trends in these inequalities; 4) the geographical clustering of unaccounted variations; and 5) the associations between health and deprivation within different levels of rurality.

What do I mean by geographical epidemiology in this study? Perhaps it is necessary to mention the research atmosphere in which geographical epidemiology came into being. A critical mass of research investigating 'place' related to health and illnesses has emerged in the last few decades. These studies that attempted to understand the roles, meaning, and relationships of 'place' with health in this period were broadly dubbed 'place and health' research. The realm of 'place and health' research comprises of multidisciplinary perspectives on the significant of human environment as a determinant of health. It originates from the need to understand the roles of so-called 'supra-individual' determinants of health—including the social and physical environment, political context, family setting, geographical location, neighbourhood socioeconomic conditions etc. that affect the health of individuals and groups—which had previously been gravely understudied. 'Place' can include not only geographical location or space as an "unproblematic, activity container"-like concept of space (Kerns and Moon, 2002), but also those supra-individual factors mentioned above. 'Place and health' has come to form a discourse involving multiple disciplines connected by a belief that 'place' matters (Moon, 1995; Kerns & Moon, 2002; Dunn, Frohlich, & Ross, et al., 2006; Kawachi, Subramanian, Almedia-Filho, 2002; Frohlich, 2000; Schwartz & Diez-Roux, 2000; Moore, Rosenberg, & Mackenzie, 2004). Moreover, the concept that these place-based factors are socially structured is a central tenet (Schwartz, 1994; Curtis & Jones, 1998; Dunn et al., 2006). The common goal of 'place and health' is therefore to understand what it is about 'place' that influences the health of individuals and populations.

What is geographical epidemiology then? Several existing definitions will help elaborate what I wish geographical epidemiology to mean in this thesis. For example, Rezaeian and colleagues (Rezaeian, Dunn, & St. Leger et al., 2006, p.100) state that "geographical epidemiology can be defined as the description of spatial patterns of disease morbidity and mortality, part of descriptive epidemiological studies, with the aim of formulating hypotheses about the aetiology of diseases." As such, geographical epidemiology is a discipline, but also a type of study. Their definition largely limits the type of study to descriptive and hypothesis building stages rather than also being more analytical. Haining (2003) states that "Geographical epidemiology focuses on the description of the geography of disease incidence. It is concerned with examining the factors associated with spatially varying levels of incidence, prevalence, mortality and recovery rates of a disease…" His definition is a little unclear about 'the factors associated with incidence…" whether the concern is to identify where it is or what it is and why. Bitchell's definition in his book, *Handbook of Epidemiology* (2005, p.861), is broader and more encompassing. He states,

> Although, at first sight, geographical epidemiology may appear to differ substantially from other areas of epidemiology, it has many features in common. … The distinctive characteristic is of course that geographical location is an important explanatory variable, either because it reflects an environmentally determined element of risk or because people with similar risk attribute live together, so that risk varies from place to place.

Another way to look at geographical epidemiology may be as part of social epidemiology, as "social epidemiology is, after all, grounded in a history that is geographic" (Koch, 2009, p.104)[1]. Then, 'geographical epidemiology' may well be a brand of social epidemiology that focuses on 'place' in which spatial distribution of diseases and risk factors is an integral part of the investigation. It also well aligns with Bitchell's definition of geographical epidemiology, though he does not explicitly express that an "environmentally determined element of risk" can constitute social environment.

For the purpose of this study, I define geographical epidemiology as a framework of research that investigates the relationships between the geographical distribution of health

[1] Koch (2009, p.100) goes on to point out that medical geography, which provides the "means of locating and analyzing data as a class and in relation to other attributes in a spatial framework" is ingrained in the work of social epidemiology.

and social environmental phenomena, with the aim of enhancing our understanding of the roles and meaning of the social environmental phenomena in the production of health and health inequalities. As such, the conceptualization of the research questions reflects a decidedly 'place and health' perspective. Specifically, this study investigates the geographical distribution of health and its relationships with two domains of deprivation as the social environmental phenomena (or 'place' factors), in the process of which the roles of deprivation might be better understood and unknown other place factors might be identified.

Methodologically, geographical epidemiology has many commonalities with spatial epidemiology. Spatial epidemiology is a strain of epidemiological discipline also interested in describing and understanding spatial distributions of health risks and outcomes, particularly at small-area levels. It has its roots in environmental epidemiology, and was primarily concerned with the spatial spread of infectious diseases (see Elliott, Wakefield, & Best et al., 2000; Ostfeld, Glass, & Keesing, 2005 for a useful discussion of the origins of spatial epidemiology)[2]. Spatial epidemiology involves four main research frameworks: 1) disease mapping, 2) geographical correlations studies, 3) the assessment of risk in relation to a point or line-source, and 4) cluster detection and disease clustering (Elliott et al., 2000). Spatial epidemiologists are probably the ones among health researchers most rigorously pushing an agenda for advancing innovative statistical tools and methods for area level investigations of health phenomena. This thesis conducts disease (and disease risk) mapping, geographical correlation studies, and cluster detection as some of its main components. Using these

[2] Prior to the publication of Elliott et al.'s book *Spatial Epidemiology* (2000), Becker and colleagues (Becker, Glass, & Brathwaite et al, 1998) examined the small-area distribution of gonorrhea and identified a core area where the high rates of incidence are concentrated. They called their study geographical epidemiology. Since then, it appears that the term geographical epidemiology has been used less often to refer to this type of study.

methods, it investigates the small-area level geographical distribution of health inequality, and its relationships with two domains of deprivation that are likely to influence the health of the individuals and groups. It also examines the geographical distribution of residuals from the regression model which assesses the associations between life expectancy and the two deprivation measures to see if any potential place-based unaccounted factors may be present and to speculate what they potentially might be.

1.3. Deprivation as a Contextual Risk Condition and Possible Pathways to Health Inequality—the Premise

This thesis examines two domains of deprivation measured at an area-level for its roles in production of health inequalities. The background concept of deprivation and how it has been used in research examining their effects on various health outcomes in populations are described in details in the literature review (Chapter 2). Deprivation may be understood as an array of indicators that represent certain constructs relevant to producing inequalities in social or health conditions, the mechanism of which may be systematic and theorized (or theorize-able). This research conceptualizes population-based or place-based deprivation as a *contextual risk condition*, borrowing some existing concepts around social environments and their roles in production of health inequalities. These concepts are: Macintyre and colleagues' (Macintyre, Ellaway, & Cummins, 2002) 'place effects,' Krieger's (2006) five pathways of social environment 'embodying' in health inequality, and 'biosocial pathways' involving contextual risk conditions proposed by Daniel and colleagues (Daniel, Moore, & Kestens, 2008). Each of the concepts is also elaborated in Chapter 2. I posit that possible causal pathways of place-based deprivation to health include: 1) A direct-contextual path through which their circumstances consciously or unconsciously produce stress; 2) An indirect-cognitive path which indirectly influences health through constituting or altering health behaviours and affecting mental health such as anxiety, loneliness or loss of ability for control through perception of their living environment; and 3) More direct physical lack of health maintenance resources such as food (nutrition), physical activity facilities and services, presence of health harming substances, and existing collective health behaviours and life styles.

Because this is an ecological level study, it does not attempt to test the plausibility of these causal pathways—whether the contextual risk conditions manifest in specific diseases in individuals. Rather, the conceptualization of deprivation as a contextual risk condition is treated as a premise, or pre-condition—than a theoretical framework to be tested—to start conceptualizing the reason why mortality levels of some areas might be more elevated than others and whether deprivation measures contribute to the resulting inequality in life expectancy.

1.4. Organization of This Thesis

This thesis is organized in the following way. The following chapter (Chapter 2) takes the form of a literature review and presents concepts of deprivation and how indicators of deprivation have been used in the studies of social and health inequalities. It describes existing definitions, discusses how it can be conceptualized as a 'place effect,' and presents some empirical evidence of the roles and effects of deprivation in health and health inequality. Deprivation has usually been treated as an array of indicators showing place-based phenomena rather than as a theoretical construct in the existing studies. Few studies have elaborated deprivation as a theoretical concept. Although there are a number of studies that link the socioeconomic position of individuals with health and health inequalities (Diez-

Roux, 2002; Berkman & Kawachi, 2000; Lynch & Kaplan, 2000, to name a few), they do not expressly equate socioeconomic position with place-based deprivation[3], nor do they always view the socioeconomic position as part of a broader concept of deprivation (Chaix, et al., 2007-a, Auger et al., 2010, Singh, 2003, Ezzati, Friedman, & Kulkarni et al., 2008). However, some relevant place-based factors and their relationships with health can be derived from some of the literature. Chapter 2 discusses some such literature and connects their conceptualization as possible ways to consider pathways of deprivation in the production of health inequalities.

Additionally, Chapter 2 introduces some critiques with regards to existing deprivation indices and their relationships with different geographic characteristics—namely, community types or levels of rurality. It has been pointed out by some scholars that the now widely used deprivation indices may not explain health inequalities in rural populations as well as they do in urban populations. These indices might also be urban biased (in which case the disadvantages estimated using these indicators would underestimate actual rural health conditions). Such discussion provides a rationale for this study to attempt to clarify the relationships between rurality and the two domains of deprivation measured.

Chapter 3 illustrates the contextual background and research framework of the thesis. First, it describes the research context and rationale for this study. Nova Scotia is a province with a relatively small population size, and few studies about social and health inequalities within the province have been produced in the past. This study addresses the need to produce

[3] Some studies explicitly distinguished place-based and individual-based socioeconomic deprivation and found some remaining effects of area-level, socioeconomic deprivation after taking into account individual level socioeconomic position (Chaix, et al., 2007-a; Davey Smith, Hart, & Watt, et al., 1998, for example).

evidence of finer-area level social inequality in health, and evidence of what communities and regions across the province need attention in research as well as policy aimed at improving the health (and social) conditions of the most disadvantaged areas.

Secondly, it describes the general research framework in which relationships of explanatory factors and health outcomes are examined. It then describes the theoretical 'premise' of place-based deprivation as contextual risk conditions which, together with unaccounted factors and geographical factors (i.e., spatial locations and community types), influence the production of health inequalities across communities. Following the description of the four main hypotheses involved in the research, it describes four specific gaps in research, including those in current 'place and health' research.

Chapter 4 describes details of the methodology involved in the study. It includes a brief description of the research design, the various data sources employed in the study, and some details of how the data were organized and constructed. While it is outside of the scope of the research problems themselves, the construction and organization of data is one of the unique features of this study and is worth elaborating on. Finally, the chapter explains what analyses involved in this thesis address which of the four hypotheses proposed.

Chapter 5 presents a series of results from the analyses. It includes maps and tables describing the distribution of the two domains of deprivation, of life expectancy for males and females before and after regression smoothing, and time trends in deprivation and life expectancy either spatially, or by community type as defined for this study, or by both. Moreover, the geographical distribution of 'unaccounted' factors is shown in maps and tables as part of the findings. The following chapter (Chapter 6) interprets these findings in light of the four hypotheses proposed, and discusses the contributions this study makes to the area of research investigating the relationships between place-based risk conditions and health inequalities. Chapter 6 then goes on to elaborate some of the main limitations of the study. This is followed by some brief concluding remarks on the possible directions for future research in Chapter 7.

Chapter 2. LITERATURE REVIEW—Deprivation and Health Inequality

2.1. What Is 'Deprivation'?

Perhaps one of the most widely accepted definitions of deprivation in social and health inequality research is that of Peter Townsend's (1987; 1993):

> "(P)eople may be said to be deprived if they do not have, at all, or sufficiently, the conditions of life—that is, the diets, amenities, standards and services—which allow them to play the roles, participate in the relationships and follow the customary behaviour which is expected of them by virtue of their membership of society" (Townsend, 1987, p.130).

Some other definitions suggest more explicitly some moral implication where a certain level of deprivation is not socially acceptable. For example, Brown and Madge (1982) stated about three decades ago:

> Deprivations are loosely regarded as unsatisfactory and undesirable circumstances, whether material, emotional, physical or behavioural, as recognized by a fair degree of societal consensus. Deprivations involve a lack of something generally held to be desirable—an adequate income, good health etc. –a lack of which is associated to a greater or lesser extent with some degree of suffering.

Earlier, Berthoud (1976) stated, "If inequality can be seen as a hill, deprivation is a ravine into which people should not be allowed to fall." The consensus among these definitions is that there is a standard of life conditions that the majority of members in a society enjoy, and all ought to be entitled to. Deprivation of the capacity to pursue the standard is, therefore, something to remedy. Such a notion is similar to an argument against poverty. However, deprivation is a broader concept than poverty as simply a lack of income and other types of wealth. Deprivation also includes—though some are less conceptually developed—material conditions such as occupational class, educational level, as well as social conditions such as the presence/absence of social support and networks, isolation, and the conditions of the physical living environment.

Deprivation of material and materialistic aspects of life conditions is defined here as 'socioeconomic' deprivation. According to Salmond and Crampton (2002), the notion of 'socioeconomic' deprivation is rooted in two schools of thoughts—one of Max Weber and the other of Karl Marx. Weberian thoughts have had a considerable influence in both sociology and epidemiology, in which—in short—distribution of various assets that stratifies people into higher or lower social classes is considered as occurring as a result of what is called "life chances" (1958) pertaining to individuals. Marxian thoughts have tended to focus more on addressing the "exploitative economic and social relations structurally embedded in (capitalist) society" (Salmond and Crampton, 2002, p. 15) through which divisions of labour and property relations determine individual positions (as either exploiters or exploited), creating "class." We may say that Weberian thought focuses on *how* the factors of deprivation are distributed, while Marxians focus on *why*, and they seek the *why's* in the social system. The absence of inquiry into *why* in the Weberian tradition has implied that "the solution to social inequalities is to be found in individuals' behaviour… (and thus the Weberian tradition has tended) to focus on incremental alternations to the status quo" (Salmond and Crampton, 2002, p.15). Today, area or group based socioeconomic deprivation factors have been used as valid bases for examining inequity in health and social science research, and deprivation inquiries have been developed around a (as Wright [1996] termed it) *hybrid* Weberian-Marxist view "that serves as a useful theoretical starting point for understanding the concept of socioeconomic deprivation" (ibid).

While Marx's and Weber's view of the social class system was more linear and may not neatly apply to social relations in a post-modern, post-globalization era, the fact remains that social structure today still largely determines the shape of social inequality, or one's socioeconomic position. Unequal (and often inequitable) positions of individuals and groups in a society are thus also socially constructed through the controlling of access of different groups of people to economic and social means. As such,

> "the social and structural relations between groups in any particular society have a broadly defined material basis that is determined by productive relations to the economy. These relations are characterized by the effective control of resources and exercise of this control exploits, dominates, alienates, and excludes other less advantaged groups" (Lynch and Kaplan, 2000, pp.20-21).

The underlying conceptual linkage that makes deprivation relevant to the research of social and health inequality is a belief that what one has and how much one has is dependent on where one is positioned in the social structure to which one belongs. How much individuals or groups are deprived or not deprived of something, particularly of economic means, places them in differentiated socioeconomic positions in a particular society they live in. It is believed that unfavourable socioeconomic positions are associated with ill-health as indicated by Lynch and Kaplan (2003) as "these structural positions are powerful determinants of the likelihood of health damaging exposures…" Thus, deprivation is a socially constructed phenomenon in which social structure regulates or limits one's access to something, such as life chances that enable aspects of one's welfare. In fact, deprivation and socioeconomic position are sometimes used interchangeably in some of the studies investigating social inequality in health (van Jaarsveld, Miles, & Wardle, 2007; Chaix, et al., 2007-a, for example).

Townsend (1987, p.125) further states, 'deprivation may be defined as a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs.' What this statement implies is that deprivation is a phenomenon in society but also is a representation, or indicator of the phenomenon. Borrowing some terms from Frohlich et al. (2006), deprivation is an array of "indicators" considered as "empirical manifestations of the meaning of a construct," or ways of operationalizing empirical analysis of constructs. Thus, deprivation here may be understood and defined as an array of indicators that represent certain constructs relevant to producing inequalities in social or health conditions, the mechanism of which may be systematic and theorized (or theorize-able). Indeed, in social and health inequality research literature, the word deprivation is understood and used almost exclusively in the context of describing an indicator rather than a construct, without further theorizing the meanings of various forms of deprivation or forming a substantive theory of deprivation.

Here, deprivation is considered as a socially constructed phenomenon in which social structure regulates or limits one's access to various resources that enable aspects of one's welfare (Revisit). In that sense, deprivation is also closely linked with concepts of social capital, social cohesion and social network (Kawachi & Kennedy, 1997; Lochner, et al., 1999; Kawachi & Berkman, 2000). In short, social cohesion is "the extent of connectedness and solidarity among groups in society," and social capital refers to "features of social structures such as levels of interpersonal trust and norms of reciprocity and mutual aid which act as resources for individuals and facilitate collective actions" (Coleman, 1990; Putnam, 1993 in Kawachi and Berkman, 2000). Another way to describe social capital and social cohesion may be that social cohesion refers to the strength of social bonds determined by the presence and absence of various types of social capital. Social networks can be considered as venues or structures that facilitate the giving and receiving of social capital, measured by size, density and duration, for instance (for a useful guide on the conceptualization of social network, see Berkmann and Glass, 2000).

Social capital may also be understood in terms of many different types of resources. For example, Gatrell et al. (2004:180) describe that there are social resources (informal reciprocal support and friendship networks), collective resources (involvement in community groups, but also feelings of belonging, and fear of crime), economic resources (levels of unemployment, quality of housing and amenities), and cultural resources (perceived quality of schools, libraries and other cultural settings).

All of these types of social capital are something that individuals or groups could be deprived by virtue of living or belonging to a certain place. Economic resources (i.e. employment, income, and education and skills to obtain economic assets) are also influenced by some form of social capital individuals or groups possess. These concepts are, therefore, useful in providing explanations to health inequalities observed, as they clarify how social relations and functions influence group and individual power dynamics, group and individual behaviours, and group and individual distribution. Likewise, these social relations and functions influence social forces in place that 'deprive' individuals and groups of various resources necessary to maintain health.

2.2. Measures of Deprivation

Since the inception of Townsend's initial deprivation index, along with other versions of deprivation indices such as those of Carstairs and Morris—commonly known as the Carstairs Index—(1991) and Jarman—commonly known as the Jarman Index (1983), more elaborate and organized measures of deprivation have been developed and used in the UK. The Indices of Multiple Deprivation (IMD) (UK Office of the Deputy Prime Minister, 2004) have been developed in England, Scotland, Wales and Northern Ireland, and they describe seven 'domains' of deprivation: 1) income, 2) employment status, 3) health and disability, 4) education, skills and training, 5) housing and services, 6) crime, and 7) living environment. These domains of deprivation measures can be used separately or as a composite. They have all been developed for the purpose of health and other planning and policy making in the four major regions, as well as the UK overall.[4]

As in the case of the UK deprivation indices, health can also be considered as some sort of asset that enables other aspects of one's welfare, instead of viewing it as an end or a component of welfare one strives to achieve using these assets. A useful discussion on the concept of health can be found in Asada (2005). The variables included in these indices are listed in Table 2-1. It should be noted that the table is not meant to show the exhaustive list of deprivation indices that exist in the UK, but rather to show some examples.

[4] The composite of all domains has been extensively used by local public health departments in England and by researchers to describe and monitor socioeconomic inequalities in health (Adams & White, 2006). Adams and White (ibid.) found that the endogeneity of health domain in examining deprivation and health—therefore examining correlation between health and health to an extent—had little influence on the result, based on their study removing the health domain from the IMD in examining socioeconomic inequality in health.

Table 2-1. Deprivation Indices in the UK

Brief background	Variables
The Townsend Index *(Source: Townsend, Phillimore, & Beattie, 1988)*	
While Townsend has published many papers on more complex conceptualizations of deprivation, the Townsend index is focused on material aspects of deprivation. The index was used by Townsend and colleagues initially to investigate the social inequality in health which showed disadvantages in Northern England.	1. Unemployment—over age 16 as a percentage of all economically active residents aged over 16 2. Overcrowding—household with 1 person per room and over as a percentage of all households 3. Non car ownership—households with no car as a percentage of all households 4. Non home ownership—households not owning their own home as a percentage of all households.
The Jarman Index (Underprivileged Area Score) (Source: Jarman, 1983)	
The Jarman Index contains variables that are considered important indicators for population groups in England and Wales that are likely to use health services more often. These variables were chosen based on survey interviews with general practitioners representing general practitioner committee areas. They were asked what factors would likely influence the health and likelihood of types of individuals using the health services more. Candidate variables were pilot tested and then 8 census variables were chosen for the composite score construction.	1. Unemployment—unemployed residents aged 16+ as a proportion of all economically active residents aged 16+ 2. Overcrowding—persons in households with 1 or more persons per room as a proportion of all residents in households 3. Lone pensioners—lone pensioner households as a proportion of all residents in households 4. Single parents—lone parents as a proportion of all residents in households 5. Born in New Commonwealth—residents born in the New Commonwealth as a proportion of all residents 6. Children aged under 5—children aged 0-4 years of age as a proportion of all residents 7. Low social class—persons in households with economically active head of household in socio-economic group 11 (unskilled manual workers) as a proportion of all persons in households. 8. One year migrants—residents with a different address one year before the Census as a proportion of all residents.
The Carstairs Index (Source: Carstairs & Morris, 1989)	
The Carstairs index was created initially to investigate reasons for the mortality differences between Scotland , England and Wales. The postcode sector based scores in Scotland and wards in England and Wales were constructed from Census data, and the corresponding area level expected and observed mortality by age and sex were compared.	1. Unemployment—unemployed male residents over 16 as a proportion of all economically active male residents aged over 16 2. Overcrowding—persons in households with 1 or more persons per room as a proportion of all residents in households 3. Non car ownership—residents in households with no car as a proportion of all residents in households 4. Low social class—residents in households with an economically active head of household in social class IV (partly skilled) or V (unskilled) as a proportion of all residents in households.

Table 2-1. Continued.

The English indices of multiple deprivation 2007 (Source: the UK Community and Local Government, 2008)	
The English IMD was first created in 2004 by a team of researchers at Oxford and several other universities commissioned by the Office of National Statistics (ONS). The construction of indices, as in IMDs of Scotland, Wales, and Northern Ireland, has its basis in Townsends' concept of deprivation. However, the domains were more elaborate and usable separately to cater to different types of research and planning objectives. A new updated IMD was constructed in 2007 and published in the following year. The measures are organized by a series of nested area levels	There are a total of 38 variables forming 7 domains of deprivation. 1. Income domain—Six variables measure the proportion of adults and children or households receiving various social welfare benefits. 2. Employment domain—Six variables measure working age individuals with benefits related to unemployment or workers compensation 3. Health domain—Four are health related (Years of Potential Life Lost (YPLL), Comparative Illness and Disability Ratio (CIDR), Measures of emergency admissions to hospital, derived from Hospital Episode Statistics, & Measure of adults under 60 suffering from mood or anxiety disorders) 4. Education domain—Seven are education level related including children's grades at school, those not entering 'higher education', secondary school absence rate, working age adults with low or no qualifications. 5. Housing and services domain—Seven variables measure housing availability, overcrowding, access to ownership, and physical barriers to services (e.g., distance) such as supermarket, primary school and post office. 6. Crime—Four variables including burglary, theft, property damage and violence 7. Living environment—Four variables measure housing condition, availability of central heating, air quality and road traffic accidents outside the house

In Townsend's earlier work (Townsend, 1993), measures such as physical environment, safety at work, home facilities, family activities, and rights to employment were suggested but seem much less used to recent days. Moreover, these aspects of deprivation are considered as being part of what Townsend called the "material" or "social" domain of deprivation (1993, 1987) without elaborating how these domains are different or related with one another. While measures not directly related with socioeconomic aspects of deprivation have been included (e.g., crime, living environment, and health) in some of these indices, the relationships among these domains of deprivation have not been well articulated. Difficulties involved in finding data to measure these different aspects of deprivation are probably contributory to the skewed balance in the development of material/economic and other deprivation measures.

Presumably, Townsend does not further elaborate the meanings of these different aspects of measures he suggested because his main objective of developing the concept of deprivation was to create an alternative to (income) poverty that characterizes non-monetary aspects that come with the state of income poverty[5]. Aspects of one's life such as rights to political and institutional participation, family activities and recreation are conceptually relatively remote from income poverty—i.e., there are likely other complex factors influencing these aspects than simply having low income. In essence, indices of deprivation were born out of the need to investigate gradients of 'socioeconomic' statuses from 'severely deprived' to 'not deprived at all' or 'affluent' instead of a dichotomous, 'have' or 'have not' categorization with a somewhat arbitrary cut-off line distinguishing the two. In the latter categorization, like that

[5] Pampalon and Raymond (2000) also suggest that 'poverty' is much narrower in its meaning, as it "is more related to lack of the resources—especially the financial resources—needed to acquire modern goods and commodities," and therefore, material deprivation should be distinguished from poverty.

of poor and non-poor, the effects of some social conditions are considered as if there were one level of effect or no effect at all (Hayes, 2004). Such a measure is inadequate to understand the gradient of social positions that affect health also in a gradient fashion.

Deprivation measures are relevant both in countries considered economically wealthy and in those considered economically poor, as "socioeconomic deprivation reflects a 'neo-materialist' standpoint (that places emphasis on relative rather than absolute material conditions), taking the view that people have material, social, cultural and spiritual needs that are linked to the norms of their society and culture" (Salmond and Crampton, 2002, p. 14). Deprivation measures are thus useful in describing and analyzing who—whether individuals or groups—is placed in a disadvantaged position in the particular society, and what factors are placing them in the position, resulting in negative health effects. This perspective is in accordance with evidence (Wilkinson, 1996, 2005; Mackenbach & Kunst, 1997, for example) that relative positions in a hierarchy of society rather than absolute poverty are more important determinants of health.

There are three sets of deprivation indices developed and widely used in Canada. Pampalon's deprivation index in Quebec borrows from Townsend's conceptualization of deprivation, categorizing factors into material and social dimensions, or 'domains'. The Socioeconomic Risk Indicator (SERI) in Manitoba borrows the concepts and methodology from the Carstairs index, but is more elaborate in its use of variables. The Vancouver Area Neighbourhood Deprivation Index (VANDIX) takes a similar strategy to Jarman's UPA in choosing variables, based on a survey of provincial medical health officers. These indicators also derive variables from the Canadian Census and are specific to Canadian contexts. Variables used in the six indices can be found in Table 2-2. Again, the three indices represent merely the main examples of indices rather than indicating these are the only indices used in Canada. With the exception of Pampalon's indices which show a conceptual separation between 'material' and 'social' deprivation, what these indices measure is still broadly the 'socioeconomic' conditions of a population.

Table 2-2. Three Canadian Indices of Deprivation

<table>
<tr><td colspan="2">Deprivation Index for Health and Welfare Planning in Quebec (DIHWPQ)-Pampalon’s index (Source: Pampalon & Raymond, 2000)</td></tr>
<tr><td>Quebec’s deprivation index is based on Townsend’s concept of deprivation, though the variables used are not very similar to Townsend’s deprivation index. Since he uses Townsend’s categorization of ‘material’ and ‘social’ deprivation, there are two sets of composite scores of deprivation. Six variables derived from the Canadian Census measured at the enumeration/dissemination area levels are involved:
Although the age cut-offs for denominators and normalization methods differ somewhat, they are overall similar to the Nova Scotia Deprivation Indices developed by Terashima (2007).</td><td>Material deprivation
1. Proportion of persons with no high school diploma
2. Ratio of employment to population
3. Average individual income

Social deprivation
1. Proportion of persons who are separated, divorced or widowed
2. Proportion of single parent families
3. Proportion of people living alone</td></tr>
<tr><td colspan="2">Socio Economic Risk Index (SERI) (Source: Frohlich and Carriere, 1997)</td></tr>
<tr><td>Manitoba’s SERI is an indicator developed to assess the needs of health services, having identified those social and economic aspects which are highly correlated with health service utilization patterns. Funding allocation is to be determined using a regression model taking into consideration SERI, age-gender distribution and population level health outcomes, for example, as adjusting factors. It is a composite score based on a set of more detailed socioeconomic conditions derived from the Canadian Census at the enumeration area (EA) level.</td><td>1. Dwelling characteristics—the average market value of owner-occupied single detached dwellings, excluding dwellings in farms and native reserves
2. Educational attainment—the proportion of residents who attained a minimum of a high school diploma for age cohorts 25-34, 35-44, and 45-54
3. Employment—labour force engaged in three occupational groupings: 1) farming, 2) manufacturing construction and transportation, 3) managerial, administrative and scientific occupations; female labour force participation, and the regional unemployment rate for four age cohorts
4. Income—total household income from all sources. Related to income, they also measured the percentage of all households in owner-occupied dwellings, the percentage of households in owner-occupied dwellings which spent 30% or more of household income on housing, and the percentage of households in tenant-occupied dwellings which spent 30% or more of household income on housing costs
5. Mobility—the proportion of an area’s population aged 5 years or older which moved into the area from other locations within Canada in the previous 5 years
6. Social charactertisics—including the age dependency ratio (the number of people 65 years of age and older to the number of people aged 15-64), the rate of single parenthood among families with young children (0-14), the rate of single female parent households among households with children (0-14), the percentage of single, young (15-24) female parent household among all households, the distribution of French and Aboriginal language speakers</td></tr>
</table>

Table 2-2. Continued.

Vancouver Area Neighbourhood Deprivation Index (VANDIX) (Source: Bell, Shuurman, Oliver, & Hayes, 2007)	
VANDIX was a socioeconomic characteristics based index constructed with health services needs in mind. Unlike SERI, however, a survey was conducted to ask medical health officers in the province about the relevance of candidate variables to health needs based on their professional experience. It is therefore, in some ways, similar to Jarman's deprivation index, though the variables involved are no more similar to Jarman's deprivation index than to any other indices described here. The VANDIX scores were constructed at the Census dissemination area and Census tract levels, and contrasted with the Canadian Community Health Survey database on self-assessed health status.	1. Proportion of the population without a high school education 2. Unemployment rate 3. Proportion of the population with a university degree 4. Proportion of families headed by a lone parent 5. Average income 6. Home ownership 7. Unemployment ratio

2.3. Empirical Evidence

Although being mainly 'socioeconomic' and having some limitations, an array of deprivation indicators has become increasingly popular as a tool to measure socio-environmental determinants of health inequalities, uncovering what makes some communities healthier than others. Indicators of deprivation have been used to analyze social and health inequalities in many parts of the world, including, Sweden (Chaix, Rosval, & Merlo, 2007-a), the United States (Singh, 2003), New Zealand (Salmond & Crampton, 2002), in addition to the United Kingdom (Townsend, 1987, Morris and Carstairs, 1991, Jarman, 1983, UK Office of National Statistics, 2004) and Canada (Pampalon & Raymond, 2000).

These studies have found that deprivation—especially socioeconomic deprivation—is associated with the health status of the given populations. For example, Cox and colleagues (Cox, Boyle, & Davey, et al., 2007) employed variables in the Carstairs deprivation index to see if the scores in the area of residence, the score of the surrounding area, and the difference between the two have an effect on Type 2 diabetes. Variables in the Carstairs deprivation index include the percentage of residents in households with no car, overcrowding measured by the percentage of residents in households with one or more persons per room, the percentage of residents in households with a head in social class IV and V in the UK (partly skilled and unskilled occupations) (OPCS, 1980), and the proportion of unemployed male residents aged over 16. They found that deprivation measured in the area of residence was positively related to diabetes incidence, and the deprivation of the surrounding areas also had a role in mediating the likelihood of diabetes incidence (Cox et al, 2007).

Chaix and colleagues (Chaix, Rosvall, & Merlo, 2007-b) used neighbourhood average income ranks between two time periods to measure socioeconomic deprivation and examined the neighbourhood effects on ischemic heart disease mortality after controlling for individual socioeconomic status. They found that the neighbourhood level income average had an effect additional to individual socioeconomic conditions and that the neighbourhood level effects widened over the study period (Chaix et al., 2007-b).

Dupont and colleagues (Dupont, Pampalon, & Hamel, 2004) examined the gender differentiated influence of material and social deprivation in Quebec. They found that, for females, material deprivation "has a substantial impact" on lung and cervical cancer, and all cancer, and social deprivation was also significantly associated with the respective cancers after controlling for material deprivation. For males, they found positive relationships with all-cancer, lung cancer and colorectal cancer, while prostate cancer risks increased with social deprivation but decreased with material deprivation.

Lang and colleagues (Lang, Llewellyn, & Langa, et al., 2008) examined the neighbourhood level deprivation and its effects on older adults' physical mobility, using the English Index of Multiple Deprivation (IMD) (UK Office of Deputy Prime Minister, 2004) and self-reported difficulty in walking and measured speed of walking. They found that, even after controlling for individual socioeconomic status and health behaviours as well as health status such as chronic illnesses, living in a deprived neighbourhood had a negative effect on mobility in older adults.

In Scotland, Mercer and Watt (2007) compared several types of health conditions between the most and least deprived regions based on the Scotland based Index of Multiple Deprivation (Scottish Executive, 2006). These health conditions included mental health measured by the General Health Questionnaire (GHQ)-12, waiting time and overall satisfaction with health services received, general self-reported health, multiple mobility, and stress levels of general practitioners. They found that patients in the most deprived areas had a greater number of psychological problems, more long term illness, more multiple morbidity, and more chronic health problems. Moreover, the satisfaction with services was significantly lower, and the waiting time was longer in respondents from the most deprived area. Stress levels of general practitioners were also higher (Mercer & Watt, 2007).

Tobias and Cheung (2003) in New Zealand examined three-year abridged life expectancy at birth for four time periods and deprivation at the small area level (mesh blocks) using a nation-wide deprivation index called NZDep96. Variables in NZDep96 include: 1) people with access to a telephone, 2) people receiving income welfare benefits, 3) unemployment, 4) equivalized household income below a threshold, 5) people with no access to a car, 6) single parents, 7) working age adults with no qualifications, 8) home ownership, and 9) overcrowding. They found about 9 years and 7 years difference in life expectancy at birth between the most and least deprived areas for males and females respectively. The inequality was stable over the study period (1995-2000).

While variables included in the measures vary, these studies all found considerable relationships between deprivation (especially 'socioeconomic' deprivation) and a range of health outcomes. These studies not only provide a rationale for better understanding the construct and mechanisms in which deprivation produces inequality in health, but they also highlight the need to understand how these deprivation factors are geographically distributed and whether the geographical distribution of deprivation has an additional influence on health.

2.4. Deprivation as a 'Place Effect'

2.4.1. Deprivation and 'Place Effect'

Although deprivation as a concept includes not only group or population level social conditions but also conditions pertaining to individuals, deprivation is usually considered a population level indicator and typically measured as the proportion of individuals with certain characteristics. Moreover, the grouping of these populations is usually based on geographical areas such as county, ward, census tract, and neighbourhood which often, though not always, signify a coherent, relatively homogeneous group identity. As such, deprivation measures something of a 'place effect.'

The motivation for the development of population level deprivation measures has its historical roots. In 1980, the Black Report (DHSS, 1980)—a landmark report that shaped population health debates in the 1990s and 2000s—legitimized what may be understood here as the 'social construction of material and materialistic circumstances' as an important determinant of health and health inequality today. The inception of deprivation indices in the UK was paralleled with the debate over health inequality or social inequality in health at the same time. In fact, Townsend was involved in the writing of the Black Report. The Report triggered population health researchers' interests in looking at social structural factors and in conducting contextual studies, including area or population level deprivation studies.

What is a 'place effect'? As part of the response from health researchers to the new focus on the material and socioeconomic 'circumstances' in the 1980s, a categorization of 'place effects' was proposed by Macintyre and colleagues (Macintyre et al., 2002; Macintyre, 1997; Macintyre, MacIver, & Sooman, 1993; Cummins, Macintyre, Davidson & Ellaway, 2005). It influenced not only population health but also other disciplines, including health geography and epidemiology[6]. The five categories of 'place effects' are the following:

> 1. Physical features of the environment shared by all residents in a locality—quality of air, climate, provision of safe drinking water etc.
>
> 2. Availability of a healthy environment at home, work and play—provision of decent housing, secure and non-hazardous employment, and safe play areas for children.
>
> 3. Services provided publicly or privately to support people in their daily lives—education, transport, street cleaning, power, policing, health and welfare services, etc.
>
> 4. Socio-cultural features of a neighbourhood—the political, economic, ethnic and religious history of a community, norms and values, the degree of community integration, levels of crime, incivilities and other threats to personal safety, and networks of community support.
>
> 5. The reputation of an area—which influences the self-esteem and morale of the residents and the attractiveness of economic investment in the area (Macintyre, MacIver and Sooman, 1993).

The first three represent material and infrastructure resources of a place, while the latter two are related to collective social functioning and practices occurring in the place. The fourth—socio-cultural features of a neighbourhood—can also point to types of social capital that individuals and groups can access by virtue of their membership to the place. All are, in various ways, contributory to forming what they call "opportunity structures" (Macintyre,

[6] In fact, the researchers involved in the conceptual development of 'place effects' do not necessarily identify themselves as population health researchers, epidemiologists, or geographers etc.. Some population researchers focus on geography, geographers examine epidemiological relations between geographical area based social determinants and health, and epidemiologists investigate population level inequality in health. This reflects the multidisciplinarity of the very questions researchers try to get at, which is the complex relationship between social determinants at an ecological as well as an individual level, and biophysiological and population health outcomes.

Ellaway, & Cummins, 2002)—the structures of a place that enable maintenance of physical and mental health. By offering an operational categorization of 'place effects,' Macintyre and colleagues prompted further examinations of what about place—physical, social, material, political, cultural and psychological—influences the place's capacity to help maintain health. The concept of deprivation is parallel to this. Deprivation of something—specifically material and materialistic circumstances—in a place that is likely health enhancing, or having something that is health damaging means that the opportunity structures of the place to produce and maintain health are poor. Put it another way, deprivation of positive opportunity structures in a place has a negative effect on health. I would also argue that place-level socioeconomic measures can also indirectly indicate (as enablers of) the quality of opportunity structures in an area. For example, the general (average) income level of an area points to the area's tax base and therefore to its ability to provide infrastructure and services, its level of unemployment likely shows the availability of employment, and the proportion of individuals with certain levels of education can be an indication of the area's collective belief with regards to the needs for education.

2.4.2. Compositional, or Contextual, or Both?

To contemplate constructs of potential indicators (deprivation or not) as place effects, it is helpful to examine them in light of 'compositional' versus 'contextual' effects. According to Kearns and Moon (2002), the terms *contextual* and *compositional* were derived from sociology. Since deprivation indices are measures of compositions or aggregates of individuals with certain characteristics of interest, they are essentially compositional measures. If an area is predominantly populated by individuals with certain characteristics—for example, older people, people with low income, people of a certain ethnicity or immigrant status, single parents and individuals with lower labour skills and education—the average socioeconomic conditions as well as average health outcomes will likely be low. The phenomena measured, however, apparently do not apply to every individual within that area. There will be young and healthful individuals and high income earners in most deprived areas. Therefore, effects that compositional measures are showing are certainly different from the factor of a place not affected by composition of individuals with particular characteristics (thus supra-individual). The latter are called contextual effects.

Composition based measures, such as deprivation measures seen in Tables 2-1 and 2-2, may start having a distinct construct other than simply presenting compositions of types of individuals in it. They might be called *contagion* variables by Susser (1994) and Diez-Roux (1998). An example may be where researchers observe rates of smoking, which is derived from counts of individuals having smoked in the past 12 months. The rates of smoking derived this way not only tells us about the concentration of smokers (which will affect the average lung cancer risk of the place) but also tells us something about a culture where smoking is encouraged for a variety of reasons—whether it is a means of socialization, a means to feel in control, or is portrayed as stylish. The smoking culture derived from the smoking rates in a place now has a meaning, which is contextual[7].

It is also possible that some contextual factors influence the concentration of certain individuals. Bernard and colleagues (Bernard, Charafeddine, & Frohlich et al., 2007) state

[7] Macintyre, Ellaway and Cummins (2002) discussed their understanding of co-called "collective properties" which are now considered by them part of 'contextual' effect, as they integrated the concept of 'contextual' as not only physical dimension of the resources available in the place, but also the collective understanding, belief, or norm. They state, "Since the collective properties of local residents (such as being fairly pro smoking) are part of the context facing any individual living in that place, we no longer think it sensible to view collective explanations as being separate from contextual ones" (p. 130). Thus, as my example above shows, I consider any collective properties as part of 'contextual' dimension of the place effect.

that "people's distribution across areas of residence is neither random nor totally intentional." For example, the fact that a place has a higher concentration of elderly, poor, or less educated individuals means that something about the place is creating the conditions which lead these individuals to concentrate there, or conversely, something about the place is creating conditions which lead younger, higher income or more educated individuals to move out of the area. Deprivation measured by unemployment rate, the proportion of individuals with lower education, or lone residents, for example, probably also tells us about the availability of jobs (and therefore the condition of the local economy), about the low emphasis in families for the pursuit of education (therefore indicating a culture or belief subscribing or resigned to the present social class position rather than aiming for upward mobility), and about lower housing prices affordable to single income households (therefore reflecting the reputation of the neighbourhood), etc.. In the case of deprivation indices employed in this thesis, the scores indicate concentration of these characteristics despite their age (and sex) composition, as the scores are age- and sex-standardized.

Macintyre et al. (2002) also cautioned that contextual and compositional variables are not always distinguishable. At the onset, their five place effects described above appear to be strictly 'contextual'. However, lack of what they call opportunity structure may be determined by what types of people are in the area. Further, Cummins and colleagues (Cummins, Curtis, & Diez-Roux et al., 2007) also argue that the research should "avoid the false dualism of context and composition by recognizing that there is a mutually reinforcing and reciprocal relationship between people and place." As Frohlich (2000, p. 58) also succinctly stated, "compositional and contextual effects are mutually reinforcing and jointly influence health outcomes." Indeed, how to separate between contextual and compositional variables depends on the very construct they are theorized to represent in a particular piece of research, rather than being based merely on whether or not they are aggregated from the data of individuals.

A supporting argument for deprivation being also a contextual effect comes from studies of the so called 'pull up/pull down' effect, such as Boyle and colleagues' (Boyle, Gatrell, & Duke-William, 2004b; also see Cox et al., 2007). They used the percentage of households in an area with members who are unemployed, households with more than one person per room, households that do not own a car, and housing ownership (ibid.). They examined not only the effects of neighbourhood deprivation on limiting long term illnesses (LLTI) but also the effect of the average deprivation level of the surrounding neighbourhood on the same health outcome. They found that those in an area with higher material deprivation are likely to report LLTI, but also the likelihood increased with an increase in the average deprivation values of the surrounding neighbourhood. This shows that the effects by the average deprivation of the surrounding area have nothing to do with the composition of individuals within the area itself. What is particularly relevant to this thesis about this Boyle and colleagues' study is that they looked at deprivation as not only contextual, but also as "socio-spatial" (Boyle at al., 2004)—meaning that deprivation is (geographical) location dependent. Even if two areas have the same deprivation value, the effects on health may be different due to the respective areas' geographical location.

Whether as a compositional or contextual effect, studies have shown that deprivation measures are highly correlated with a health enhancing or damaging environment. For example, in the study of a number of grocery stores in neighbourhoods in North Carolina, Moore and Diez-Roux (2006) found that non-white low income neighbourhoods had more grocery stores, but less fruit and vegetable markets than higher income, mainly white neighbourhoods. The same study showed that there were more liquor stores in poorer neighbourhoods than in wealthier neighbourhoods (Moore & Diez-Roux, 2006). Gordon-Larsen and colleagues (Gordon-Larsen, Nelson, & Page, et al., 2005) examined the correlations between the community level socioeconomic status of 'block groups'—overlapping areas of samples with approximately an 8km buffer zone—measured by education level and number of physical activity facilities such as beaches, tennis courts, pools, parks, YMCA, dance studios, golf courses etc. in the US. They found that block groups with higher socioeconomic status had significantly higher odd ratios of having more than one or more physical activity facilities. The number of facilities was also correlated with overweight patterns.

In Scotland and England, a team of researchers (Cummins, McKay, & Macintyre, 2005) found that the mean number of McDonald's outlets per 1,000 persons was positively associated with, again, deprivation measured by the 2004 version of the Index of Multiple Deprivation (Scottish Executive, 2004; Office of the Deputy Minister, 2004), showing a ready accessibility of not so healthy food in deprived areas. On the other hand, a study in Nova Scotia found, community-level material deprivation and the mean number of fast food restaurants per 1,000 people was inversely associated (Jones, Terashima, & Rainham, 2009), which is the reverse of the result found by Cummins and colleagues. This shows that the meaning of having a high density of fast food outlets could be context/place-dependent. For example, in a Nova Scotia context, materially deprived areas tend to be in rural areas where population size is too small to exceed the threshold required to open fast food businesses. In any event, such empirical evidence suggests that measures of deprivation—again, particularly socioeconomic deprivation measures—can be surrogate measures for health behavioural factors or factors indicating the health enhancing resource availability—again, a type of opportunity structure—in the place.

2.4.3. Positioning Deprivation in the Pathway of Health Inequality

Stafford and colleagues (Stafford, Sacker, & Ellaway, et al., 2004) stated that "many studies document associations between area deprivation and health but the explanatory pathways linking deprivation to health are not clear." A number of studies conceptualize the pathways of socioeconomic position (Diez-Roux, 2002; Berkman & Kawachi, 2000; Lynch & Kaplan, 2000), which articulate the socioeconomic domain of deprivation. But few elaborate on the causal pathways between a broader concept of deprivation, including social domain in the context of this study, and health or health inequalities. However, relevant arguments can be drawn from some literature. For example, Krieger (2006), in her elaboration of how people 'embody' social inequality in health, lists five main pathways:

> 1. Economic and social deprivation, including lack of access to adequate food, housing, and physical and social relations;
>
> 2. Toxic substances, pathogens and hazardous conditions at work, in the neighbourhood, and more generally;
>
> 3. Social trauma, including institutional interpersonal discrimination and violence, plus additional psychosocial stressors;
>
> 4. Targeted marketing of commodities that can harm health, e.g., junk food and psychoactive substances (alcohol, tobacco, and other licit and illicit drugs); and
>
> 5. Inadequate or degrading medical care.

It is easy to see a parallel with Macintyre and colleagues' five place effects. While Krieger does not necessarily consider them as 'place' level occurrences, it is apparent that the respective pathways involve a process in which health damaging factors in some social environment—may it be toxic substances, or health damaging social relations or institutions, or lack of means for health maintenance—'get into' the bodies of those who receive them. The ways through which this occurs may be 1): more directly—e.g., via lack of nutrition in the body, physical danger inflicting injury, inhaling or ingesting toxins, or 2): indirectly—e.g., via psychosocial stress, subscribing to certain collective health behaviours, or not being able to prevent further health damage by accessing service from a family physician. The chance of a person receiving these health damaging factors is determined by the type of place one lives or works.

Likewise, Macintyre's five categories of place effect point to similar pathways. For example, people can become less healthy inhaling unclean air or drinking water; unsafe play areas increase the likelihood of children's injury; lack of educational services providing information related to health may lead to certain health behaviour; and shortage of police service may cause fear and anxiety in the residents, leading to chronic stress. Less integrated social relationships may lead to hostility and anger. Certain cultural norms and values influence people's diets in ways that may be health enhancing or damaging. The sense of place perceived by the residents may influence the collective efficacy[8], leading to an increase or reduction of violence in the area—which (if increased) could directly harm individuals or cause anxiety in residents.

Another helpful causal pathway framework in which place-based deprivation can be conceptualized is what Daniel and colleagues (Daniel et al., 2008) proposed as 'biosocial

[8] Collective efficacy can be understood as "shared expectations and mutual engagement [as well as confidence and trust] by members in local social control"—e.g., maintaining public order (Sampson, 2004).

pathways.' In short, they coined the term biosocial pathways to refer to "person-place interactions linking structural-contextual attributes" to chronic diseases such as cardiovascular diseases and diabetes (2008, p.119). According to them, there are two paths through which social-environmental factors manifest in biophysiological outcomes (health/disease) in addition to individuals' current lifestyle and health behaviours (though they are also influenced by social environment through time). One is a "*direct-contextual path* by which context directly affects health outcomes through non-conscious stress responses associated with allostatic load.[9]" (ibid. Italics in original) Another is an *indirect-cognitive path* represented by behavioural and psychosocial venues through which social-environmental factors influence health related behaviours and sense of control, mastery and affect (ibid. Italics in original). By contextual risk conditions, they mean "*Risk conditions* [which] *constitute the objective and subjective properties of the social and physical environs or places that increase the underlying vulnerability of people exposed to those places*" (Daniel et al., 2008, p120. Italics in original).

Deprivation and its effects, therefore, may be conceptualized here by summarizing Macintyre and colleagues' 'place effect' argument, Krieger's five pathways of social environment 'embodying' in health inequality, and concepts of 'biosocial pathways' involving contextual risk conditions proposed by Daniel and colleagues. In other words, deprivation can be considered here as an array of indicators representing health damaging place-level (or contextual) risk conditions that, through pathways linking the socially structured living environment and biophysiology, influence the health of individuals and populations,

[9] *Allostasis* is a process in which cortisol production is escalated from stress, and is considered as having deleterious associations with cardiovascular, metabolic, immune system, brain activity, or central nervous system functioning (McEwen, 1998). Allostatic load refers to the level at which the deregulation of the metabolic regulatory system is elevated.

ultimately producing inequalities in health. I posit that possible causal pathways of place-based deprivation to health include:

1) A direct-contextual path through which their circumstances consciously or unconsciously produce stress;
2) An indirect-cognitive path which indirectly influences health through constituting or altering health behaviours and affecting mental health such as anxiety, loneliness or loss of ability for control through perception of their living environment; and
3) More direct physical lack of health maintenance resources such as food (nutrition), clean air, water, climate, physical activity facilities and services, presence of health harming substances, and existing collective health behaviours and life styles.

2.5. Deprivation and Rurality

Of particular interest to this thesis is how geography—especially the types and location of communities in relation to one another—is related to health inequality and deprivation. While the position of deprivation for a neighbourhood or community or other type of area is likely socially structured, it is also likely that the geographical location in relation to areas of varying levels of deprivation is also patterned. If the existing deprivation indices always correlate neatly with the level of health status regardless of different area types and relational locations, then the strengths of associations between deprivation and the health status of communities should be consistent across communities. In that case, health resource allocation solely based on these deprivation indicators would also be equitable between communities. However, this is probably not the case in reality. Variables included in these indicators may not be as relevant to certain communities (such as rural communities or urban centres) as others.

Deprivation measures might be more relevant to (or have stronger associations with) health in some types of communities than others. For example, Haynes and Gale (1999) examined whether there was any systematic bias towards or against rural areas when determining health resource allocation based on area level deprivation, using the Townsend, Carstairs and Jarman indices. Their study revealed that there were weaker associations between deprivation and health in rural communities and Inner London areas than in other areas. That is, on average, rural communities and Inner London residents are healthier than deprivation scores would suggest. They concluded that the health needs of rural populations can be assessed only to a very limited extent from the social deprivation (they mean socioeconomic deprivation) scores of wards as measured by the Townsend, Carstairs or Jarman indices" (Haynes & Gale, 1999, p.309).

They further explained that this is partly because of the variables employed by the indices. For example, high proportions of car ownership in the rural population—which is a variable included in the Townsend and Carstairs indices—does not necessarily indicate that rural communities are less deprived, but rather it shows that cars are a necessity in these areas. Although more specific to the UK context, the proportion of the population born in the New Commonwealth[10]—a variable in the Jarman index—is not high in rural areas because of the historical pattern of immigration into cities (Haynes and Gale, 1999, p.302). Thus, these indices do not necessarily point to rural life conditions that lead to unfavourable health status.

[10] The term 'New Commonwealth' is used here to refer countries decolonized in the 1960s and 1970s which are predominantly non-white and developing. These countries include Nigeria, Sierra Leone, India, Pakistan and Bangladesh ("Blair calls for quotas," 2004).

Another explanation they offer was that rural areas tend to have smaller numbers of people than city wards, and there is a much greater variation between rich and poor within rural communities than their urban counterparts. Lee, Murie, and Gordon (1995) also pointed out that most 'poor areas' contain only a minority of 'poor' households and a majority of 'nonpoor' households. Likewise, Davey Smith and Gordon (2000) explain that "the majority of 'sick' people in Britain do not live in 'unhealthy neighbourhoods'." Therefore, the average deprivation scores hide the relationships between more deprived individuals and groups and their health conditions within these areas (also see Haynes & Gale, 2000). Haynes and Gale (1999) conclude that the health needs of rural populations are underestimated (p. 302).

The Townsend, Carstairs and Jarman indices are composite scores of all variables examined, leaving it unclear whether these show what Townsend conceptualized as only materialistic conditions, or also of social conditions. Both Philibert and colleagues' (Philibert, Pampalon, & Hamel, et al., 2007), and Terashima's (2007) studies showed that, based on variables in Pampalon's index in Quebec and Nova Scotia respectively, rural communities tend to be generally more materially deprived but urban communities tend to be generally more socially deprived. Thus, relationships between rurality and deprivation may be more complex than a simple gradient showing always the same direction. In Canada, moreover, rural communities are highly diverse. Physically remote communities, agricultural communities, and manufacturing based communities outside urban centres, for example, are likely to have different sets of challenges. For example, agricultural communities may have lower average income than industrial based communities, but they may enjoy higher physical environmental quality and accessibility to healthy food. Remote communities are likely to have heightened risks of not being able to minimize progression of illnesses due to inaccessibility to hospitals and other health services. Since many studies only employ socioeconomic indicators of deprivation, these studies may miss the complexity of effects due to 'other' deprivation, which might predict the risk of the health of communities differently. Perhaps it is important, therefore, to also gauge the effects of what has not been accounted for, if limited data availability inhibits measurement of 'other' deprivation. It is also important to examine the difference in the degree of effects of the same measure of deprivation between different community types (by rurality).

Chapter 3. EMPIRICAL PROBLEM

3.1. Understanding Social Inequality in Health in Nova Scotia—Geographically

Nova Scotia was reported to have the highest rates of death from cardiovascular and respiratory diseases, and the second highest rates of circulatory death and diabetes in the country (Nova Scotia Office of Health Promotion, 2005). Obviously, it is of interest for the province to catch up with healthier provinces and territories by raising the average health status to the nation's standard. However, it is also important to narrow the inequalities in health among subpopulations within the province. Some empirical evidence suggests that the substantial inequalities in health within the province do exist (Read Guernsey, et al., 2000; Veugeler & Read Guernsey, 1999-a; Pong et al., 2010). Narrowing the gap in health inequality is important both from an economic cost point of view (LaVeist, Gaskin, & Richard, 2009; Mackenbach, Meerding, & Kunst, 2007), and an equity point of view (Sen, 2002; Braveman, 2006). In order to do so, it is necessary for relevant authorities to know whose health within the province should be considered as a priority, and where these priority people are. Small-area level investigations of health inequalities across the province can play an important role in this effort, elucidating 'toward whom' and 'where' potential policy strategies should be targeted.

A few figures describing health status differences across the province are available (e.g., live birth by age of mother, cause specific mortality, and hospital discharges by Nova Scotia Community Counts (2010)) but they are at county or district health authority levels, which do not tell us about important variations <u>within</u> these area levels. Even when relatively small administrative units such as Census Subdivisions (CSDs) are used, they still tend to miss some important variations within—particularly within the CSD for Halifax (which is equivalent of Halifax County). The characteristics of where one lives that are likely to affect her or his health may be different depending on the community or neighbourhood—a much finer scale of area than county or municipality—she or he lives in. Thus, the investigation of some (though not all) social environmental characteristics may need to take place at a finer area level. While studies that show small area-specific health conditions within the province exist (Veugeler, Kim, & Guernsey, 2000; Read Guernsey et al., 2000; Veugeler & Read Guernsey, 1999-a), few studies have shown finer area level health inequalities across the entire province. One of the few studies investigating small-area variations across the province, conducted by Veugeler and colleagues (Veugeler, Yip, & Elliott, 2003), showed variations of specialist visit and life expectancy in the late 1990s across 64 areas comprising 51 census consolidated subdivisions in rural areas and Metropolitan Halifax and Cape Breton Regional Municipality divided into 15 neighbourhoods, which are created by aggregating census enumeration areas. Amalgamation of Metropolitan Halifax into Halifax County in 2000, however, made the health difference within the county—which now contains communities of very diverse characteristics challenging to measure.

Small-area studies of health inequalities tend to face many challenges such as the conceptualization of 'area' where the effect of interest occurs, data availability (that can be linked to the area units), and difficulty in spatially referencing data used. This is particularly the case when the investigation includes rural areas where the population is sparse and location information such as addresses does not necessarily point to the actual geographical location, and consequently, to the area defined. This is certainly a dilemma for researchers in Nova Scotia, though it is not only a Nova Scotia problem.

It further adds difficulties when investigating the relationships between geographical distribution of health and inequalities of social conditions because data pertaining to health and social information are not always easily linkable to geographical locations of these phenomena. Efforts to improve the health of populations should not only be about allocating health services where there is the most need, but should also be about strategically removing the social obstacles that hinder a population from achieving a level of health most others enjoy.

Hence, deprivation becomes a relevant concept as it can be considered as a measure of some 'obstacles' to remove. Much of the relationship between deprivation and health inequality, particularly across different geographical and temporal contexts in Nova Scotia at a small-area level has yet to be explored. This thesis, therefore, aims to produce much needed evidence pertaining to the geographical distribution of health and relevant social environmental conditions across communities, and to explain how they might be related to one another.

3.2. Conceptual Framework

3.2.1. Geographical Epidemiology of Health and Deprivation

This thesis employs geographical epidemiology as a research framework to ask a set of questions. By geographical epidemiology, I specifically mean that it investigates the small-area level geographical distribution of health inequality, and its relationships with some place factors that are likely to influence the health of the individuals and groups. In this study, those 'place factors' are two domains of deprivation. The two domains of deprivation are representations of two types of socially constructed phenomena in which social structure regulates or limits one's access to something, in this case, access to material and social aspects of opportunity structures that enable maintenance of health.

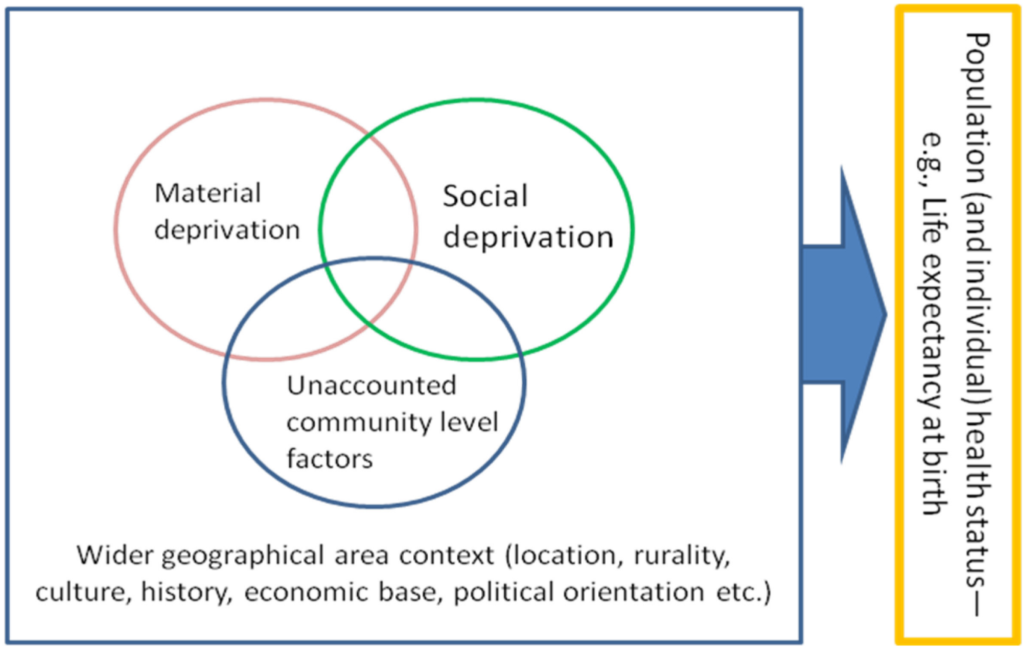
In addition, the geographical distribution of residuals from the regression model assessing the associations between life expectancy and the two deprivation measures will be examined to see if any potential place-based unaccounted factors may be present. The 'geographical distribution' includes spatial distribution as well as distribution by community type (or rurality). Community type here means the five groups of communities categorized by levels of 'rurality' defined for this study (see below [3.2.3.] the discussion of deprivation and rurality and the construction of the five community type [rurality] category).

The study shares the methodological framework with spatial epidemiology as disease mapping, geographical correlation study and identification of spatial clusters are some of the main components of the research. Moreover, it goes one step further in investigating the role and meaning of place factors—deprivation, rurality, as well as unaccounted factors—which are likely socially structured. In summary, this study examines: 1) the distribution patterns of health inequalities (measured by life expectancy at birth) and social inequalities (measured by two domains of deprivation); 2) the associations between health and deprivation; 3) time trends in these inequalities; 4) the geographical clustering of unaccounted variation; and 5) the associations between health and deprivation compared by rurality.

The following diagram (Figure 3-1) describes the conceptual framework of this research, delineating the relationships between explanatory factors and health outcome that this thesis investigates. This is not a complete map of pathway mechanisms and does not show individual level factors (e.g., age, sex, smoking status, body mass index, individual income and education status etc.) that are apparently also at work in producing health variations. Five factors are included: 1) material deprivation, 2) social deprivation, 3) unaccounted factor(s), 4) geographical location, and 5) community type (or rurality). Material and social deprivation as well as unaccounted factors are overlapped since they could influence together on the health conditions as more than the sum of their individual influences (interaction effect). Unaccounted factors can be many things. They can be either contextual based factors—e.g., community characteristics such as the crime rate, the strength of social cohesion, or the political leverage the community may have—or composition based factors—e.g., the proportion of ethnic minority groups, of those receiving social assistance, or of workers in the labour force in a particular industry or a particular type of occupation.

Community level contextual risk conditions are considered to be not independent of geographical location or rurality (Boyle et al., 2004-b). Geographical location in this study may be about being a certain region of the province, or being adjacent to communities with certain levels of health status. If it is the former, it would mean there is some regional- (more macro-) level phenomenon not captured by the two domains of deprivation that is influencing the health status of the communities in the particular region. For example, the region may have a particularly effective school program that promotes health, or the region may subscribe to a unique culture or historical make-up of community memberships which influences their lifestyles or beliefs around health in a certain way. Or it may have a particular climate that is different from the rest of the province, or differences in political leverage the region has in relation to the provincial government.

Figure 3-1. Conceptual Framework of the Relationships Between Place-Based Factors and Health Outcome



Previous studies suggested that the effects of place-level socioeconomic deprivation on LE for males and females were different (Raleigh & Kiri, 1997; Singh & Siahpush, 2006). Therefore, this study examined whether the socioeconomic and social deprivation measured have different degrees of effects on males and females LE and the ways they differed were consistent with these studies.

3.2.2. Deprivation as a Contextual Risk Condition of Health Inequality—the Premise

Two domains of deprivation were examined for their roles in the production of health inequality. They are: 1) material deprivation; and 2) social deprivation, following the terms used by Pampalon and Raymond (2000). The following census based variables are included in the indices:

a. Material Deprivation:
1. Average individual income (15 years and older)
2. Proportion of unemployed persons in the population (25 years and older)
3. Proportion of individuals without high school diploma (15 years and older)

b. Social Deprivation:
1. Proportion of single parents (15 years and older)
2. Proportion of people living alone (15 years and older)
3. Proportion of individuals who are separated, widowed or divorced (15 years and older)

Material deprivation indicates the community level socioeconomic deprivation or socioeconomic position. It may also function as a marker for various opportunity structures in the community, such as the quality of infrastructure, the availability of services, amenities related with physical activities or healthy food sources, as well as the availability and likelihood of people's access to health information. Social deprivation essentially shows the concentration of individuals who typically lack immediate support, which may be a proxy for the general level of trust and integration among community members. According to Pampalon and Raymond (2000), "(s)ocial deprivation,…, is more closely related to the concept of 'social capital,' reflecting certain characteristics of social organization, such as isolation or cohesion, individualist or co-operation, mutual assistance and trust." It may also indirectly indicate the ecological characteristics of communities that tend to attract more or fewer individuals who are isolated or lack immediate social support. These may be housing prices, or the availability of particular services catered for individuals with independent living arrangements—in which case it is an opportunity structure for attracting certain types of individuals rather than an opportunity structure to promote and maintain health.

Details of how these two indices were constructed are described in the Methods section.

Borrowing Daniel et al.'s (2008) terms, the respective deprivations represent *contextual risk conditions* that are assumed to ultimately lead to the production of inequality in health across space and time. The pathways proposed by Daniel et al. (2008) that are likely relevant to deprivation are: 1) the direct-contextual pathway (through which their circumstances consciously or unconsciously produce stress); 2) the indirect-cognitive pathway (through which circumstances indirectly influence health through constituting or altering health behaviours and affecting mental health resulting in conditions such as anxiety, loneliness or loss of the sense in ability to control their lives); and 3) through more direct influence such as the physical lack of health maintenance resources such as food (nutrition), physical activity facilities and services, the presence of health harming substances, and existing collective health behaviours and life styles. Material deprivation measured in this study reflects the place level conditions of material resources, from the tax base that maintains public amenities, community upkeep in residential neighbourhoods, to job and educational opportunities which could reduce stress, enhance collective efficacy, to the ability to access health enhancing goods and services. Thus it is likely to be related to all three pathways. Social deprivation measured is likely more related to the direct-contextual and indirect-cognitive pathways, as it reflects lack of immediate support and general sense of isolation which may lead to conscious or unconscious inducing of stress and general lack of trust among members of the community.

While an assumption is made that such contextual risk conditions as place-based deprivation ultimately lead to health manifested in the biophysiology of individuals and groups, this study does not intend to prove what specific biophysiological symptoms or diseases the measured deprivation contributes to. Nor is this study able to pinpoint through which pathway(s) the two domains of deprivation manifest in health. Rather, this study only looks at a population level health status and their associations with population (place) level factors. Therefore, the understanding of pathways articulated by Daniel et al. (2008) (also by Krieger [2006]) and implied in the conceptualization of 'place effect' by Macintyre and colleagues (Macintyre, MacIver, & Sooman, 1993) above in the literature review—is a premise or pre-condition to start conceptualizing the reason why the mortality levels of some areas might be more elevated than others and whether deprivation measures contribute to the resulting inequality in life expectancy.

3.2.3. Deprivation and Rurality

This study creates a category describing classes of rurality within Nova Scotia, using Nova Scotia Community Counts' community units. As with many other existing rurality definitions in Canada (du Plessis, Beshiri, & Bollman, 2001), this category is based on population density. The reason for this is that the community type category should not be—though conceptually it is somewhat unavoidable—about the characteristics of what is in the community. Instead, rurality in the context of this study should be about something inherent such as the physical, geographical forming of the community—i.e., how big the population size is, how densely populated it is.

If rurality is defined based on, for example, what types of people live in an area—e.g., people engaged in agriculture, people with certain occupational training, education level—then it may be confounded with the effect of other such characteristics of a community, such as deprivation or something else about the community that is yet unknown. Definitions of rurality based upon predominant industry types—e.g., the proportion of working age individuals engaged in resource based industry—may be useful, but information on the industry workforce composition at the community level is not easily available. Moreover,, some industries (such as mining and steel production) are not typically located in either rural or urban setting but rather exist in both (Riva, Terashima, & Curtis, 2010). The presence of some of the predominant industries may not be 'inherent.' They might be located there because the land price is low—but are land prices in rural communities always low?

Moreover, 'rural' can mean different things to different people (du Plessis et al., 2001). Some may focus on the perceived quality of landscape, others may consider it as indicative of the types of social network or family structures prominent in the area. These are fairly subjective understandings of rurality rather than objective levels of rurality (the physical, geographical forming of a community). Community types are represented by five levels of rurality in this study, based on the number of residents per km road within the respective communities, and are categorized as:

1) Metro & big towns
2) Metro fringe & mid-size towns
3) Small towns
4) Villages
5) Sparse settlements

The method used to classify the communities is described in the Method section. This categorization conceptually distinguishes the community types from 'what is in them,' and therefore helps untangle the meanings of deprivation and rurality.

For the same reason this study is unable to pinpoint pathways of deprivation measured to biophysiological health outcomes, this examination of health inequality by rurality is also unable to identify at what level of rurality (or what community type) unhealthy individuals are concentrated. As in the case of the UK (Davey Smith & Gordon, 2000), the majority of unhealthy individuals may not live in unhealthy communities. Therefore, this ecological level study does not say anything about whether unhealthy individuals are concentrated in any communities of varying rurality. Instead, it stops at where low average health status is concentrated regionally.

3.3. Hypotheses

Five specific hypotheses are proposed:

1. Health and social inequalities (including temporal trends) have patterns by geographical location or by community type, or both.
2. Both material and social deprivation as measured in this study affect the health status of the community as contextual risk conditions, and the effects differ by gender.
3. The social inequalities in health between communities (highest and lowest classes of deprivation) have widened in the last decade.
4. The variances in health that are not accounted by deprivation (therefore unknown factors) have patterns by geographical location.
5. The strengths in the effects of measured deprivation on (and 'explainability' of variation in) health are not necessarily the same between 'urban' and 'rural' communities.

3.4. Addressing the Research Gaps

This thesis intends to address some of the important gaps in research, including those in current 'place and health' research. Namely, it endeavours to: 1) Add empirical evidence of well-defined, rural-urban comparable small-area health and social inequalities in Nova Scotia; 2) Adapt an inductive-(quasi-)deductive approach in identifying explanatory variables; 3) Temporally observe place and health phenomena; and 4) Add clarity to the relationships between deprivation and rurality.

3.4.1. Adding Empirical Evidence of Well-Defined, Rural-Urban Comparable Small-Area Health and Social Inequalities

As mentioned earlier, there is a shortage of empirical evidence showing social and health inequalities in Nova Scotia at the small-area level. While there is a wealth of local knowledge as to what regions perform better in socioeconomic conditions and health, there have been few studies that clearly show variations in health, socioeconomic conditions and conditions of other relevant social determinants across the entire province. This study adds to the short list of studies presenting such empirical evidence.

In doing so, the study will also add an example study that uses an area unit which is both conceptually suitable (i.e., the effects are likely to occur at the area level) and comparable between urban and rural regions. A number of 'place and health' studies looking at small-area inequalities in social and health conditions in the past have used either some of the smallest existing administrative area unit such as the ward and the postal code area (Yen & Kaplan, 1999), neighbourhood (Galea, Ahern, & Nandi, et al., 2007; Diez-Roux, 1998; Frohlich et al., 2002), or mesh blocks (Tobias & Cheung, 2003; Blakely, Tobias, & Atkinson, 2008). Use of ward and postal code area units are beneficial in ensuring the homogeneity of the people the research is interested in studying. In Canada, the census dissemination area (DA) is the smallest administrative area unit, and variables such as those used to construct deprivation indices in this study are available at this area level. However, there is a challenge in linking health data to this area level. For example, the Vital Statistics data obtained for this study included postal code information in addition to street address and town information. Assigning the DA with postal code geocoding of records using Postal Code Conversion File (PCCF+, Version 5G, 2010 was available at the time of this study) would be relatively accurate in the urban core of Halifax, but would be highly unreliable in the rest of Nova Scotia. Accurate records of street and town names would allow accurate point locationing of each record. However, the accuracy of records had an urban bias. A substantial number of records of more rural residents had only street names (and not numbers), or only town names (and not street addresses), which led to assigning a considerable number of records in rural areas to the centroid of a town. While this does not affect the assigning of community, which is larger, it would not have been possible to link this to the DA. Mesh blocks are useful in identifying clusters unbiased by area size differences. However, the use of mesh blocks would require reinterpretation of where each block belongs to (e.g., neighbourhood, community, community health board, municipality etc.) if the results of the study were to be used in policy.

Neighbourhood—though it is also subjective to choice of definitions—can be considered a unit on which many important social relations are based (Sampson, Morenoff, & Gannon-Rowley, 2002). Neighbourhood (albeit well-defined and well-drawn) would be ideal to examine the relationships between health and deprivation, for example, in urban regions. However, due to the sparseness of the population, neighbourhood based measures are often unavailable in rural regions. What is perceived as 'neighbourhood' in rural and urban regions is also unlikely the same.

Therefore, this study employs 'community' units[11] which are defined by Nova Scotia Community Counts. Due to the size of the population, aggregation of some very small communities was necessary for the purpose of calculating life expectancy at birth. Thus, it lost some level of sensitivity to any uniqueness of these community characteristics. These are 'community clusters' rather than 'communities. However, these small communities were aggregated based on adjacency and common community types. Using other characteristics such as similar socioeconomic conditions for a basis for area aggregation would lead to spurious results as it presumes a correlation with health. Using community types (which is population density based) will minimize the possibility of spuriously enforcing the correlations.

Despite the necessary aggregation of the communities and resulting loss of sensitivity to the uniqueness of some communities, the use of the Community Counts' community units is still beneficial for two reasons. First, the boundaries were drawn in consultation with local public officials to represent the recognizable 'community identities' instead of mechanically divided small-area units. Therefore, the communities are more homogeneous in their characteristics than mere administrative boundary units. Secondly, while a so-called 'neighbourhood' could be a better representation of geographically based homogeneous

[11] Nova Scotia Community Counts' community units were constructed by aggregating General Services Area—administrative units drawn and maintained by Nova Scotia government; conventional, historical place names are attached to them—to compose communities, ensuring a certain minimum population size. They were designed so that each area makes sense as an entity entailing community group identity, which was ensured through consultation with local officials.

grouping in more populated or 'urban' areas, there are often no comparable neighbourhood units for more sparsely populated or more 'rural' areas. Geographically organized 'communities' can be considered as a group of similar sub-units (i.e., neighbourhoods) (Sampson, et al., 2002). Thus, the study considered communities as more comparable entities between rural and urban areas of Nova Scotia. The use of this community unit enables a province-wide small-area comparison, which is often a challenge in a study that looks at both urban and rural regions.

Several definitions of 'rurality' exist in Canada. They are mostly based on density and size of the population, with an exception of Metropolitan Influence Zone which takes into account the proportion of commuters to the metro area (du Plessis et al., 2001). Which one of the definitions to use depends on the specific question research asks (ibid.). However, none of the existing definitions fit into the 'community' unit employed for this research. Therefore, a rurality typology needed to be constructed that fit the unit. How it was constructed is described in the Method section.

3.4.2. Adapting an Inductive-(Quasi-)Deductive Approach to Identification of Explanatory Factors

What has been considered as one of the main shortcomings in 'place and health' research is its heavy reliance on existing administrative data. The selection of variables from available data only allows for inductive lines of reasoning. As such, the relations between the variables and health outcomes can be explainable, but not provable as the only possible explanation (which would only amount to the level of post-hoc speculation—for a useful discussion of secondary [administrative] data issues, see Frohlich et al., 2006). On the other hand, data unavailability is a reality.

This study is no exception to those relying on census derived variables. However, it attempts to go a step further and let the outcomes of the statistical analysis inform what other, unaccounted factors could be. The Bayesian approach employed in this research allows interpretation that the random components in the model show degrees of unaccounted effects on life expectancy in each community. The random components are divided into spatially correlated and uncorrelated effects which may show geographical clustering—either regionally, or by community type (or rurality). Such a model starts out with inclusion of inductively chosen explanatory variables, but it also allows the clustering of random effects shown by the model to tell us what unaccounted factors could potentially be. Thus, it is in a way a hybrid of inductive and (quasi-)deductive approaches to identifying the explanatory factors given the limitation in the availability of data.

3.4.3. Temporal Observations of Place

Another shortcoming in current 'place and health' research is that it has often viewed a phenomenon—whether a place based characteristics such as deprivation or socioeconomic position, or health status—in a temporarily static manner. This is, again, largely due to unavailability of data that allows longitudinal investigation of these phenomena, as readily available secondary data such as census are collected cross-sectionally. While studies that view widening or narrowing inequality in health among sub-populations—particularly in developed countries—exist (Auger et al., 2010, Singh, 2003, Ezzati, Friedman, & Kulkarni et al., 2008, for example), few also look at the change in the geographical patterns of these phenomena. Not only people in a place change but also the place itself changes (Boardman, 2004). Although this study is still limited by the cross-sectional nature of data employed—it does not account for in- and out-migration, for example—it attempts to show the change in health status and relative positions of deprivation across communities, and the change in geographical patterns of inequalities in health and deprivation between two time periods.

3.4.4. Adding Clarity to the Relationships Between Deprivation and Rurality

There is a wealth of research describing the disadvantages in health of rural populations in Canada and elsewhere (Pong et al., 2010; Pampalon, Martinez, & Hamel, 2006; Eberhardt & Pamuk, 2004; Australian Institute of Health and Welfare, 2007). However, there are also a number of studies showing conflicting results where, depending on the country or type of health outcome observed, rural groups perform better (Riva, Curtis, & Gauvin, et al., 2009; Brown, Young, & Byles, 1999; Haynes & Gale, 1999). Such conflicting evidence suggests that "living in rural areas is not systematically associated with ill-health" (Riva et al., 2009). Then, perhaps it is necessary to conceptually separate 'rurality' and what is <u>in</u> rural areas in order to better understand what about rural that influence certain health outcomes (and not others). One underlying question for this thesis is, therefore, is rurality *per se* associated with low life expectancy at birth, or is life expectancy in rural communities lower than their non-rural counterpart because they are more deprived? To answer this question, this study examines the three-way relationships separately: 1) whether levels of deprivation are different by community type (rurality), 2) whether health status is different by levels of deprivation, and 3) whether health status is different by community type. Previous studies (Philibert et al., 2007, Terashima, 2007) show that levels of material deprivation in rural communities tend to be higher than those in urban communities, while social deprivation is high in urban communities. If health status is not different by deprivation but different by community type, then, there is something else about rural (or urban) communities other than relative socioeconomic conditions or levels of isolation—which is unknown in this study—that is affecting health. It is highly unlikely that deprivation measures have little effect on health. On the other hand, if health status is different by deprivation but not by community type, it likely means that rurality (i.e., size or density of the community) is not what affects health. Rather, it would be socioeconomic or social conditions that tend to be unfavourable in certain community types (or rurality) that affect health.

In summary, this thesis attempts to produce much needed empirical evidence for small-area health inequality in Nova Scotia based on a sounder conceptualization of 'place' and deprivation. It also attempts to point to temporal trends of social and health inequality in the last decade, which might be used as a basis to identify target communities for potential public health intervention. Moreover, it tries to 'do the best' with identifying important explanatory factors with the limitations of available data, while narrowing down possible other factors that might be influencing the production of health inequality by examining how these unknown effects are spatially distributed.

Chapter 4. METHODS

4.1. Research Design

Methodologically, this research uses many frameworks from spatial epidemiology. For example, the investigation involves components such as disease and disease risk mapping, geographical correlation study, and cluster detection. While these components are 'geographical,' they are also statistical. The study also involves non-spatial statistics, and both contribute to the descriptive and analytical components of this investigation. It takes the research design of a repeated cross-sectional, ecological study, examining the geographical distribution of life expectancy at birth and its relationship with two domains of deprivation—material and social—at two time periods (1995-1999 and 2003-2007). Measures of deprivation were derived from a set of indices (Pampalon's indices) now widely used in Quebec.

First, life expectancy at birth was calculated as a measure for community level health status, stratified by gender. Then the distribution of community level health status was examined in relation to geographical location, community types, and scores of community level relative deprivation derived from variables in 1996 and 2006 Canadian census data. Secondly, spatial, multivariate regression models examined the influence of: 1) the two domains of deprivation; 2) neighbouring communities; and 3) unknown factors. Both life expectancy at birth estimated by the regression models and residuals—1) spatial autocorrelation; and 2) spatially uncorrelated heterogeneity—were mapped. Thirdly, data were stratified into rural and urban communities, and the influences of explanatory variables were compared between the two. Rural communities are comprised of three of the more rural community types (small town, village, and sparse settlements), and urban communities are combination of metro & big town, and metro fringe & mid-size town. A Geographic Information System

(GIS) was extensively used to spatially link the data and map health and social inequalities observed.

4.2. Data

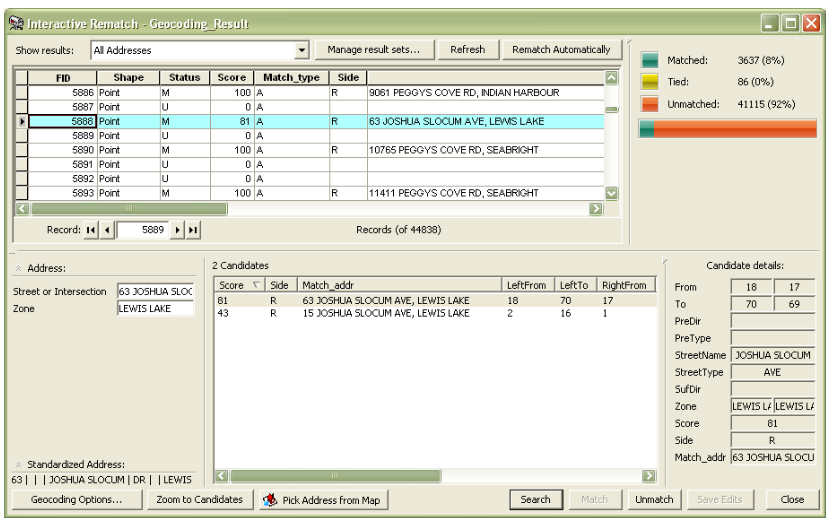
The following data were used to operationalize the analyses for this study:

4.2.1. Vital Statistics Data (1995-2007)

The vital statistics death data were obtained in two stages. The first dataset contained only identification numbers and information on the residence of individuals at the time of death. The types of residence information contained varied from only town and county, only street address, only the name of the apartment building or home, or only postal code, to various combinations of these elements. Out of the initial data containing 104,786 records, 104,696 (99.9%) had at least town locations, 90,494 (86.4%) had either one or both of the two address columns filled—usually one column was used for street address and another for the names of the apartment or building—and 93,464 (89.2%) had postal codes. 14,264 (13.6%) records had town names but no street or apartment information, 77.5% (11,063) of which had postal codes. While 93,464 (89.1%) of the records had postal codes, they were less useful to identify community locations because postal code areas—particularly in non-urban areas—did not neatly fit into the community units, and postal code geocoding was not reliable in rural areas. Postal codes were therefore only used as a guide to indicate the general region when the community could not be identified with other types of information. Particularly, they were used when there were two or more choices of locations due to the same town name or street name existing in different regions.

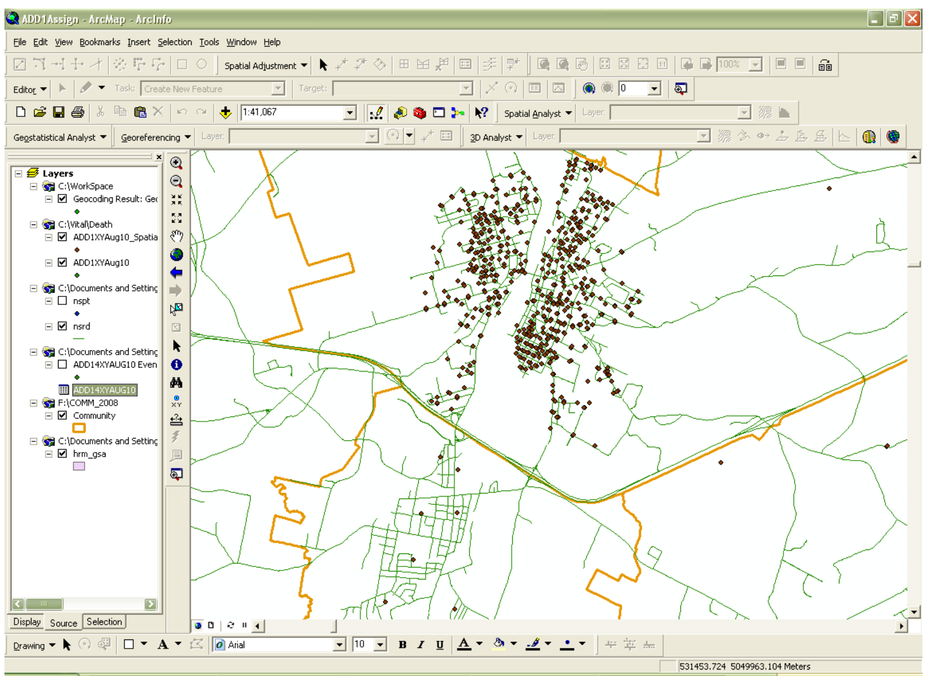
Where records had complete street addresses and town names, the Nova Scotia Address Locator (2009; see 4.2.4. Nova Scotia Address Locator below) was used to match point locations in the GIS environment. Where there was only the town name, the General Services Area (GSA) file containing about 2,230 small area names and locations in the same Nova Scotia Address Locator file was used to assign the centroid of the matching area name. Many of the records which could not initially be matched with the address match process needed to be verified for spelling and affixes (street, avenue, drive etc.) and then re-entered into the address match function (Figure 4-1 shows how the software matches addresses). About half of the records needed spelling and prefix or suffix corrections to find a match.

Figure 4-1. Address Match Process in ArcGIS



Records with only the names of the facility such as nursing homes, seniors' homes, and clinics were assigned point locations by searching the names through Google Maps. These were then verified using the Address Locator. The Nova Scotia Department of Health (2009-a, 2009-b) holds a directory of nursing, seniors', and other assisted homes and their respective addresses. The directory was also used to identify street addresses for the records which only indicated the names of the nursing and seniors' homes, and the street addresses were matched to point locations. These nursing/seniors' home deaths and other non-residential location deaths were flagged at this point. Out of province deaths and records with unidentifiable locations were also flagged. Once the point locations were overlaid with the 'community' boundary file in the GIS environment, the community name in which the point was located was assigned (see Figure 4-2 below). Then the identifiers and community data were sent back to Vital Statistics.

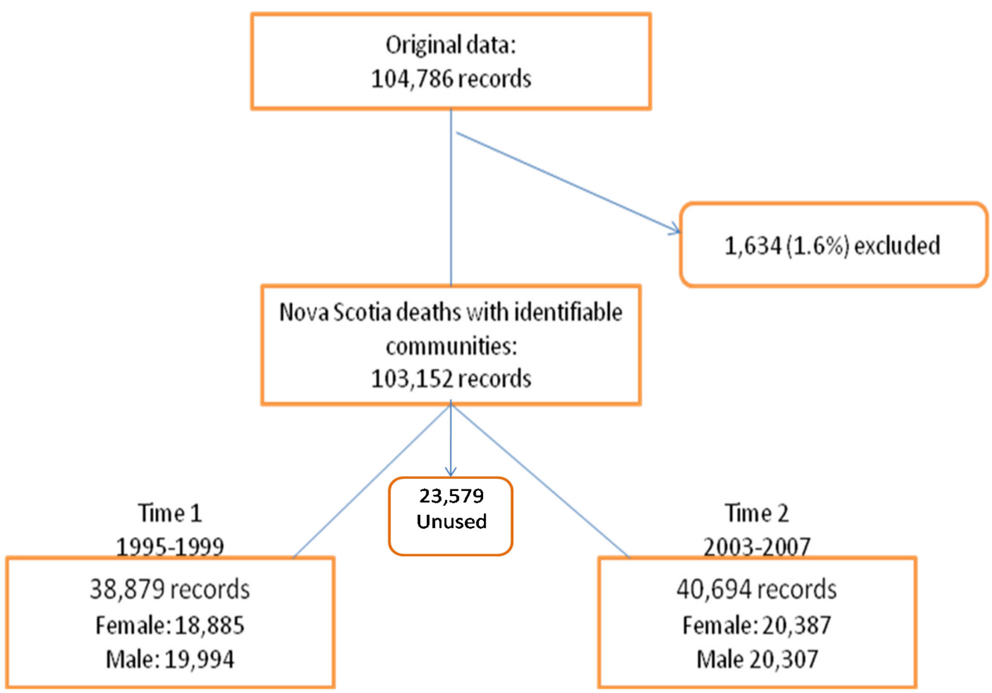
Figure 4-2. Point Allocation and Community Assignment of Records Matched



The second dataset was created by a Vital Statistics official by linking the identifier, community and the rest of the information needed for the study. As a result, the second dataset contained the age of death, gender, select cause of death (cardiovascular disease, malignancy and stroke), community name, and flagged status (whether they were nursing home/seniors' home or other institutional locations, whether they were out-of-province residents, or whether the locations were unidentifiable).

Out of the initial data containing 104,786 records, 1,634 (1.6%) records were excluded due to their out of province or non-identifiable location status. Out of the total of 13-year data of 103,152 records, the following numbers of records were used for the analyses of the two time periods—1995-1999 and 2003-2007 (Figure 4-3). The records for years between 2000 and 2002 (23,579 records) were not used. Address matching and exclusion of out-of-province records was conducted before other types of information of the records (gender, age, year of death etc.) were added by Vital Statistics. Therefore, the number of out-of-province records from the year intervals used is unknown.

Figure 4-3. Data Inclusion/Exclusion Process



Roughly 20% of the death records indicated non-private homes—such as nursing homes, seniors' homes, long-term care facilities, and hospitals—as their residence (Table 4-1). These records were kept and used for analyses. The rationale for keeping these records and how they were used are described in Section 4.3. Variables and their construction.

Table 4-1. Proportion of Records Indicating Nursing Home, Seniors' Home and Hospital as Their Residence

	Females	Males	Total
Time 1 (1995-1999)			
Death counts total	18,885	19,994	38,879
Nursing/seniors' home/hospital deaths	4,736 (25.1%)	2,427 (12.1%)	7,163 (18.4%)
Time 2 (2003-2007)			
Death counts total	20,387	20,307	40,694
Nursing/seniors' home/hospital deaths	5,931(29.1%)	2,929(14.4%)	8,860(21.8%)

The following table (Table 4-2) shows the age and sex distribution of the death records and the age- sex group mortality rates (per 1,000) for the two time periods.

Table 4-2. Mortality Counts and Rates-Nova Scotia for Time 1 (1995-1999) and Time 2 (2003-2007)

	Time 1						Time 2					
	Females			Males			Females			Males		
	Death	Population	Rate	Death	Population	Rate	Death	Population	Rate	Death	Population	Rate
0	112	22,965	4.9	122	24,109	5.1	75	20,653	3.6	104	21,756	4.8
1-4	24	108,874	0.2	23	114,285	0.2	15	84,449	0.2	19	87,671	0.2
5-9	17	149,062	0.1	34	155,174	0.2	12	121,782	0.1	8	126,872	0.1
10-19	68	303,680	0.2	140	316,285	0.4	56	293,864	0.2	125	304,176	0.4
20-29	118	307,578	0.4	281	294,882	1.0	99	277,622	0.4	235	258,405	0.9
30-39	233	386,134	0.6	505	366,906	1.4	182	312,955	0.6	327	288,561	1.1
40-49	579	359,419	1.6	891	346,581	2.6	595	391,273	1.5	922	367,309	2.5
50-59	1,097	247,881	4.4	1,727	244,250	7.1	1,187	344,058	3.5	2,021	331,035	6.1
60-69	2,108	188,133	11.2	3,411	173,664	19.6	2,134	224,919	9.5	3,335	213,909	15.6
70-79	4,517	160,309	28.2	5,992	117,616	50.9	4,158	161,500	25.7	5,451	131,339	41.5
80-84	3,279	54,432	60.2	3,168	31,597	100.3	3,444	61,075	56.4	3,201	37,157	86.1
85+	6,733	46,744	144.0	3,700	19,141	193.3	8,430	62,033	135.9	4,559	26,802	170.1
Total	18,885	2,335,211	8.1	19,994	2,204,490	9.1	20,387	2,356,183	8.7	20,307	2,194,992	9.3

Note: Rate is per 1,000. Population is 5-year cumulative.

4.2.2. Census Data (1996 and 2006)

Two sources of census data were used. First, to calculate the Nova Scotia standard rates, a set of census data was extracted from a database made available to Dalhousie University through the Data Liberation Initiative (DLI) agreement with Statistics Canada. Secondly, there are a number of census items that were recalibrated into the 'community' unit as defined by Nova Scotia Community Counts (2010) and these data are publicly available and accessible online. The variables included in the calculation of the two deprivation indices were derived from their database. The variables in the Nova Scotia Community Counts database were not divided into age and sex groups. Therefore, indirect age-sex standardization was employed for the communities to be comparable with the province.

4.2.3. Geography Files of Nova Scotia Community Counts Communities

Nova Scotia Community Counts also holds several geographical boundary unit files. Their 'community' boundaries were specifically created by the Community Counts for the purpose of helping Nova Scotia researchers analyze various small area unit level social characteristics. The boundary file was obtained from Community Counts under an agreement for a non-commercial/research use.

4.2.4. Nova Scotia Address Locator

The government of Nova Scotia holds a variety of geographical information pertaining to locations of buildings and civic addresses, which was created by the Nova Scotia Geomatics Centre, a government unit under Service Nova Scotia and Municipal Relations. The Geomatics Centre has published a series of the province's civic address and point location files linkable to these addresses, starting in 2001, which have been updated since (Nova

Scotia Gemoatics Centre, 2001). Point locations and civic addresses (civic number and street name) of all recognized, current and previously existing building locations were collected and organized in the files. A Middleton-based GIS service firm (Landmark Geographic Solutions, 2009) has designed an address locator—a GIS geodatabase[12] that allows automated identification of point locations based on street address, town and other information—using the set of address files published by the Geomatics Centre. This Address Locator was used to identify one of the 276 communities for each death record.

4.3. Variables and Their Construction

4.3.1. Dependent Variables—Life Expectancy at Birth (LE)

The Chiang method (1984) was employed to calculate community level, abridged life expectancy (LE) at birth. Age grouping was as follows: less than 1 year, 1-4 years, 5-9 years, 10-19, and 10-year groups up to 70-79, 80-84, and over 85. Literature (Adekola, 2002; Veugeler et al., 1999) suggests that, in order to derive a stable calculation for life expectancy, the area or population unit should have 5,000 or more people. In any given year in the last decade or so, only about 25 of Nova Scotia's 276 communities had a population of more than 5,000 for each gender.

In order to deal with the issue of areas with such small population size, a combination of two types of aggregation of data were conducted. One was pooling of deaths for multiple years instead of annual life expectancy. Another was aggregation of communities with very small populations. For the former, 5-year pooling was employed since it minimizes the number of communities needed to be aggregated into a larger area, while it still gave some

[12] Database that stores spatial information such as location of points (e.g., buildings), lines (e.g., roads), and polygons (e.g., areas), their geographical coordinates, coordinate systems, attribute names and meaning, etc..

time gap between the two time periods. The life expectancy calculated, therefore, was 5-year averages for time periods 1995-1999 and 2003-2007. For the latter kind of aggregation, 131 small communities (mostly adjacent communities) were combined to form 59 areas based on their initially calculated community types, resulting in a total of 182 areas (thus some of them are technically 'community clusters' but they are generally called 'communities' here) after excluding 22 extremely small communities—mainly parks and census defined Indian Reserves—for which the census data were suppressed. A few Indian Reserves which had a large enough population for the census data not to be suppressed, but did not have reserves of similar characteristics nearby to be combined, were also excluded.

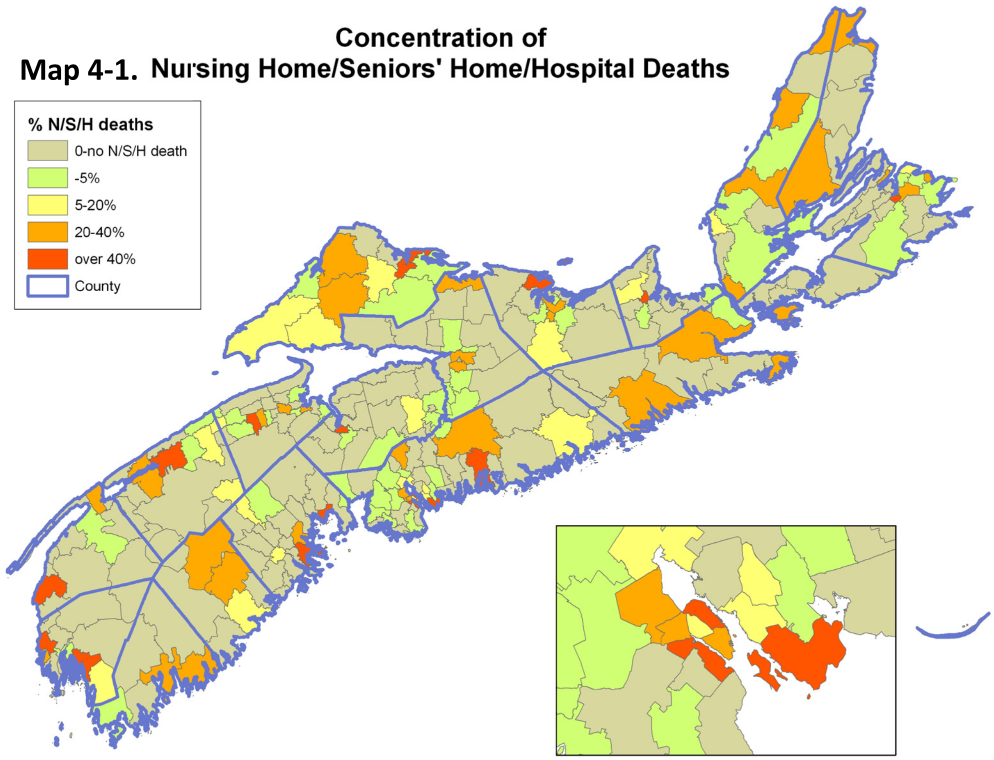
Community level age group population (denominator) data were only available for census years and those for other years needed to be estimated. Cubic spline was applied (Veugelers et al., 2000) using SAS software (Version 9.1, Cary, NC) to estimate age group population data for the intercensal years using 1991, 1996, 2001 and 2006 census data for each community.

The initial, raw calculation of LEs resulted in extremely large variation ranging from 50 years of age to 120 years of age. One of the main reasons—other than the small sizes of communities—was the fact that a large proportion of deaths were concentrated in communities with large nursing homes, seniors' homes and some hospitals. This concentration not only drove the mortality rates of communities with these institutions to a very high level for older age groups, but also left many other communities with extremely low counts of deaths, resulting in estimating extremely high LEs for those communities.

This posed a unique dilemma as excluding the deaths from these institutions would only address extremely high mortality rates, but not extremely low mortality rates.

In order to address both ends of the problem, county average mortality rates for age groups 70-79, 80-84 and 85+ were applied for all communities, with an assumption that older age individuals requiring assisted living would likely choose to move to a nursing home/seniors' home in the same county. As for the absolute number of death records with hospital as the residence, they were concentrated in Halifax Citadel, which had a large population in the age groups and therefore including these records from the hospitals did not greatly affect the LEs. In addition, in the case of these records which indicate hospitals as the residence, the deceased were likely to have lived in the facility for a long time rather than being hospitalized shortly before death. While it may not always be the case, the geographical distribution of nursing homes/senior's homes/hospitals deaths shows that these facilities are strategically located in each of the 18 counties (Map 4-1) and individuals are more likely than not to choose to live closer to where they used to live, as it enables them to continue to access their social networks. As a result of this adjustment, it is likely that the community level life expectancy for each community is somewhat closer to the average than it may actually be for some communities, as any excess deaths actually occurring in the communities for these age groups due to some community specific factors will not be accounted.

Map 4-1. Concentration of Nursing Home/Seniors' Home/Hospital Deaths



4.3.2. Independent Variables—Pampalon's Deprivation Indices Calculated at 'Community' Level

Two sets of deprivation indices were constructed using 1996 and 2006 census data, following the indices previously constructed by a group of researchers (Pampalon & Raymond, 2000) and now widely used primarily in Quebec and elsewhere in Canada (Pampalon et al, 2006; Pampalon, Hamel, & Gamache, 2008; Pampalon, Hamel, & Gamache, 2009-a; Auger, Alix, & Zang et al., 2010). The two indices are called Material Deprivation and Social Deprivation and the two are composed of the following census based variables:

a. Material Deprivation:
1. Average individual income (15 years and older) [Income]
2. Proportion of unemployed persons in the population (25 years and older) [Unemp]
3. Proportion of individuals without high school diploma (15 years and older) [Lesshigh]

b. Social Deprivation:

1. Proportion of single parents (15 years and older) [LoneP]
2. Proportion of people living alone (15 years and older) [Alone]
3. Proportion of individuals who are separated, widowed or divorced (15 years and older) [SWD]

Each of the variables was age-sex standardized, and log-normalized except for proportion of individuals without high school diploma which had normal distribution, before being combined. Principal Component Analysis (PCA) was conducted to determine the weight for individual variables. The result is the following (Table 4-3-a, & -b):

Table 4-3 Principal Components Analysis Results

a. Time 1

	Factor1	Factor2	Weight
Variables			
Income	-0.88244	-0.16673	-0.40257
LessHigh	0.89410	-0.12055	0.43282
Unemp	0.76261	0.20151	0.34296
Alone	0.03456	0.78682	0.38842
LoneP	0.14917	0.77092	0.37063
SWD	0.04906	0.88290	0.43496
Variance explained	41.89%	29.14%	
Cumulative variance	41.89%	71.02%	

b. Time 2

	Factor1	Factor2	Weight
Variable			
Income	-0.88831	-0.22307	-0.39508
LessHigh	0.91049	-0.01482	0.43763
Unemp	0.76429	0.17327	0.34243
Alone	0.04176	0.85592	0.43379
LoneP	0.19777	0.69105	0.32821
SWD	0.11132	0.90114	0.44766
Variance explained	46.23%	26.40%	
Cumulative variance	46.23%	72.63%	

(Showing principal components exceeded eigenvalue=1; After varimax rotation, and weights based on the PCA)

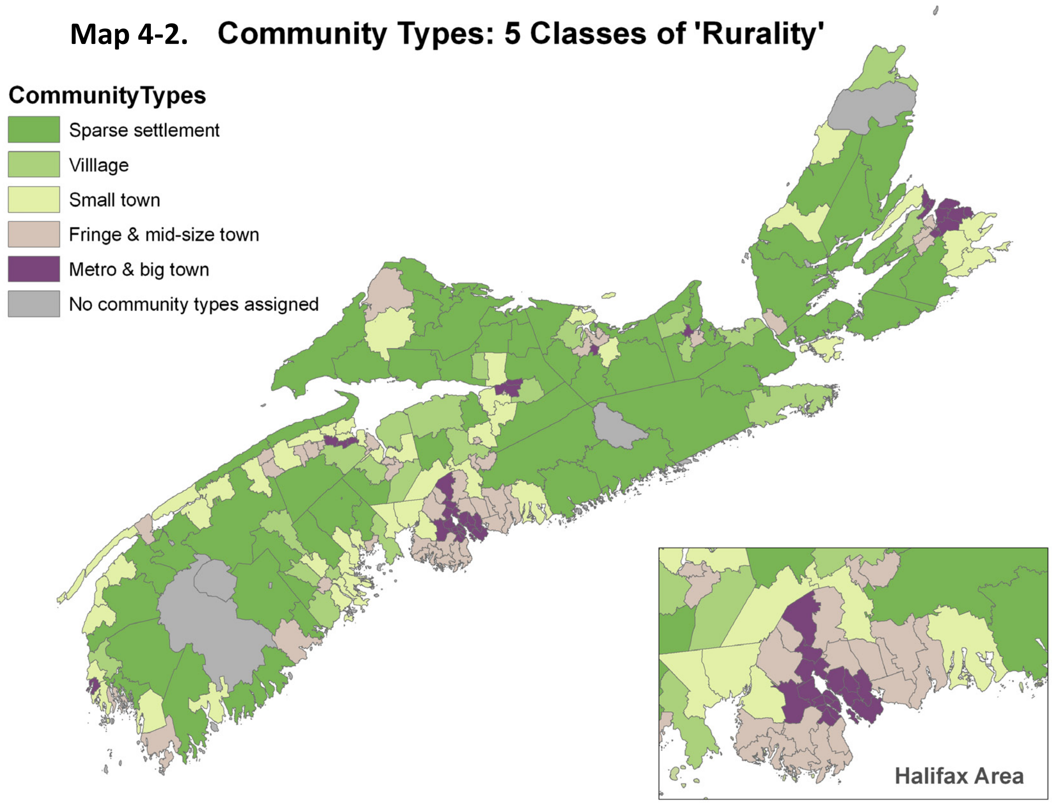
For the 1996 indices, each of the two components accounted for about 41.9% and 29.1%, respectively of the variations in the six variables, totaling approximately 71%. In the case of the 2006 indices, the two components that exceeded eigenvalue of 1 accounted for 46.2% and 26.4%, respectively, of the variations in the six variables, totaling 72.6%.

It should be noted here that the mid points of the 5-year average life expectancy for the two time periods were 1997 and 2005, while the two time periods at which deprivation was measured were 1996 and 2006. Some literature suggests that relative deprivation tends to be stable for a relatively long period of time (Shaw, Davey Smith, & Dorling, 2005; Singh & Siahpush, 2006), and this discrepancy is unlikely to affect the analysis. A similar study investigating time trends of life expectancy by classes of deprivation (Auger, Alix, & Zang et al., 2010) used the mid-point deprivation for the entire study period (1989-2004), assuming that the deprivation—especially viewed as a position in 10 classes—was relatively stable over the 15-year period.

4.3.3. Community Types—Degrees of Rurality

As mentioned earlier, several definitions of 'rurality' exist. They are mostly based on density and size of the population, with the exception of the Metropolitan Influence Zone, which also takes into consideration the proportion of commuters to the metro area in the particular province (du Plessis et al., 2001; Pong, MesMeules, & Heng, et al., 2010). However, none of the existing definitions applies neatly to the 'community' units employed for this research. Further, rural means different things to different people. For this study context, the ideal would be to create a new typology which differentiates communities, though not by characteristics of populations or groups directly related to explanatory variables such as socioeconomic or social attributes. An alternative was, therefore, to construct a community typology that describes gradients of 'rurality'—much like existing rurality categories—but specifically for the Nova Scotia context.

Several candidate measures were considered, including population per square kilometre area, lengths of roads per square kilometre area, and population per kilometre of road. Different sets of intervals were mapped and reviewed if they visually 'made sense'—whether they are distinguishing metro urban areas, fringes of these areas, big and medium size towns, or small and sparse rural communities. The measures were classified into five groups, using geometric intervals within the GIS environment. Geometric intervals determine the cut-off points between groups so as to minimize the variation (square sum of element) within each category (ESRI, 2007). A five-class category of population density per kilometre of road was chosen as it appeared to best depict the perceived community type differences, including: 1) metro and big towns, 2) metro fringes and mid-size towns, 3) small towns, 4) villages, and 5) sparse settlements (Map 4-2).



Map 4-2. Community Types: 5 Classes of 'Rurality'

4.4. Analyses

The thesis employed descriptive and analytic approaches to address the hypotheses at hand. The descriptive component includes the basic statistics of the population and the variables employed in the study. Disease/risk mapping would show spatial/geographical patterns of social and health inequalities. The analytic component includes multivariate, spatial regression models that examine geographical and non-geographical correlations among explanatory variables and their relationships with health outcomes—LE at birth. Analytic statistics were then fed back into mapping, which showed the presence (or absence) of clustering of unaccounted effects as well as the geographical distribution of LE after smoothing.

First, the visual geographical patterns of health inequality and relative deprivation by classes were examined in maps for both females and males, at two time periods (1995-1999 and 2003-2007). Average LE and deprivation scores were compared for the five community types. Median LE was also compared for the highest and lowest deciles of deprivation scores. Growth in LE for each community was also examined. Those communities whose LE grew within the 0.5 years range from the provincial average between the two time periods (1.006 for females and 1.735 for males) were considered as having 'normal' growth. Three categories of those with LE growth: 1) higher than the average, 2) lower than the average, and 3) normal—were mapped to determine their geographic distribution. These series of mapping and basic statistical analyses are together to address the first hypothesis—*Health and social inequalities (including temporal trends) have geographical patterns by geographical location or by community type, or both.*

Secondly, statistical associations between the two sets of deprivation scores and LE across communities for females and males were examined for the respective two time periods. Stepwise multiple regression models were run, starting with only random effect (differentiated by spatially correlated and uncorrelated components) (Model 1), and then adding: material deprivation only (Model 2), social deprivation only (Model 3), material and social deprivation (Model 4), material, social deprivation and the interaction term of the two (Model 5), and finally, population per km road (continuous values the community types are based on) (Model 6). Thus, in the case of LE for each gender for each of the two time periods, the full model (Model 6) would be:

$$LE = a + \beta_1 \times X_1 + \beta_2 \times X_2 + \beta_3 \times X_1 \times X_2 + \beta_4 \times X_3 + U + V$$

β1 is the coefficient for the material deprivation score, *β2* is for the social deprivation score, *β3* represents the coefficient of the interaction of material and social deprivation*, β4* is rurality, *U* is a random, spatial autocorrelation term (or residuals), and *V* is remaining, spatially uncorrelated random effects (residuals). A conditional autoregression (CAR) model included in WinBUGS (Lunn, Thomas, & Best et al., 2000) was applied to calculate spatial autocorrelation as follows:

$$u_i \sim N(\overline{u}_i, \sigma_u^2 / n_i)$$

$$\overline{u}_i = \sum_{j \in neigh(i)} w_{i,j} u_j / n_i$$

Where u_i is the effect on the community, which is the equally weighted average of the random component in the surrounding communities. Both spatially correlated and uncorrelated random effects were assumed to be normally distributed.

Deviance Information Criterion (DIC) was used to examine the goodness-of-fit, which can also be calculated with WinBUGS. DIC is similar to Akaike Information Criterion (AIC)—the calculation involves deviance (-2 log likelihood) and number of parameters—but does not require maximum likelihood calculation which is not readily available with Markov Chain Monte Carlo simulation (for a more detailed explanation, see Spiegelhalter, Best, & Carlin et al., 2002). The smaller DIC is, the better the model fit. The best fit model was to be chosen to estimate LE for each community. This in effect smoothes the maps as the model estimation would simulate the scenario where there are a large number of samples and would stabilize the estimation, leading to the estimates being closer to the average than the raw calculations. While the models will not 'prove' that the deprivation measures cause premature mortality and lower health expectancy in communities, the correlations observed will support the premise that material and social conditions of communities are possible direct or indirect contributors of biological illnesses through several pathways. Therefore, this component addresses the second hypothesis—*Both material and social deprivation measured in this study affect the health status of the community as contextual risk conditions, and the effects differ by gender*—while also provide a clue to possible unaccounted factors by identifying their geographical distribution.

Spatially uncorrelated random effects will point to the residual variances that have not been explained away by both deprivation measures and spatial autocorrelation. Spatial autocorrelation (or geographical autocorrelation) is a term used to describe a general rule of geographical phenomena, that, usually, like things tend to be located (e.g., live, work) closer to one another[13]. Having this spatial dependence violates one of the assumptions of regression that each observation is independent of the others. Therefore, inclusion of the spatial autocorrelation term is important as it compensates for the spatial dependency. Mapping of the residuals for each community may or may not show a clustering, which can help identify what other major factors may or may not be at work. This component contributes to addressing the fourth hypothesis—*Unaccounted variance measured by spatially correlated and spatially heterogeneous random effect (residuals) have patterns by region or community type, or both.*

Thirdly, the degrees of difference between the health status of the most and least deprived communities were examined and compared between the two time periods. Since the raw scores of deprivation are not directly comparable, they were transformed into relative

---

[13] This concept of geographical autocorrelation is rooted in Tobler's first law of geography (Tobler, 1970), that "Everything is related to everything else, but near things are more related than distant things."

deprivation expressed by deciles of positions for each community. The differences between the median LEs of the least and most deprived 10% of the 182 communities were examined for each of the genders and time periods. Then the changes in the differences between the two time periods for both genders were calculated. This is similar (though simpler) to the analysis conducted by Auger and colleagues (Auger et al., 2010) in Quebec.

As mentioned in the literature review section, some population health studies have shown that the health inequalities between the more affluent and more deprived have widened in many developed countries in the last few decades. Nova Scotia is not independent of, but rather susceptible to, the globalizing economy and its influences on employment as well as the rise and fall of particular industries—resource reliant industries in particular. Thus, this part of the analyses addresses the third hypothesis: *The social inequalities in health between communities have widened in the last decade.*

Lastly, the comparisons of health status and their relationships with deprivation measures were extended to examine how the strengths in effects of deprivation measured across the province may differ between communities that are more typically considered 'urban' and communities considered 'rural' if they were analyzed separately. Moreover, the unaccounted variances in the respective models were compared to see if the two domains of deprivation 'explain away' the variations to the same extent between the urban community-only and rural community-only models. If they are in fact different, then it would indicate that the use of universal deprivation measures to predict health status may bias toward or against either end of rural-urban continuum of communities. Thus, this component compares the strengths of the coefficients and unstructured random effects (residuals) involved in the regression models—without the spatial autocorrelation term—between urban community-only models and rural community-only models. As such, this section addresses the last hypothesis—*The strengths in the effects of measured deprivation on, and 'explainability' of variation in health, are not necessarily the same between 'urban' and 'rural' communities.*

Chapter 5. RESULTS

5.1. Basic Statistics of the Population

5.1.1. Population by Community Type

The following population figures are based on five-year cumulative population using census year population and intercensal year estimation. According to the definition used in this study, almost half of the population in Nova Scotia live in Halifax and Sydney metro areas or satellite big towns such as Truro across the province (Table 5-1).

Table 5-1. Population Distribution by Community Type—5-Year Cumulative

	Both sex (%)	Females (%)	Males (%)
Time 1 (1995-1999)			
Metro & big town	2,130,985 (47.1)	1,118,733 (48.1)	1,012,252 (46.1)
Metro fringe & mid-size town	857,505 (18.6)	438,434 (18.8)	419,071 (19.1)
Small town	692,949 (15.3)	351,393 (15.1)	341,556 (15.5)
Village	224,139 (5.0)	111,157 (4.8)	112,982 (5.1)
Sparse settlement	619,154 (13.7)	308,133 (13.2)	311,021 (14.2)
Total	4,524,732	2,327,850	2,196,882
Time 2 (2003-2007)			
Metro & big town	2,149,895 (47.4)	1,136,080 (48.4)	1,013,815 (46.4)
Metro fringe & mid-size town	882,162 (19.5)	452,777 (19.3)	429,385 (19.6)
Small town	683,594 (15.1)	348,429 (14.8)	335,165 (15.3)
Village	219,839 (4.8)	109,690 (4.7)	110,149 (5.0)
Sparse settlement	598,399 (13.2)	300,367 (12.8)	298,032 (13.6)
Total	4,533,889	2,347,343	2,186,546

When we consider metro and big towns and their fringe and mid-size towns as 'urban' and the rest 'rural', about two thirds of the population fall into the urban category and one third into the rural category (Table 5-2). There was no difference in population distribution in each community type between females and males for both time points.

Table 5-2. Population Distribution by 'Urban' and 'Rural'—5-Year Cumulative

	Both sex (%)	Females (%)	Males (%)
Time 1 (1995-1999)			
Urban (75)	2,988,490 (66.0)	1,557,167 (66.9)	1,431,323 (65.2)
Rural (107)	1,536,242 (34.0)	770,683 (33.1)	765,559 (34.8)
Total	4,524,732	2,327,850	2,196,882
Time 2 (2003-2007)			
Urban (75)	3,032,057 (66.9)	1,588,857 (67.7)	1,443,200 (66.0)
Rural (107)	1,501,832 (33.1)	758,486 (32.3)	743,346 (34.0)
Total	2,988,490	2,347,343	2,186,546

5.1.2. Population by Levels of Material and Social Deprivation

Material and social deprivation decile classes are created such that 10% of the total number of communities (i.e., 18 or 19 communities each) falls into each category. As Tables 5-3-a & -b show, the population for each decile class varies. For example, the least two materially deprived classes of communities consist of about 35% of Nova Scotia's population, while the least two socially deprived classes of communities have only 16% of the total population. On the other hand, about 40% of the total population reside in the two most socially deprived classes of communities and only 12% live in the two most materially deprived classes of communities. This indicates that, not surprisingly, that most materially deprived communities tend to be more sparse and rural, while most socially deprived groups tend to be in more populated, 'urban' communities. The population distributions by classes of deprivation have remained largely unchanged between Time 1 and Time 2.

Table 5-3-a. Population Distribution by Class of Deprivation-Time 1 (1995-1999) —5-Year Cumulative

Material deprivation	Both sex (%)	Females (%)	Males (%)	Social Deprivation	Both sex (%)	Females (%)	Males (%)
1	980,291	511,795	468,496	1	441,927	219,683	222,244
(Least deprived)	(21.7)	(22.0)	(21.3)	(Least deprived)	(9.8)	(9.4)	(10.1)
2	591,951	300,366	291,585	2	275,044	136,454	138,590
	(13.1)	(12.9)	(13.3)		(6.1)	(5.9)	(6.3)
3	645,250	336,779	308,471	3	257,644	129,060	128,584
	(14.3)	(14.5)	(14.0)		(5.7)	(5.5)	(5.9)
4	307,747	157,749	149,998	4	376,592	190,036	186,556
	(6.8)	(6.8)	(6.8)		(8.3)	(8.2)	(8.5)
5	417,025	214,742	202,283	5	447,904	226,606	221,298
	(9.2)	(9.2)	(9.2)		(9.9)	(9.7)	(10.1)
6	363,445	186,478	176,967	6	293,546	147,939	145,607
	(8.0)	(8.0)	(8.1)		(6.5)	(6.4)	(6.6)
7	254,688	127,545	127,143	7	285,793	143,570	142,223
	(5.6)	(5.5)	(5.8)		(6.3)	(6.2)	(6.5)
8	407,688	210,947	196,741	8	357,787	185,680	172,107
	(9.0)	(9.1)	(9.0)		(7.9)	(8.0)	(7.8)
9	302,332	153,988	148,344	9	691,150	365,458	325,692
	(6.7)	(6.6)	(6.8)		(15.3)	(15.7)	(14.8)
10	254,315	127,461	126,854	10	1,097,345	583,364	513,981
(Most deprived)	(5.6)	(5.5)	(5.8)	(Most deprived)	(24.3)	(25.1)	(23.4)
Total	4,524,732	2,327,850	2,196,882	Total	4,524,732	2,327,850	2,196,882

Table 5-3-b. Population Distribution by Class of Deprivation-Time 2 (2003-2007) —5-Year Cumulative

Material deprivation	Both sex (%)	Females (%)	Males (%)	Social Deprivation	Both sex (%)	Females (%)	Males (%)
1	1,139,843	597470	542,373	1	396,935	197,845	199,090
(Least deprived)	(25.1)	(25.5)	(24.8)	(Least deprived)	(8.8)	(8.4)	(9.1)
2	489,145	250018	239,127	2	411,704	209,000	202,704
	(10.8)	(10.7)	(10.9)		(9.1)	(8.9)	(9.3)
3	536,382	279521	256,861	3	255,113	129,087	126,026
	(11.8)	(11.9)	(11.7)		(5.6)	(5.5)	(5.8)
4	434,818	224927	209,891	4	294,742	150,187	144,555
	(9.6)	(9.6)	(9.6)		(6.5)	(6.4)	(6.6)
5	462,543	241083	221,460	5	522,804	267,277	255,527
	(10.2)	(10.3)	(10.1)		(11.5)	(11.4)	(11.7)
6	284,521	144509	140,012	6	274,473	140,419	134,054
	(6.3)	(6.2)	(6.4)		(6.1)	(6.0)	(6.1)
7	355,171	182572	172,599	7	273,953	139,766	134,187
	(7.8)	(7.8)	(7.9)		(6.0)	(6.0)	(6.1)
8	338,226	176627	161,599	8	297,099	152,730	144,369
	(7.5)	(7.5)	(7.4)		(6.6)	(6.5)	(6.6)
9	253,841	129241	124,600	9	812,177	429,341	382,836
	(5.6)	(5.5)	(5.7)		(17.9)	(18.3)	(17.5)
10	239,399	121375	118,024	10	994,889	531,691	463,198
(Most deprived)	(5.3)	(5.2)	(5.4)	(Most deprived)	(21.9)	(22.37)	(21.1)
Total	4,533,889	2,347,343	2,186,546	Total	4,533,889	2,347,343	2,186,546

5.2. Distribution of Deprivation

5.2.1. Material and Social Deprivation and Individual Variables by Community Type

The following tables (Tables 5-4-a & -b) show the mean scores of material and social deprivation, ranking (1 to 182) of deprivation, and six individual variables included in the deprivation indices (with 95% confidence intervals to show the spread) by the five community types. The individual variables shown are non-age-sex adjusted, non-centred raw rates. It is important to note here that the scores of deprivation of the two time points were calculated to be comparable with the provincial standard at the respective time points, and they are not directly comparable between the time points. Moreover, the values of the six variables used to construct the scores can have different significance at different times. For example, the nominal values of income may have increased over the years, but that does not necessarily mean that the real value of the income earned has also increased at the same rate. Therefore, the comparisons between the two time points in these tables are limited to the relative ranking of deprivation.

Time 1 (1995-1999)

The five community types are along the rural-urban continuum and it appears that the material deprivation examined present gradients in their values along the same line. For example, the average score of material deprivation is the lowest for metro & big town (most urban), and the number gradually increases with the highest average score for the sparse settlement (most rural). Although the confidence intervals for adjacent classes of rurality (i.e. metro & big town versus metro fringe & mid-size town, metro fringe & midsize town versus small town, small town versus village and so on) overlap, the confidence intervals for the next level of rurality (metro & big town versus small town, metro fringe & mid-size town versus village and so on) did not. Therefore, although the difference between the adjacent classes of rurality is not shown at the statistically significant level, the gradient appears to exist. Social deprivation, on the other hand, did not have an observable gradient pattern. Metro & big town had the highest score and ranking and the confidence interval that did not overlap with rest of the rurality groups. The average score and the rank of village type was the smallest (thus least deprived), and the confidence intervals of four types other than metro & big town all overlapped with each other. As for individual variables, average income is the highest and unemployment the lowest in the metro fringe & mid-size town, while the lowest income and the highest unemployment rates are seen in sparse settlements. The proportion of adults with less than high school education was the lowest in metro & big towns, while the highest rates were in the sparse communities, showing that more rural communities are generally more socioeconomically deprived. Variables included in the index of social deprivation show that the metro & big towns have the highest proportion of people living alone, the highest proportion of single parents, and the highest rate of adults who are separated, widowed or divorced. Villages had the lowest rates for these three counts.

Time 2 (2003-2007)

The trends in Time 2 are very similar to those of Time 1. Both the scores and ranking of material deprivation had a gradient with the lowest for metro & big town and the highest for sparse settlement, though the adjacent groups' confidence intervals, again, did overlap. However, with some exceptions of slight overlap, the confidence intervals between the next levels of rurality groups were distinct. Social deprivation had the same pattern as Time 1, where other than metro & big town, which had the highest score and ranking, and the confidence interval was distinct from the rest of the community types. The four remaining types had overlapping confidence intervals, with village having the lowest score and ranking. Sparse settlements are the most materially deprived and had the lowest income, highest unemployment and highest proportion of people with less than high school diploma, while metro & big town had the highest proportion of people living alone, single parents and divorced, separated, or widowed individuals.

Table 5-4-a. Characteristics of Communities by 6 Factors of Deprivation and Multiple Deprivation Scores —Mean (95% CI) for Time 1 (1995-1999)

	Metro & big town (35)	Metro fringe and mid-size town (40)	Small town (45)	Village (16)	Sparse settlement (46)
Material Deprivation score	-0.646	-0.547	0.128	0.522	0.660
	(-1.061, -0.230)	(-0.838, -0.256)	(-0.093, 0.348)	(0.091, 0.954)	(0.481, 0.840)
Ranking	61.5 (41.7, 81.2)	61.1 (46.2, 75.9)	95.9 (83.5, 108.3)	114.3 (91.1, 137.4)	128.6(117.7, 139.6)
Social Deprivation score	0.916	-0.144	-0.179	-0.486	-0.227
	(0.532, 1.299)	(-0.531, 0.242)	(-0.393, 0.035)	(-0.737,-0.235)	(-0.380, -0.075)
Ranking	133.4 (115.9, 150.9)	85.4 (65.3, 105.5)	86.0 (72.3, 99.7)	62.6 (42.9, 82.2)	80.4(69.1, 91.7)
Individual variables					
Average income ($)	21,775	22,276	20,140	18,956	18,407
	(20,273, 23,277)	(21,089, 23,463)	(19,427, 20,854)	(17,955, 19,957)	(17,830, 18,985)
Unemployment (%)	5.2 (4.5, 5.8)	5.0 (4.4, 5.6)	6.5 (5.5, 7.5)	7.1 (5.1, 9.1)	7.8 (6.8, 8.8)
Less than high school (%)	29.1 (25.7, 32.6)	31.16 (28.7, 34.6)	37.4 (35.5, 39.3)	40.2 (35.6, 44.7)	40.8 (38.7, 42.8)
Living alone (%)	11.0 (9.2, 12.9)	8.1 (7.0, 9.1)	8.8 (8.0, 9.5)	7.5 (7.0, 8.1)	9.1 (8.6, 9.7)
Single parents (%)	6.6 (5.9, 7.4)	4.6 (3.9, 5.3)	4.3 (3.9, 4.6)	3.7 (3.2, 4.2)	3.9 (3.6, 4.3)
Separated/widowed/divorced (%)	17.6 (16.3, 18.9)	15.5 (14.1, 16.9)	16.0 (15.1, 17.0)	13.8 (12.5, 15.1)	15.8 (15.1, 16.6)

Deprivation scores are centred to 0 as mean. CIs in blue highlight show the scores are negative (less deprived) or positive (more deprived) than the standard at a statistically significant level.

Table 5-4-b. Characteristics of Communities by 6 Factors of Deprivation and Multiple Deprivation Scores — Mean (95% CI) for Time 2 (2003-2007)

	Metro & big town (35)	Metro fringe and mid-size town (40)	Small town (45)	Village (16)	Sparse settlement (46)
Material Deprivation score	-0.63	-0.433	0.063	0.434	0.638
	(-1.018, -0.243)	(-0.780, -0.086)	(-0.183, 0.320)	(-0.014, 0.882)	(0.465, 0.811)
Ranking	60.9 (42.3, 79.4)	68.3 (52.4, 84.2)	92.7 (78.6, 106.8)	110.4 (85.6, 135.3)	127.2 (116.5, 137.8)
Social Deprivation score	0.911	-0.223	-0.167	-0.463	-0.174
	(0.571, 1.252)	(-0.640, 0.194)	(-0.421, 0.086)	(-0.772, -0.154)	(-0.327, -0.021)
Ranking	135.4 (118.4, 152.5)	84.0 (63.8, 104.2),	85.4 (71.8, 99.0)	61.9 (40.4, 83.3)	80.8 (70.2, 91.5)
Individual variables					
Average income ($)	31,653	32,754	29,452	28,250	27,141
	(29,471, 33,835)	(30,721, 34,786)	(28,194, 30,710)	(26,487, 30,013)	(26,217, 28,064)
Unemployment (%)	3.6 (3.1, 4.2)	3.9 (3.2, 4.6)	4.4 (3.7, 5.2)	5.3 (3.2, 7.3)	5.6 (4.9, 6.3)
Less than high school (%)	18.5 (15.8, 21.2)	21.8 (19.0, 24.7)	25.1 (23.1, 27.1)	26.9 (27.8 (23.4, 32.1)	28.6 (26.7, 30.4)
Living alone (%)	14.2 (12.3, 16.1)	9.9 (8.7, 11.0)	10.9 (10.1, 11.7)	9.4 (8.5, 10.4)	11.9 (11.2, 12.5)
Single parents (%)	7.3 (6.2, 8.3)	5.8 (4.9, 6.6)	4.9 (4.5, 5.3)	4.8 (4.2, 5.4)	4.4 (4.1, 4.6)
Separated/widowed/divorced (%)	19.2 (17.9, 20.4)	17.0 (15.6, 18.4)	18.3 (17.4, 19.2)	16.4 (15.1, 17.6)	18.3 (17.6, 19.1)

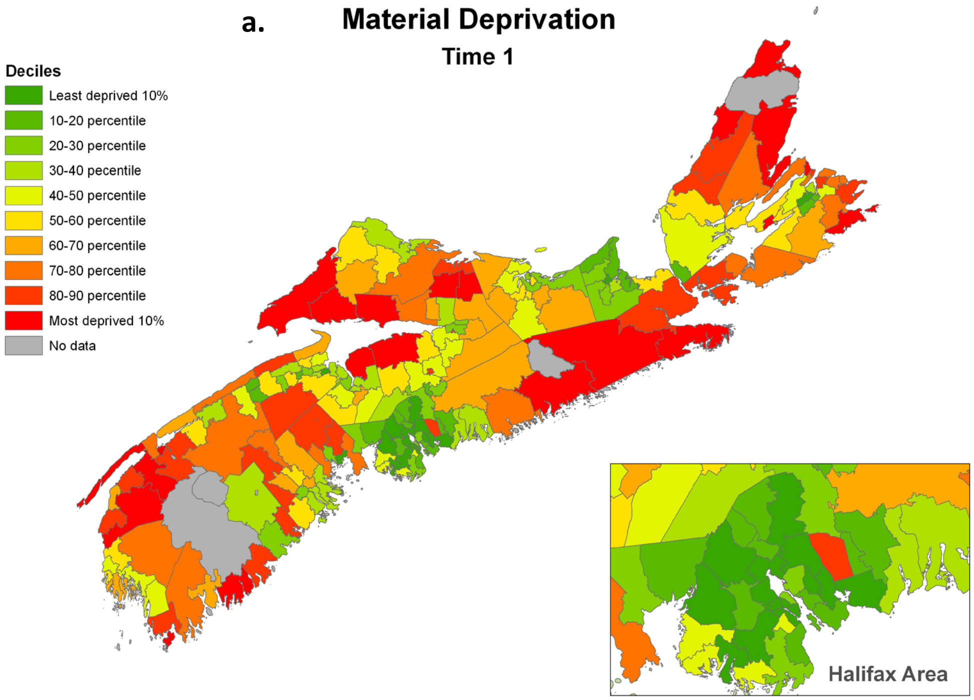
Deprivation scores are centred to 0 as mean. CIs in blue highlight show the scores are negative (less deprived) or positive (more deprived) than the standard at a statistically significant level.

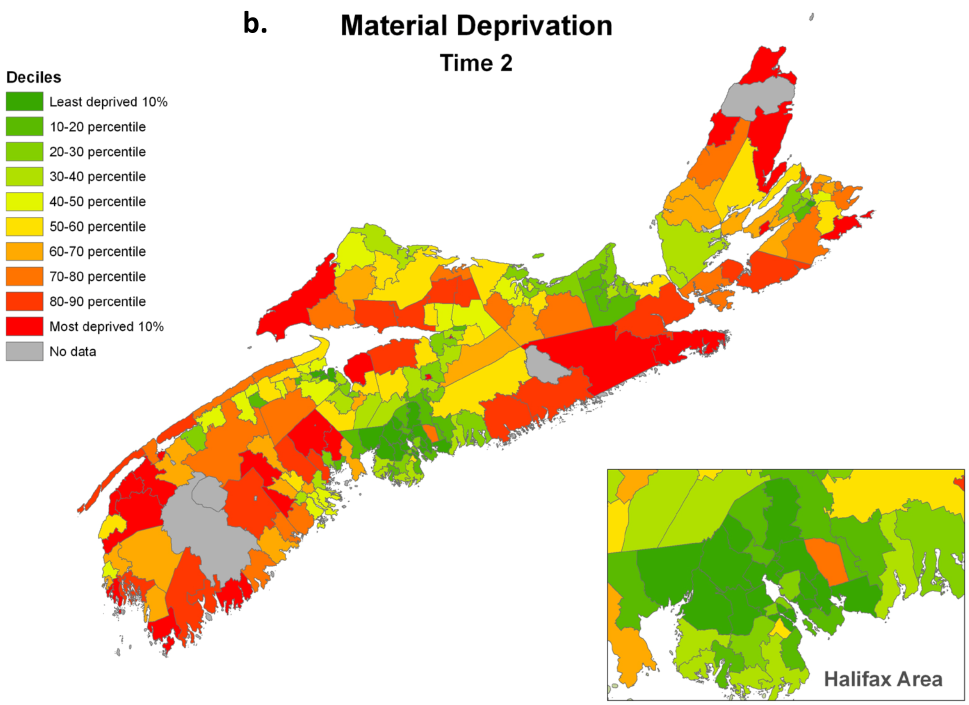
5.2.2. Spatial Distribution of Deprivation

The following maps (Maps 5-1-M-a,b & 5-1-S-a,b) show levels of material and social deprivation by decile classes for Time 1 (1995-1999) and Time 2 (2003-2007). Although there are slight changes in classes for some communities, overall spatial patterns are largely unchanged between Time 1 and Time 2 for both material and social deprivation. Some of the most materially deprived communities are seen in the outskirts of the province, while Halifax metro and surrounding areas are some of the least deprived. Also notable is a different trend for Preston in the metro fringe, which stands out as being surrounded by less deprived communities.

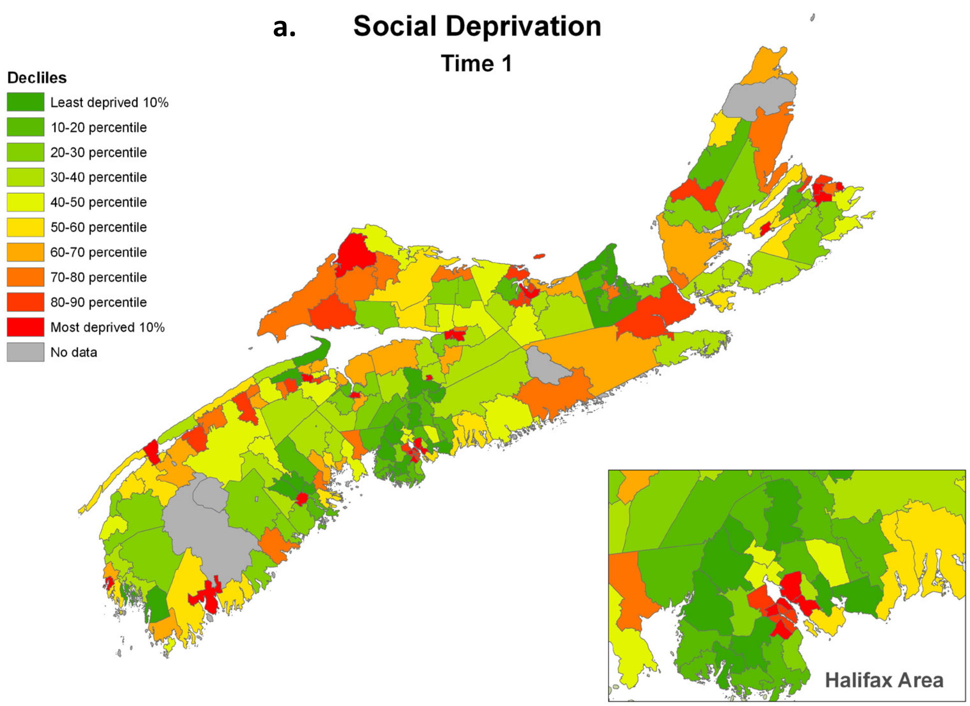
Social deprivation presents a different picture from material deprivation. The Halifax metro area stands out as some of the most socially deprived (communities with concentration of many isolated individuals). Areas surrounding the metro areas appear to be on the socially less deprived end of the scale, and communities that are farther away from the metro area that show high levels of material deprivation are also now some of the less socially deprived. The more socially deprived communities appear to be those small- to mid-size satellite towns which are located around the coastal line of the province. Overall maps of social deprivation—both Time 1 and Time 2—are greener than material deprivation maps due to the differences in area sizes of more rural and more urban communities. In other words, when more rural communities are more deprived, the map will look redder overall because rural communities tend to be larger. It is another piece of visual evidence that rural communities tend to be more materially deprived than socially deprived.

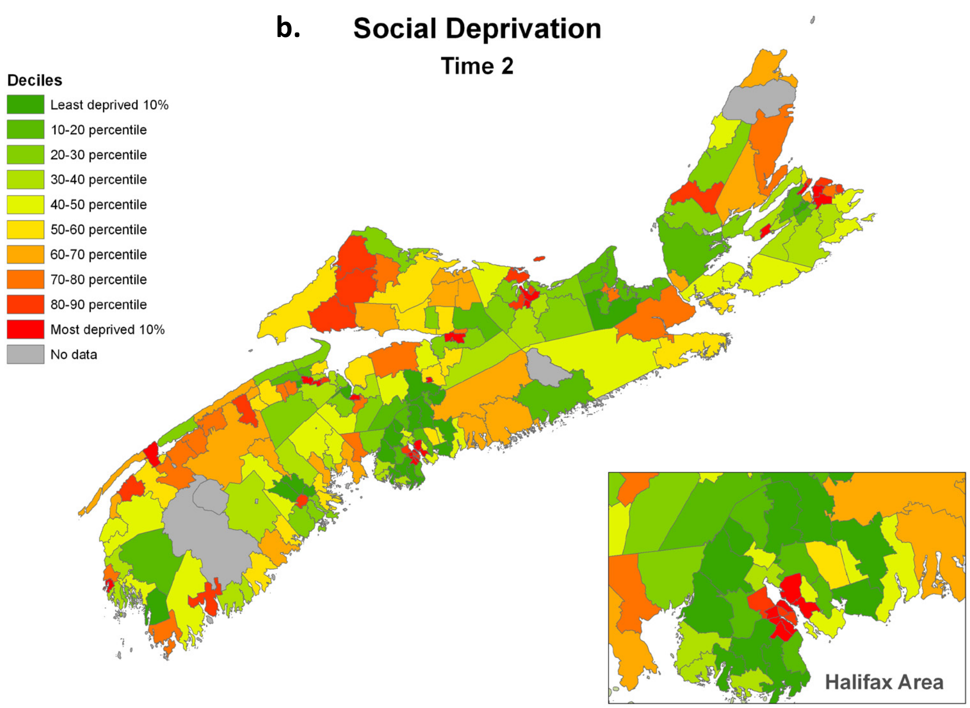
Maps 5-1-M. Spatial Distribution of Material Deprivation at Time 1 and Time 2





Maps 5-1-S. Spatial Distribution of Social Deprivation at Time 1 and Time 2





5.3. Distribution of Life Expectancy (LE) at Birth—Pre-Regression Modeling

5.3.1. LE by Community Type

Life expectancy at birth (LE) was calculated by gender for each community at two time points. The actual years of age of LE for each community calculated with the Chiang method as well as LE post- regression modeling can be found in APPENDIX B. The distributions of LEs for both genders and both time points were fairly normal (see APPENDIX C). Table 5-5 shows the pre-regression average LE and the 95% confidence intervals (to show the spread) by types of communities. There seem to be hardly notable patterns in LE for both females and males, for both time points, by types of communities. At Time 1, both male and female LEs were the lowest (shaded in pale orange) in metro & big towns, while villages had the lowest LEs at Time 2 for both genders. Metro fringe & mid-size towns had the highest LEs (shaded in pale green) for both females and males at Time 2, while small towns had the highest LEs for females and villages had the highest LE for males at Time 1. The difference between the highest and lowest average LE also varied. At Time 1, there was only a difference of 0.64 for females, while about twice as much difference (1.27) was observed for males in that time period. At Time 2, the trend was reversed. There was 1.26 years difference between the highest and lowest average for females, while, there was only 0.38 years—hardly any difference by community type for males.

Table 5-5. Distribution of Average Life Expectancy by Community Type—Pre-Regression

	Metro & big town (35)	Metro fringe and mid-size town (40)	Small town (45)	Village (16)	Sparse settlement (46)
Life expectancy average (CI)					
Females					
Time 1	80.13 (79.57, 80.68)	80.43 (79.85, 81.00)	80.77 (80.36, 81.18)	80.34 (79.39, 81.30)	80.26 (79.81, 80.70)
Time 2	81.26 (80.62, 81.90)	81.98 (81.53, 82.42)	81.31 (80.89, 81.72)	80.72 (79.63, 81.82)	81.37 (80.84, 81.90)
Males					
Time 1	73.65 (72.69, 74.62)	74.57 (74.13, 75.01)	74.01 (73.45, 74.57)	74.92 (73.98, 75.87)	73.78 (73.13, 74.43)
Time 2	75.79 (74.96, 76.61)	76.03 (75.29, 76.76)	75.78 (75.22, 76.34)	75.65 (74.55, 76.74)	75.77 (75.13, 76.41)

5.3.2. Spatial Distribution of LEs

Map 5-2 (below) shows the 18 counties of Nova Scotia as a reference. The following four maps (5-3-T1-a.b & 5-3-T2-a,b) show the pre-regression spatial distribution of life expectancy at birth (LE) for females and males at Time 1 and Time 2, classified into 5 groups. The mid-class is communities that have less than 1 year of age difference from the provincial average. The two adjacent classes are more than 1 to 3 years below (pale pink) or above (pale green) average, and the further classes are 3 or more years below (dark pink) or above (dark green) average LE. The provincial average LE of females at Time 1 was 80.45 years, while the average for males was 74.2 according to the calculations. At Time 2, the average LEs were 81.48 for females, and 75.87 for males (See APPENDIX C).

Time 1

Map 5-2. Counties

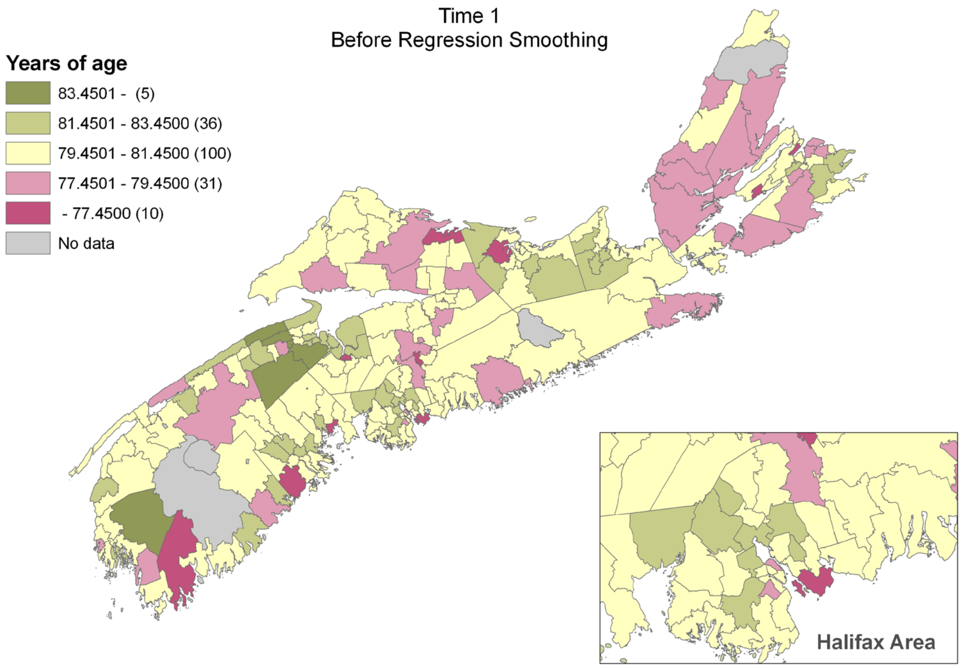
There is a small cluster of the highest LE category communities for females in the Annapolis Valley (including Kings and Annapolis Counties), in the northwest of the province, while the lower LE communities (but not the lowest) area clustered in all counties in the Cape Breton region(Richmond, Victoria, Inverness, and Cape Breton). Cumberland and Colchester Counties also saw relatively low LEs, while LEs are relatively high to normal for Antigonish

County. The Halifax metro area shows a mix of high and low LEs, with Halifax Needham, Spryfield and Eastern Passage having low LEs, and suburbs such as Cole Harbour, Clayton Park, and Bedford having high LEs. The fringes of metro Halifax had high to average LEs. For males, the lowest category LEs are seen in more rural (small town, village, sparse settlement) communities in Digby, Cumberland, Shelburne, Halifax Counties and counties in Cape Breton. Again, the Annapolis Valley areas, as well as inner Lunenburg County show a cluster of relatively high LEs. As with females, LEs for males in the Halifax metro area are mixed, with the metro fringe community having higher than average LEs. Females had LEs close (within 1 year) to the provincial average in 100 communities, while males were within the 'normal' range in 77 communities.

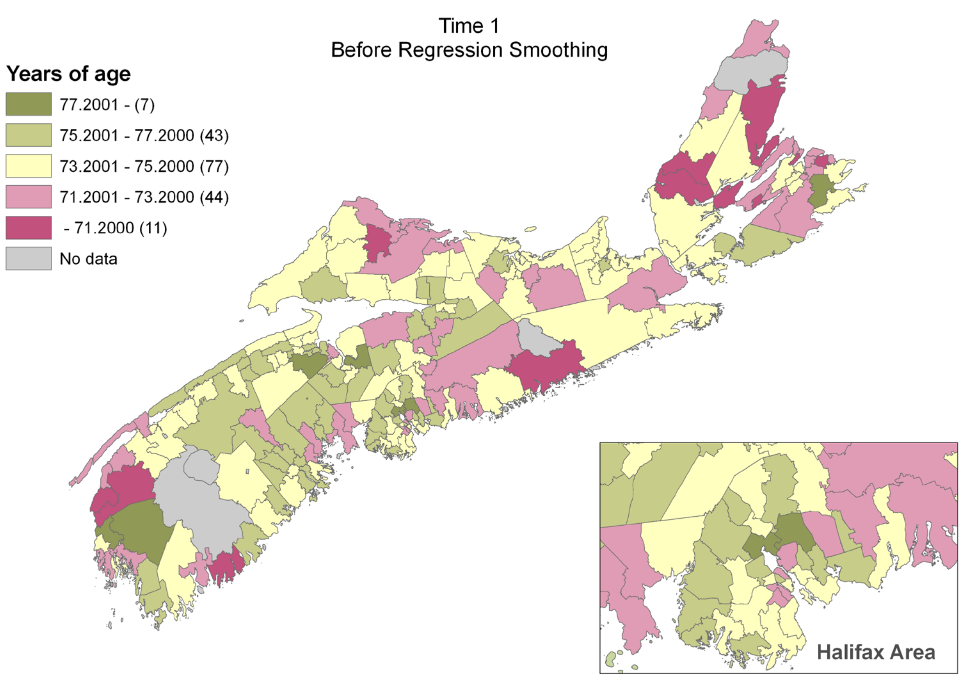
Time 2

The spatial pattern of LEs for females at Time 2 is somewhat different from the pattern for females at Time 1. For example, the cluster of low LEs is no longer notable in Cape Breton region, and instead there is a group of communities showing lower than average LEs in Annapolis, Digby and Queens Counties, in the southwest of the province. The metro and fringe areas largely show average to higher LEs with the exceptions of Preston and Halifax Needham. For males, lower LEs persisted in some communities in the Cape Breton region. As in Time 1, there is a band of relatively high LE communities for males in areas from Kings County, Luneburg County up to the western part of Halifax metro. Metro and fringe areas again have a mix of low and high LE communities for males with Halifax Needham, Dartmouth North and Preston showing lower than average LEs. The number of within-normal range communities slightly decreased from Time 1 for both females (85) and males (68).

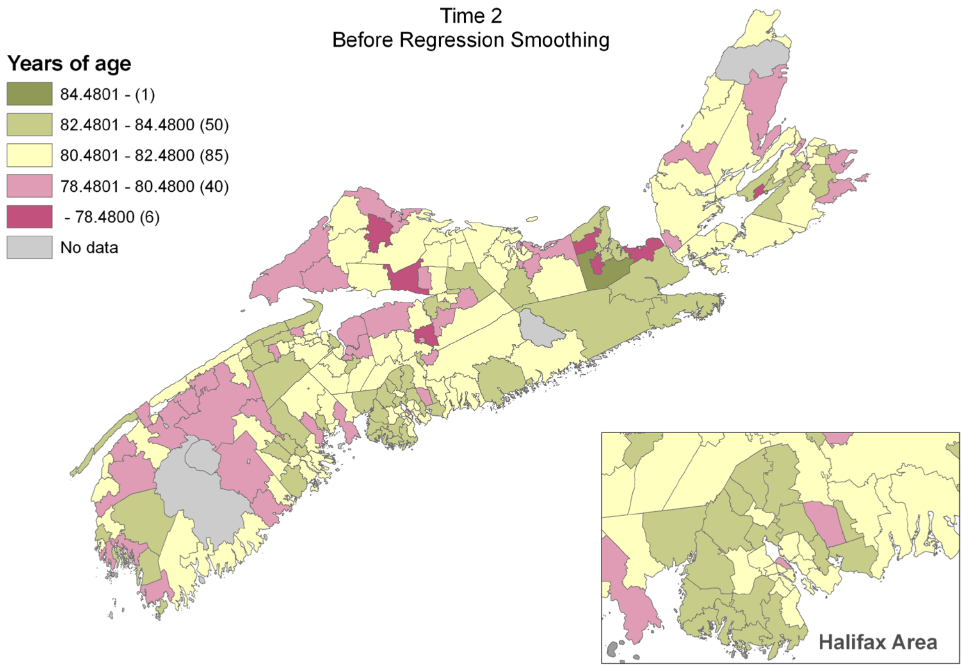
Map 5-3-T1-a. Life Expectancy at Birth - Females



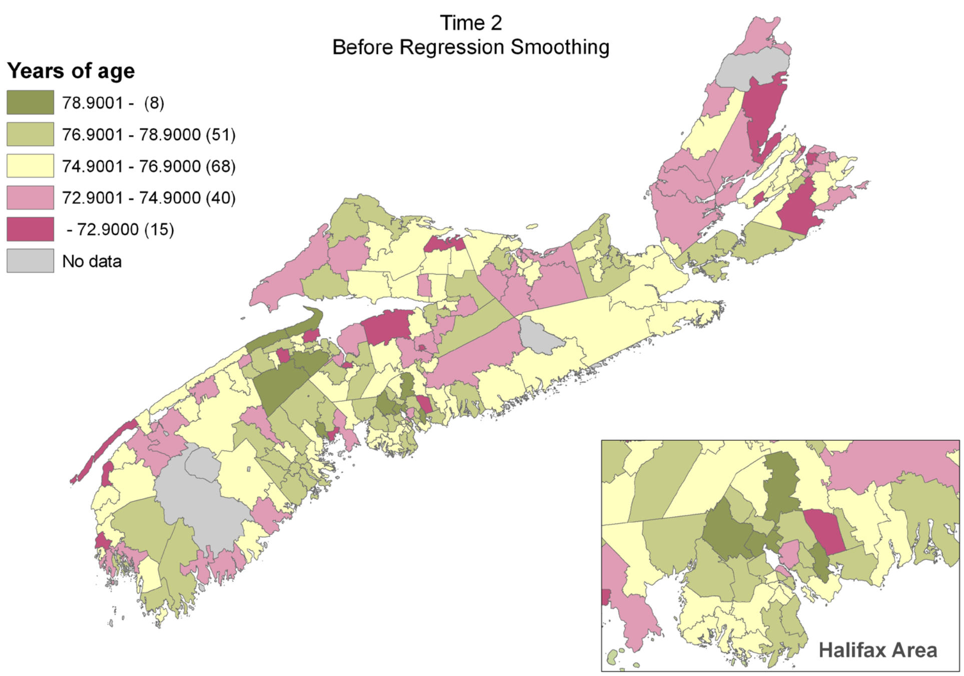
Map 5-3-T1-b. Life Expectancy at Birth - Males



Map 5-3-T2-a. Life Expectancy at Birth - Females



Map 5-3-T2-b. Life Expectancy at Birth - Males



5.4. Statistical Associations Between LE and Explanatory Variables

The following (Tables 5-6-a & -b) show the results of the Bayesian regression models for females and males, at Time 1 and Time 2. The mean of the inference by 100,000 iteration and 95% (without asterisk) or 90% credible intervals (with asterisk) are shown. Credible intervals can be interpreted here as being similar to confidence intervals, by which the interval not crossing 0 means that there is a statistical certainty of 90% or 95% that the coefficient has positive or negative (depending on which side of 0 the interval it lies) effect on the outcome. The smallest Deviance Information Criterion (DIC) was considered the best fit. Because lower the LE the lower the health status is, the relationships between worse health status and deprivation are negative.

Females

For both Time 1 and Time 2, material deprivation and social deprivation were associated with low LEs, meaning that the more materially or socially deprived, the lower the LE of the community was. Average LEs of communities were fairly consistent across all models. Moreover, the result shows the presence of interaction, indicating that if the community were both materially and socially deprived, it exacerbated the effect on LEs such that it was more than the (additive) effect from merely material and social deprivation. Model 5 had the lowest DIC for Time 1, indicating the best model fit. Although Model 4 had the lowest DIC for Time 2 and not Model 5 (which had the second lowest DIC), Model 5 was chosen because the interaction term also had an important level of effect the credible intervals of which did not cross 0. An additional reason for this choice was to allow for consistency with the model for Time 1 for regression smoothing as well as LE estimation. The WinBUGS code for Model 5 for females at Time 1 is shown in APPENDIX F (models for males at

Time 1 and 2 and females at Time 2 are the same). Adding continuous variables for rurality—measured by population per km of road—did not improve the model. For both Time 1 and Time 2, adding the interaction term seemed to improve the overall explainability of material and social deprivation (the coefficients became higher, indicating that they can explain away more of the variation).

Males

As with females, the average LEs of communities were consistent across models. Again, Model 5 was statistically the best fit for Time 1, but the DIC of Model 5 was not the lowest for Time 2. Nevertheless, the interaction term seems to contribute to the effect on LEs for both Time 1 and Time 2. Moreover, adding interaction between material and social deprivation improved the overall explainability of LE inequality by material and social deprivation across communities, explaining away more of the unaccounted variation than Model 1-4 did. Again, Model 5 was chosen for regression smoothing and re-estimation of LEs for each community. As with females, adding the rurality term did not improve the model and the importance of the effect was not clear.

Between males and females within the same time points

The scale of effects (size of coefficients) cannot be compared across the time points because the scales of deprivation measures are not consistent. Comparing females and males within the same time points , the effects of both material and social deprivation seems to be greater for males than females for both Time 1 (Males—Material: coefficient: -0.6601; 95%CI [-0.9555, -0.3823], Social: coefficient: -0.7853: 95%CI [-1.027, -0.2499], Females—Material: coefficient: -0.2801; 95%CI [-0.505, -0.05104], Social: coefficient: -0.5167; 95%CI [-0.7288,

-0.2956], respectively) and Time 2 (Males—Material: coefficient: -0.641; 95%CI [-0.9101, -0.3627], Social: coefficient: -0.7601; 95%CI [-1.02, -0.4916], Females—Material: coefficient: -0.4428; 95%CI [-0.6749, -0.202], Social: coefficient: -0.5788; 95%CI [-0.8044, -0.3582], respectively). Being both materially and socially deprived had a significantly greater effect on men (coefficient: -0.4782; 95%CI [-0.7161, -0.2499]) than women (coefficient: -0.17; 90%CI [-0.3442, -0.0032]) at Time 1, but the effect was similar for men (coefficient: -0.2355; 95%CI [-0.4599, -0.01976]) and for women (coefficient: -0.2274; 95%CI [-0.4261, -0.03084]) at Time 2.

It also appears that social deprivation has a greater magnitude of effect on LEs than material deprivation for both females and males, meaning that one unit increase in the social deprivation score reduces LEs by a greater number (of years) than the same unit increase in material deprivation. However, the difference in magnitudes between the two domains was relatively narrower for males (coefficients for material deprivation: 0.66 and social deprivation: 0.78 for Time 1, 0.64 and 0.76 for Time 2) than females (0.28 and 0.52 for Time 1, 0.44 and 0.58 for Time 2, respectively) for both time points[14]. Moreover, the scores of material and social deprivation have different ranges, and the nominal values cannot be directly compared.

[14] Regression models with six individual variables used in the deprivation indices were also run (Appendix D) but the results are not shown here. Only variables that are, in classical statistical term, significant—that the parameter inference at 90% level did not cross 0—were proportion of single parents for female at Time 1, less than high school and single parents for male at Time 1, and unemployment and single parents for male at Time 2.

Table 5-6-a. Model Comparison-Females Note: Lowest DIC shows the best fit

[shaded]: Model used for regression smoothing for life expectancy mapping/ "*" =90% credible intervals. Otherwise 95%

Females						
Time 1						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	80.38	80.38	80.38	80.36	80.39	80.39
	(80.18, 80.61)	(80.17, 80.61)	(80.18, 80.59)	(80.15, 80.57)	(80.17, 80.6)	(80.06, 80.71)
Material		-0.3409		-0.2596	-0.2801	-0.259
		(-0.569, -0.0738)		(-0.4788, -0.05705)	(-0.505, -0.05104)	(-0.4798, -0.0281)*
Social			-0.5091	-0.4609	-0.5167	-0.5246
			(-0.716, -0.2926)	(-0.6707, -0.2283)	(-0.7288, -0.2956)	(-0.8183, -0.2673)
Mat*Soc					-0.17	-0.1577
					(-0.3442, -0.0032)*	(-0.3313, 0.0221)*
Popperrd						0.000498
						(-0.00425, 0.00587)*
Spatially structured variance	0.07716	0.1454	0.1568	0.05658	0.08475	0.07692
	(0.01374, 0.4419)	(0.01455, 0.8893)	(0.01461, 0.9428)	(0.0135, 0.3278)	(0.01404, 0.3089)	(0.01366, 0.3099)
Unstructured variance	1.504	0.9031	0.8573	0.9912	0.6362	1.185
	(0.5486, 1.721)	(0.01633, 1.654)	(0.0163, 1.6)	(0.01705, 1.596)	(0.01497, 1.569)	(0.01831, 1.602)
DIC	-823.867	-37126.500	-36747.400	-33010.100	**-51780.000**	-14207.800
Time 2						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	81.38	81.4	81.39	81.37	81.43	81.33
	(81.17, 81.6)	(81.17, 81.66)	(81.17, 81.58)	(81.14, 81.59)	(81.21, 81.66)	(80.99, 81.67)
Material		-0.5381		-0.4101	-0.4428	-0.3436
		(-0.7511, -0.2923)		(-0.6392, -0.1941)	(-0.6749, -0.202)	(-0.6245, -0.07098)
Social			-0.5691	-0.4886	-0.5788	-0.6514
			(-0.7824, -0.3272)	(-0.7098, -0.2388)	(-0.8044, -0.3582)	(-0.9481, -0.3885)
Mat*Soc					-0.2274	-0.2019
					(-0.4261, -0.03084)	(-0.3679, -0.02663)*
Popperrd						0.0026
						(-0.00234, 0.00769)*
Spatially structured variance	0.1267	0.1322	0.1764	0.0546	0.05965	0.05999
	(0.01369, 1.135)	(0.01456, 0.8949)	(0.01505, 0.8339)	(0.01337, 0.2098)	(0.01391, 0.2327)	(0.01343, 0.2288)
Unstructured variance	1.449	1.187	1.277	0.745	0.9335	1.097
	(0.0289, 1.855)	(0.02023, 1.72)	(0.02369, 1.723)	(0.01609, 1.655)	(0.01662, 1.65)	(0.01686, 1.662)
DIC	-10443.200	-25219.100	-12791.200	**-59960.200**	-36310.100	-29620.50

Table 5-6-b. Model Comparison-Males Note: Lowest DIC shows the best fit

(shaded): Model used for regression smoothing for life expectancy mapping/ "*" =at 90% credible intervals. Otherwise 95%

Males						
Time 1						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	74.07	74.08	74.06	74.05	74.13	74.2
	(73.86, 74.31)	(73.85, 74.32)	(73.87, 74.27)	(73.8, 74.28)	(73.92, 74.36)	(73.88, 74.55)
Material		-0.6966		-0.626	-0.6601	-0.6767
		(-1.015, -0.3615)		(-0.9103, -0.3336)	(-0.9555, -0.3823)	(-1.032, -0.2582)
Social			-0.7248	-0.6482	-0.7853	-0.7515
			(-0.982, -0.458)	(-0.8951, -0.354)	(-1.027, -0.2499)	(-1.085, -0.4624)
Mat*Soc					-0.4782	-0.4628
					(-0.7161, -0.2499)	(-0.6978, -0.2187)
Popperrd						-0.00104
						(-0.006858, 0.00476)*
Spatially structured variance	1.747	1.229	1.678	0.6669	0.6629	0.4112
	(0.9855, 2.501)	(0.0192, 2.308)	(0.9921, 2.253)	(0.0151, 1.919)	(0.018278, 1.612)	(0.01468, 1.849)
Unstructured variance	1.238	1.306	0.9142	1.037	0.8645	1.529
	(0.02082, 1.854)	(0.01833, 1.959)	(0.018, 1.625)	(0.01757, 1.881)	(0.0162, 1.744)	(0.1594, 1.86)
DIC	-8934.610	-27474.100	-21003.500	-38161.400	**-45315.600**	-1970.530
Time 2						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	75.81	75.81	75.77	75.77	75.85	75.64
	(75.55, 76.14)	(75.53, 76.1)	(75.51, 76.02)	(75.51, 76.02)	(75.6, 76.09)	(75.27, 76.03)
Material		-0.7826		-0.6011	-0.641	-0.4825
		(-1.072, -0.4799)		(-0.8718, -0.3361)	(-0.9101, -0.3627)	(-0.8122, -0.1736)
Social			-0.8196	-0.6621	-0.7601	-0.8812
			(-1.085, -0.5693)	(-0.9295, -0.3846)	(-1.02, -0.4916)	(-1.238, -0.5666)
Mat*Soc					-0.2355	-0.1984
					(-0.4599, -0.01976)	(-0.396, 0.01386)*
Popperrd						0.004775
						(-0.0006, 0.01082)*
Spatially structured variance	0.1333	0.1036	0.2004	0.05779	0.0726	0.06336
	(0.014, 0.5775)	(0.01439, 0.6793)	(0.01487, 1.218)	(0.01323, 0.2205)	(0.01389, 0.3532)	(0.01342, 0.2812)
Unstructured variance	2.037	0.9617	0.9189	1.475	0.8808	1.417
	(1.823, 2.27)	(0.01597, 2.055)	(0.01595, 2.016)	(0.02022, 1.962)	(0.01534, 1.92)	(0.01832, 1.951)
DIC	-254.824	-75625.900	**-78110.200**	-18028.100	-71135.600	-23512.600

5.5. Distribution of Life Expectancy at Birth—Post-Regression Modeling

5.5.1. LE by Community Type

Average LEs post-regression modeling by community are shown on Table 5-7. In the same manner as Table 5-5 showing pre-regression average LE by community type, the lowest average LE for each gender and time point was shaded in pale orange, and the highest average LE was shaded in pale green. As in the pre-regression distribution of LEs by community type, there are no apparent patterns as to what type of communities tend to have clearly higher or lower LEs, nor is there a clear gradient along the urban (metro & big town)-rural (sparse settlement) continuum. The gap between the highest and lowest average LEs has generally shrunk after regression smoothing. Respectively, the gap for females was 0.57 at Time 1, and 0.76 at Time 2, for males 0.99 at Time 1 and 0.52 at Time 2.

Table 5-7. Distribution of Average LE by Community Type—Post-Regression

	Metro & big town (35)	Metro fringe and mid-size town (40)	Small town (45)	Village (16)	Sparse settlement (46)
Life expectancy average (CI)					
Females					
Time 1	80.07 (79.64, 80.49)	80.53 (80.22, 80.84)	80.64 (80.41, 80.87)	80.52 (80.12, 80.91)	80.28 (80.04, 80.52)
Time 2	81.23 (80.73, 81.72)	81.82 (81.47, 82.17)	81.40 (81.12, 81.69)	81.06 (80.39, 81.74)	81.32 (80.98, 81.66)
Males					
Time 1	73.69 (72.85, 74.53)	74.50(74.17, 74.83)	74.12 (73.72, 74.52)	74.68 (74.05, 75.31)	73.79 (73.35, 74.23)
Time 2	75.59 (74.91, 76.27)	76.11 (75.60, 76.63)	75.90 (75.52, 76.29)	75.88 (75.23, 76.53)	75.64 (75.27, 76.01)

5.5.2. Spatial Distribution of LEs

After regression smoothing, many communities which showed more than 3 years below or above average LEs in the pre-regression maps have disappeared (See Maps 5-4-T1-a, b & 5-4-T2-a, b). Some communities showing 1 to 3 years below or above average LEs have also turned to the 'normal' range where the difference is only 1 year or less. Still, there remain some areas of high or low LEs.

Time 1

For females (Map 5-4-T1-a), some clusters of relatively high LEs remained, namely around Kings County and Antigonish County. Metro fringe areas can also be characterized by relatively high LEs. Many of the low LE communities in Cape Breton also remained low after regression modeling. However, through the regression model, LEs of the majority (130) of the 182 communities were now estimated to be within 1 year of the provincial average for females, leaving a smaller number of communities with substantially below or above average LEs. For males (Map 5-4-T1-b), still a little less than half of the communities (84) were estimated to be substantially below or above average LEs, with the rest (98) within 1 year of the provincial average for males. The Annapolis, Kings, Lunenburg, and Queens Counties to the west of Halifax Metro, again, seem to have higher LE statuses in general than the rest of the province. The rural end of Halifax County, Guysborough County, Digby County, Cumberland-Colchester border, and the Cape Breton region, still had a few communities with low LEs.

Time 2

For females (Map 5-4-T2-a), communities with low LEs tend to be clustered more in the west side than the east side of the province, though relatively high LE communities are also distributed right across the province from west to east. The central region of the province—Halifax metro, the fringe of metro (which overall seems to have higher LEs than metro communities), and surrounding communities seem to have normal to relatively higher LEs overall, while the further away from the metro, the more communities with low LEs are seen. For males (Map 5-4-T2-b), lower LE communities are generally, though not all, located in peripheral areas of the province, and higher LE communities tend to be around Halifax metro, in addition to some in Kings and Antigonish Counties. For both females and males, a few communities in Metro—i.e., Halifax Needham, Spryfield, Northend Dartmouth, and Preston—tend to show lower LEs. Moreover, compared with Time 1, there are slightly fewer communities with LEs that are within the 1-year range of the provincial average for both females (115) and males (95).

5.5.3. Outliers

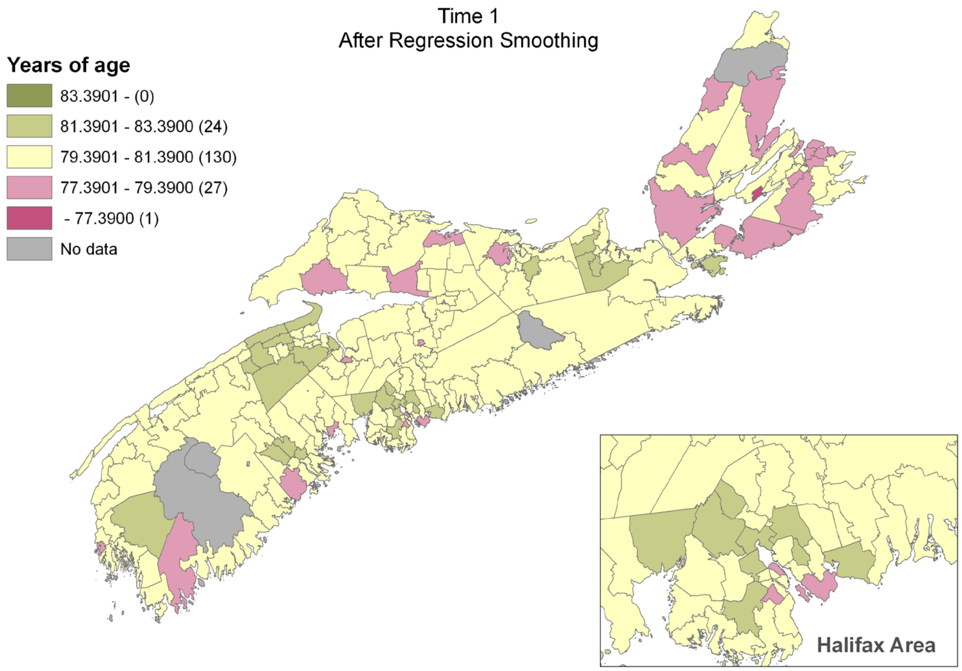
After regression smoothing, the LEs of four communities remained over 4 years lower compared with the Nova Scotia average (Table 5-8). There were no community clusters that exceeded 4 years above the Nova Scotia average LEs.

Table 5-8. Outlier Communities

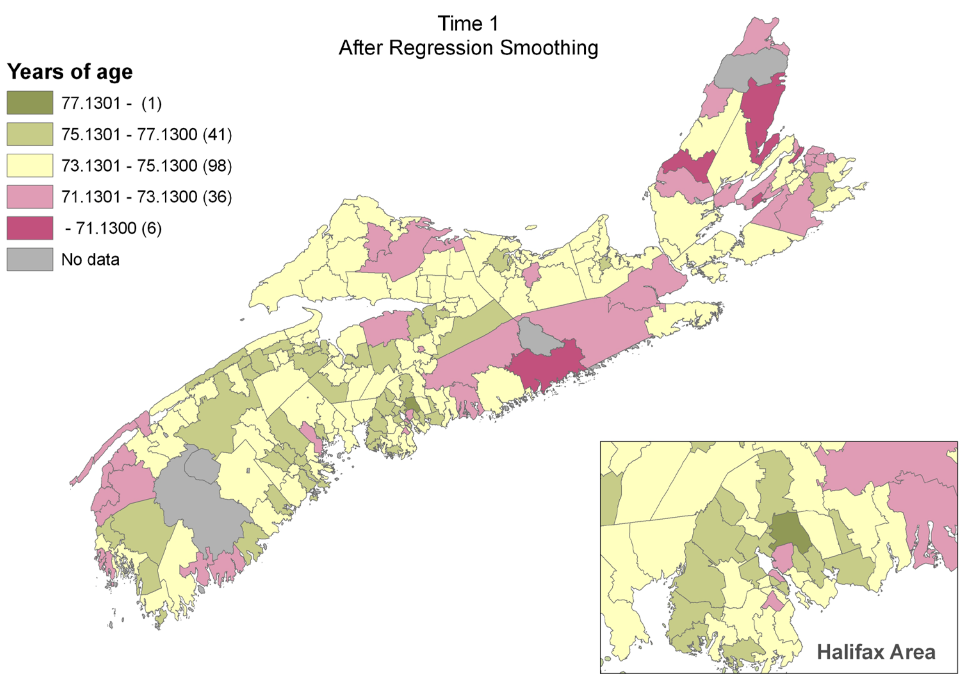
Females LE	After regression	Male LE	After regression
Time 1			
• Eskasoni IR 3 (75.82)	76.28	• Eskasoni IR 3 (61.65)	63.71
		• Englishtown/Ingonish (66.19)	68.09
		• Inverness (69.4)	70.13
Time 2			
• Eskasoni IR 3 (72.11)	74.56	• Eskasoni IR 3 (67.26)	69.14
		• Indian Brook IR 14/Millbrook IR 27 (70.63)	71.42

The outlier communities are the three communities designated as census Indian Reserves (Eskasoni IR 3, Indian Brook IR 14/Millbrook IR 27), and two communities in Victoria and Inverness Counties in Cape Breton (Englishtown/Ingonish and Inverness). These are not the communities with denominator sizes below 5,000, and the instability of the calculation is unlikely the sole reason for the extreme values. If there are an extremely small number of death counts, it can lead to unusually high LEs. However, none of the outliers are in the higher end of the tails. Therefore, there are likely to be some risk factors producing the low health outcomes in the communities that call for attention. In fact, both Eskasoni IR 3 and Indian Brook IR 14/Millbrook IR 27 were in the highest decile deprivation groups for both material and social domains. English/Ingonish was in the highest decile group in material deprivation, the third decile in social deprivation, Inverness was in the fourth decile in material deprivation and the second decile of social deprivation.

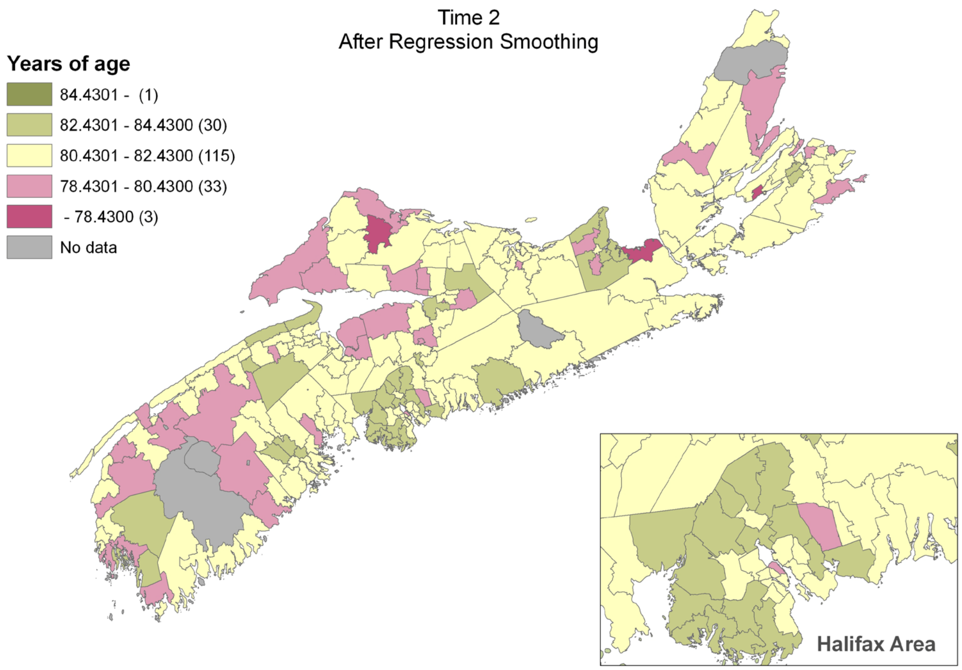
Map 5-4-T1-a. Life Expectancy at Birth - Females



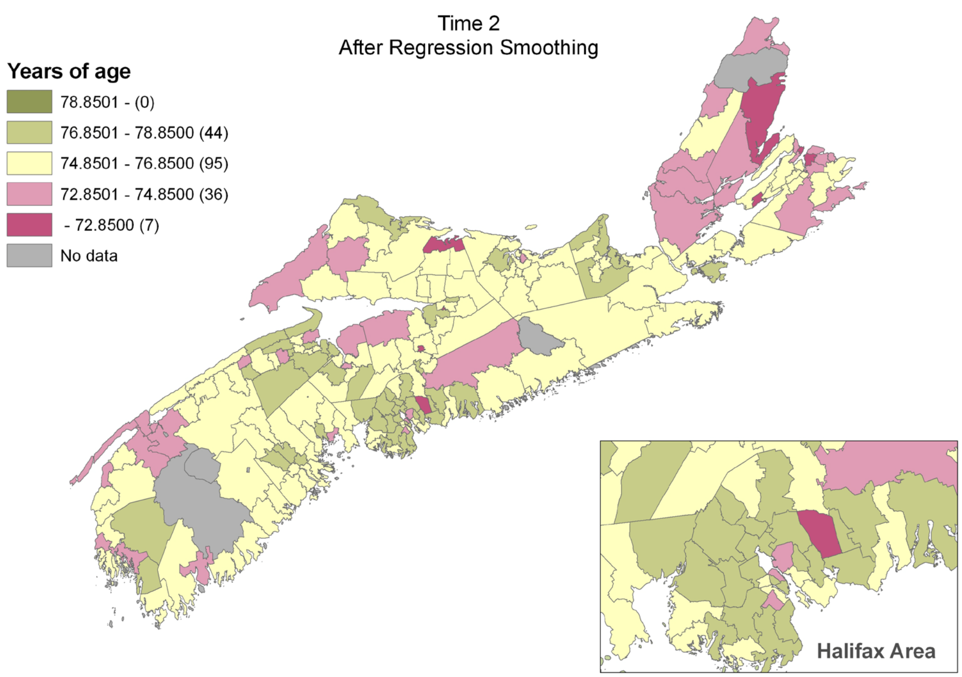
Maps 5-4-T1-b. Life Expectancy at Birth - Males



Map 5-4-T2-a. Life Expectancy at Birth - Females



Map 5-4-T2-b. Life Expectancy at Birth - Males



5.6. Time Trends of Deprivation and Life Expectancy at Birth

5.6.1. Inequality in LE by Deprivation—Has the Gap Widened?

Table 5-9 shows the gaps in LE in Nova Scotia (median), median LE in the least and most materially deprived decile classes before regression modeling, gaps between the least and most materially and socially deprived decile classes for each of the two time points before and after regression modeling, and how the gaps have widened (or reduced) over the time period before and after regression.

Females

Nova Scotia's median LE for females has grown by 1.27 years (80.49 to 81.76 years of age) over the study period. The gap between LEs of the least and most socially deprived communities by decile classification was about 1.8 years of age, about 0.5 years larger than the gap between the least and most materially deprived communities for females at Time 1. The relationship remained unchanged though the differences narrowed after regression smoothing. At Time 2, the gap of LEs for the top and bottom material deprivation groups was larger than that between the top and bottom social deprivation groups, but the relationship was reversed after regression smoothing. After the regression smoothing, the LE gap between the top and bottom material deprivation groups was reduced, while the LE gap widened for the top and bottom social deprivation groups. Overall, the gaps between the top and bottom deprivation groups—for both material and social accounts—widened over time. The growth in years of LEs for the least materially deprived group was about 4 times as high as that of the most materially deprived group, while the LE growth of the least socially deprived group was about 20% higher than that of the most socially deprived group.

Males

The provincial median LE for males has grown by 1.81 years over the study period—a somewhat larger growth than that of the female median LE—from 74.34 to 76.15 years of age. The LE gaps between the least and most deprived groups were notably larger for males than for females. At Time 1, the LE gap between the least and most materially deprived groups was close to 3 years of age, while the gap between the least and most socially deprived group was about 2.2 years of age. At Time 2, the LE gap between the least and most materially deprived group was over 4 years of age, while the gap for the top and bottom socially deprived groups was 1.6 years. Therefore, the gap between top and bottom social deprivation groups had narrowed by a little over half a year over time, while the gap between the top and bottom material deprivation groups had widened by nearly 1.5 years. Interestingly, the growth in median LE of the most socially deprived communities was higher (2.04) than that of the least socially deprived communities (1.45), which was the opposite of the pattern for females (1.13 for the least deprived versus 0.95 for the most deprived) and of the pattern with material deprivation (2.65 for the least deprived versus 1.20 for the most deprived). The sizes of the gaps were reduced after regression smoothing for both material and social deprivation, where the gap was still widening between the two points in the size of gap for material deprivation, while there was no change for social deprivation.

Figures 5-1 (-a to -d) give another look at the difference in LEs between top and bottom deciles in both domains of deprivation, as well as the difference with the Nova Scotia median. Figures 5-1-a and 5-1-b show patterns for females before and after regression smoothing, and 5-1-c and 5-1-d show patterns for males. Interestingly, the gaps between the most and least deprived groups—for both the material and social domains—are smaller for females than males. Beside the fact that regression smoothing generally reduced the gaps between the groups compared, the overall time trends remained the same. By the difference from the provincial median, for females, it appears that the advantage of the least deprived communities in LE remained unchanged, while the disadvantage of the most deprived communities worsened—though more clearly so by material deprivation than by social deprivation. On the other hand, the advantage of the least materially deprived communities for males seems to have strengthened, while the disadvantage of the most materially deprived communities appears stable after regression smoothing. The trend in gaps by social deprivation for males is somewhat unclear. For example, the gap between the most and least deprived communities, pre-regression, was smaller at Time 2, where the differences for both the most and least deprived groups from the median shrunk. However, post-regression adjustment resulted in a similarly wide gap to that of Time 1, with the advantage in LE of the least deprived communities being marginally stronger, and the disadvantage of the most deprived communities being marginally weaker than Time 1.

Table 5-9. Health Inequality by Deprivation and Its Temporal Variability Between the Two Time Periods

	LE Time 1 (1995-1999)	LE Time 2 (2003-2007)	Difference between Time 1 and 2
Females			
Nova Scotia	80.49	81.76	1.27
Decile 1 median (least materially deprived)	81.30	82.48	1.18
Decile 10 median (most materially deprived)	79.99	80.29	0.30
Decile 1 median (least socially deprived)	81.72	82.85	1.13
Decile 10 median (most socially deprived)	79.93	80.88	0.95
Difference between least and most materially deprived	1.31	2.19	+0.88
Difference between least and most socially deprived	1.79	1.97	+0.18
Difference between least and most materially deprived after regression (in years)	1.37	2.00	+0.63
Difference between least and most socially deprived after regression (in years)	1.77	2.10	+0.33
Males			
Nova Scotia	74.34	76.15	1.81
Decile 1 median (least materially deprived)	75.54	78.19	2.65
Decile 10 median (most materially deprived)	72.64	73.84	1.20
Decile 1 median (least socially deprived)	75.38	76.83	1.45
Decile 10 median (most socially deprived)	73.19	75.23	2.04
Difference between least and most materially deprived	2.90	4.35	+1.45
Difference between least and most socially deprived	2.19	1.60	-0.59
Difference between least and most materially deprived after regression (in years)	2.76	3.36	+0.60
Difference between least and most socially deprived after regression (in years)	2.46	2.46	0

Figure 5-1. Difference in LE from Nova Scotia Median-Females

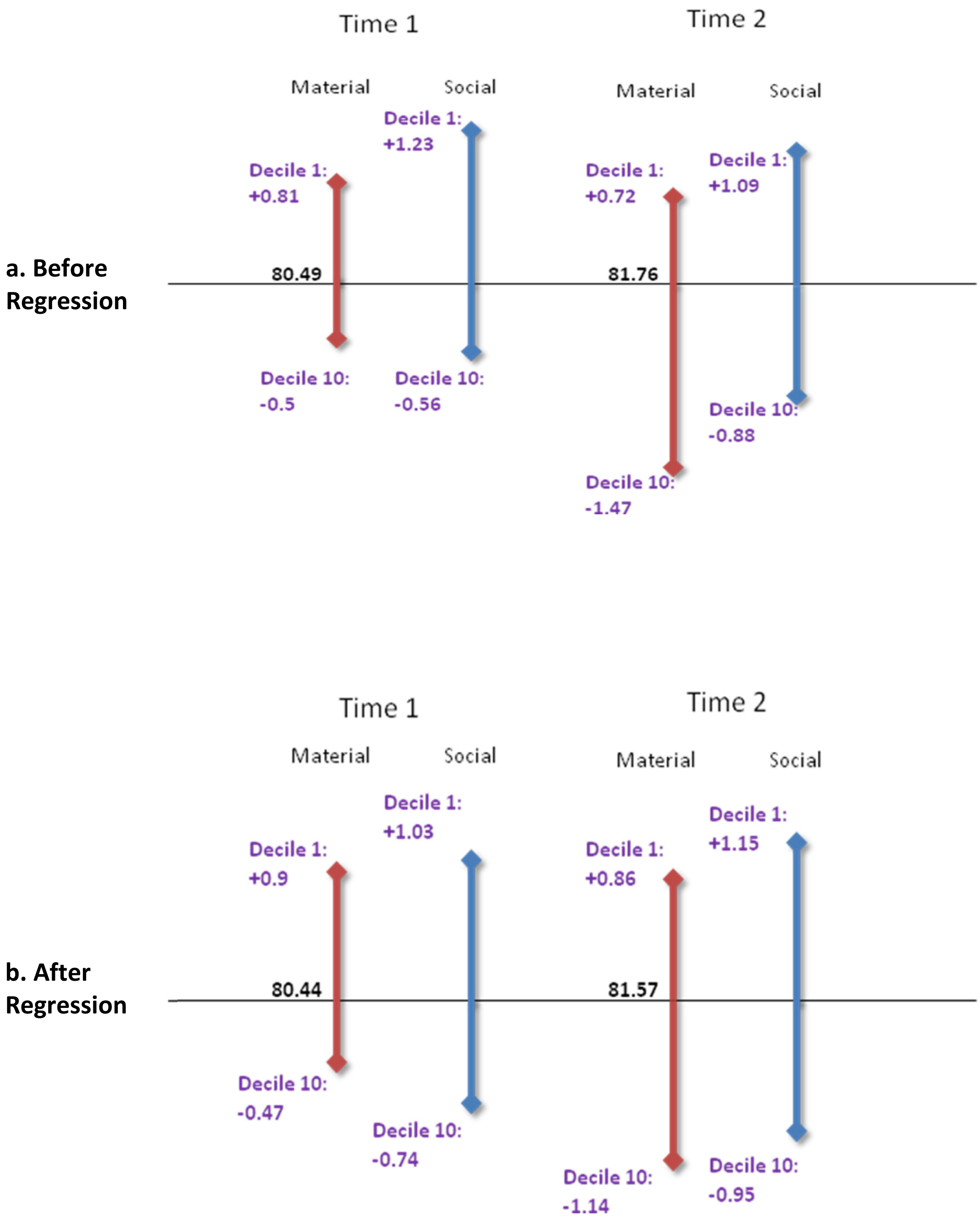
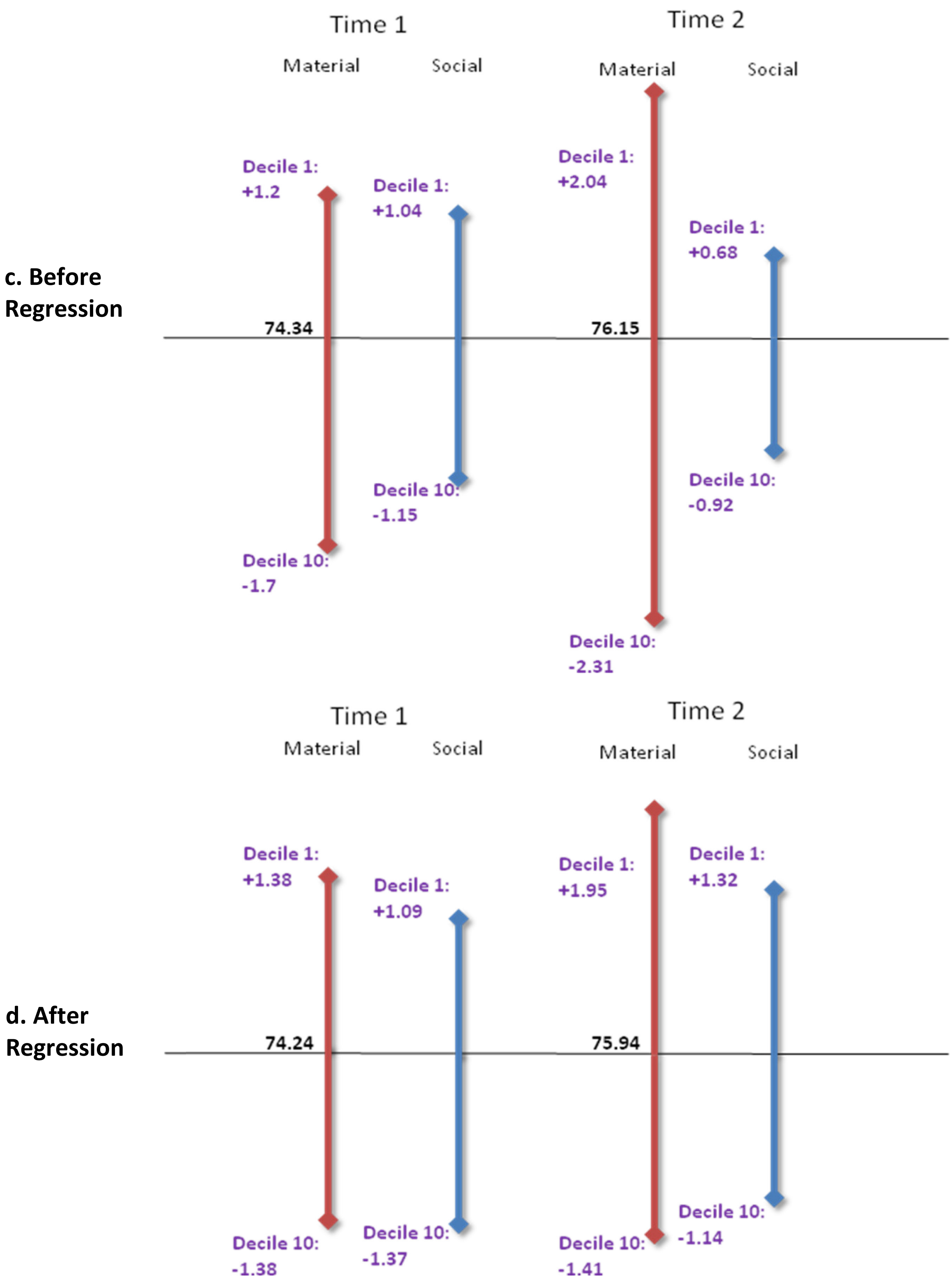


Figure 5-1. Difference in LE from Nova Scotia Median—Males

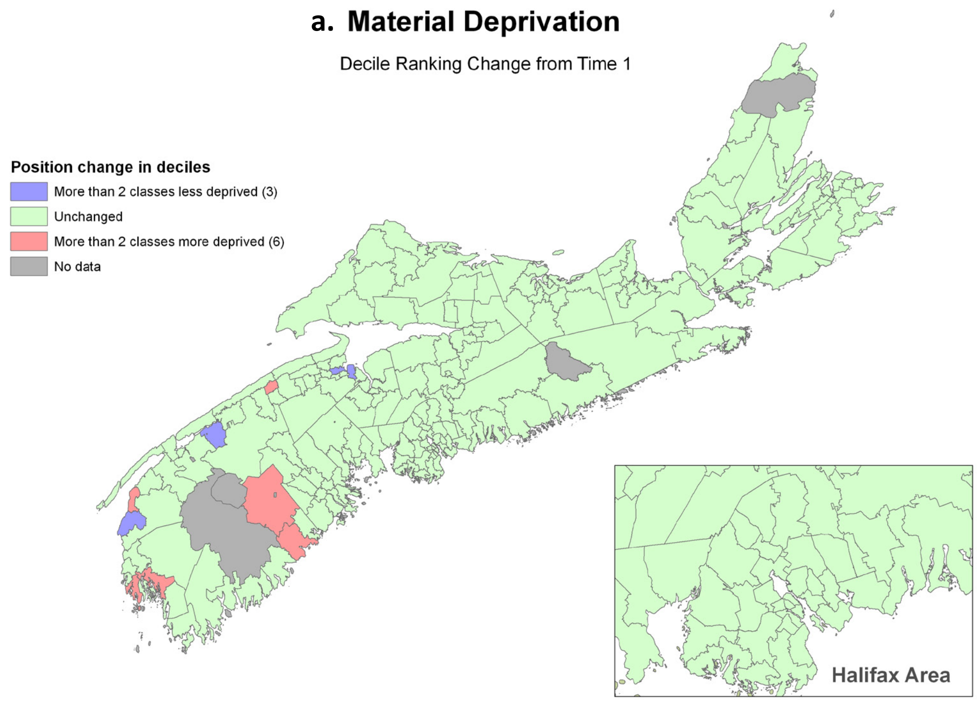


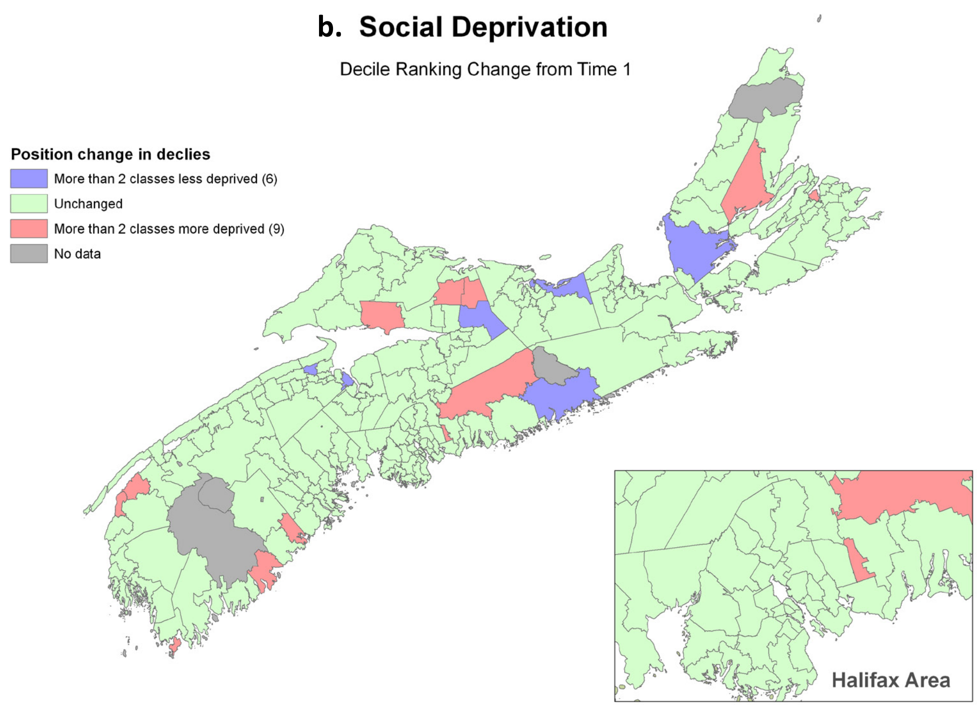
5.6.2. Changes in Deprivation Over 10 Years

The literature indicates that levels of relative deprivation do not change for a relatively long period of time (Shaw, Davey Smith, & Dorling, 2006, Singh & Siahpush, 2006, Auger, et al., 2010). This seems to mostly be the case in this study where the two time points at which deprivation was measured were 10 years apart. Indeed, the two deprivation scores between the two time periods were highly correlated (Pearson correlation coefficient was 0.93 for material deprivation and 0.92 for social deprivation, respectively). However, a few communities have 'moved up' or 'moved down' the community level positions of deprivation. Maps 5-5-a &-b show the communities whose decile class of material and social deprivation ranking changed by more than 2.

Blue areas are communities whose deprivation class became lower by more than 2, meaning that they became less deprived in comparison to the provincial average over the 10 years. Pink areas show the opposite trend; they became more deprived over the 10 years as their deprivation classes became higher by more than 2 deciles. The rest of the communities were unchanged. For material deprivation, both better-off (blue—Centreville, East Mountain, Hantsport, Little Harbour/Merigomish/Pictou Landing, Long Point/Glendale/Port Hood) and worse-off (pink—Annapolis Royal, Grand Pre/Port Williams, Metaghan) communities are located in the western half of the province. For social deprivation, both worse-off (Church Point/Saulnierville, Arcadia, Greenfield/North Queens, Kingston, Liverpool, Tusket/Argyle) and better-off (Baddeck, Cape Sable Island, Earltown/New Annan/Economy, Lake Echo, Medway/Port Mouton, Point Edward Peninsula, Upper Musquodoboit/Middle Musquodoboit, Weymouth) communities are broadly distributed. Only one community (Church Point/Saulnierville) experienced negative change (became more than 2 classes worse-off) in both domains of deprivation. It appears that those communities that experienced negative change are all small size towns to sparse settlements rather than metro & big towns or fringe & mid-size towns.

Map 5-5. Communities Whose Positions of Material (a) and Social (b) Deprivation Changed Between Time 1 and Time 2



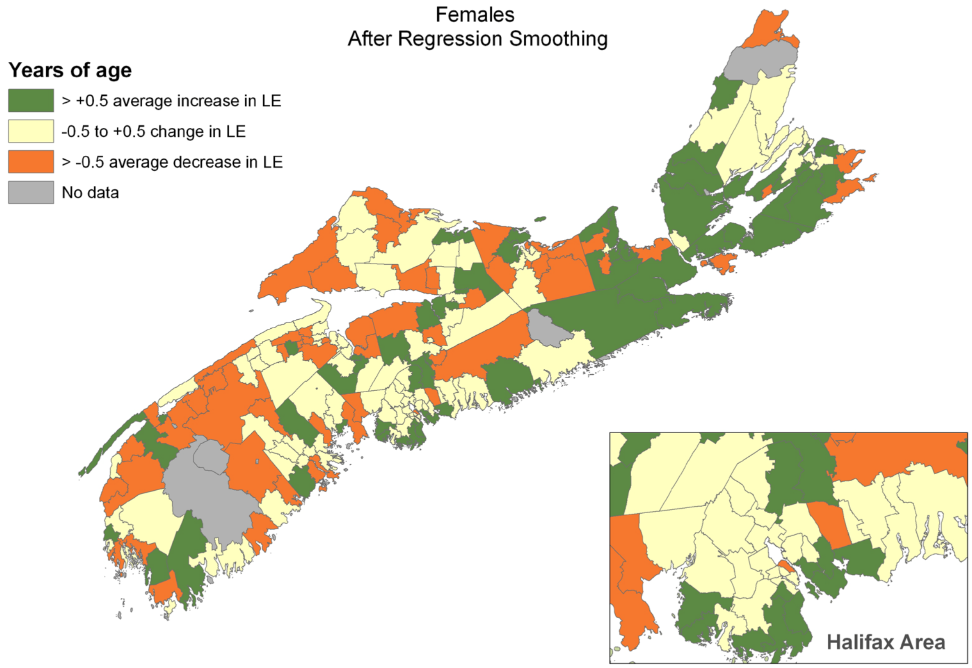


5.6.3. Distribution of LE Growth Over Study Period

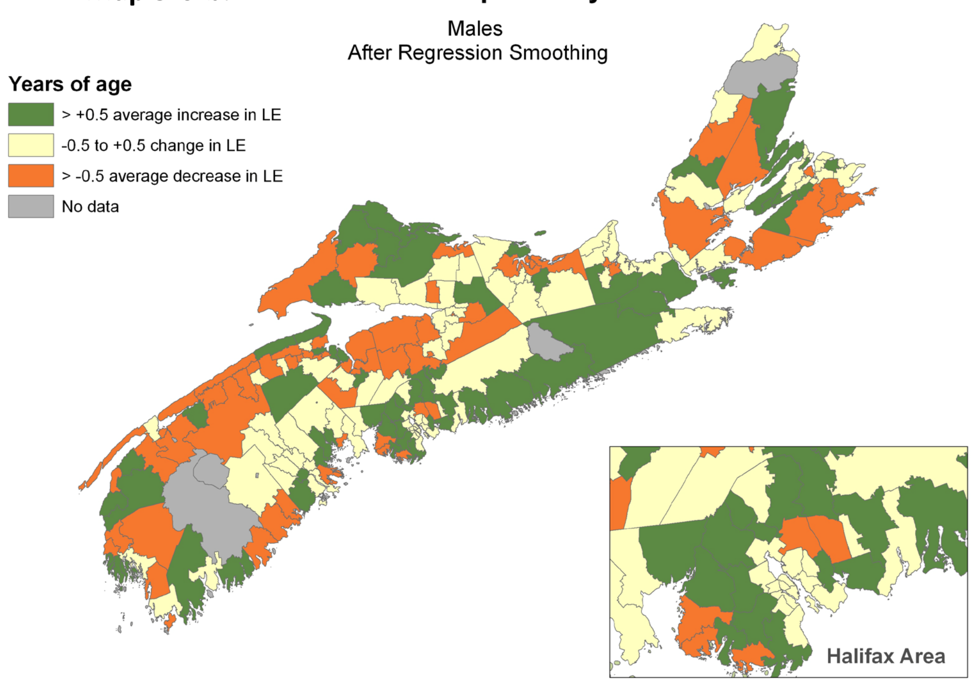
Is there a spatial pattern in communities which experienced substantially larger and smaller LE growths than the Nova Scotia average? The following maps (Maps 5-6-a & -b) show three classes of communities with growth in estimated LE which were: 1) more than 0.5 years above average (dark green), 2) more than 0.5 years below average (orange), and 3) within 0.5 of the average (pale yellow). The LEs are post-regression estimates. Growth in LE pre-regression is not shown.

It appears that, for females, communities with larger growth than average are more prominent in the northeastern part of the province, including Guysborough, Inverness, Richmond, and Cape Breton and Antigonish Counties, compared with the western part of the province. For males, it appears that communities with larger than average growth in LE are distributed more evenly across the province, as are communities with smaller than average growth. Growth in Halifax metro tends to be about average for both females and males. Perhaps notable is that for males, there is a mix of communities in the Cape Breton region, some with low growths and some with high growths, while for females in this region, most communities had high growth in LE. There appears to be little patterning by different community types, as there was both higher and lower than average growth for small towns, villages and sparse settlements. However, mid to large size towns and metro and fringe communities seem to have, relatively uniformly, close to average growths.

Map 5-6-a. Growth in Life Expectancy at Birth



Map 5-6-b. Growth in Life Expectancy at Birth



When looking at the average LE growth by community type (Table 5-10), it appears that rural communities (especially small towns and villages) had considerably lower growth for females. However, for males, only village groups in rural communities had somewhat lower growth, while sparse settlements experienced one of the highest average growths, close to that of metro & big towns.

Table 5-10. Average Growth in LE by Community Type

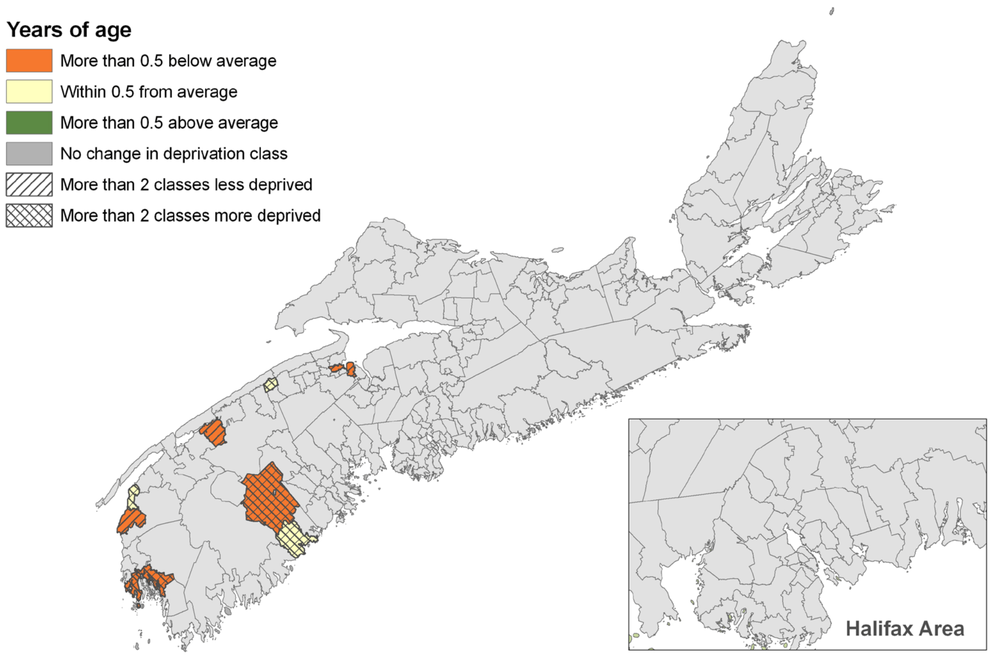
	Metro & big town (35)	Metro fringe & mid-size town (40)	Small town (45)	Village (16)	Sparse settlement (46)
Females	1.160	1.288	0.764	0.546	1.041
	(0.882, 1.438)	(0.958, 1.617)	(0.486, 1.042)	(-0.238, 1.330)	(1.190, 1.371)
Males	1.902	1.618	1.784	1.202	1.849
	(10608, 2.196)	(1.225, 2.010)	(1.440, 2.127)	(0.744, 1.661)	(1.480, 2.129)

5.6.4. LE Growth and Change in Relative Deprivation

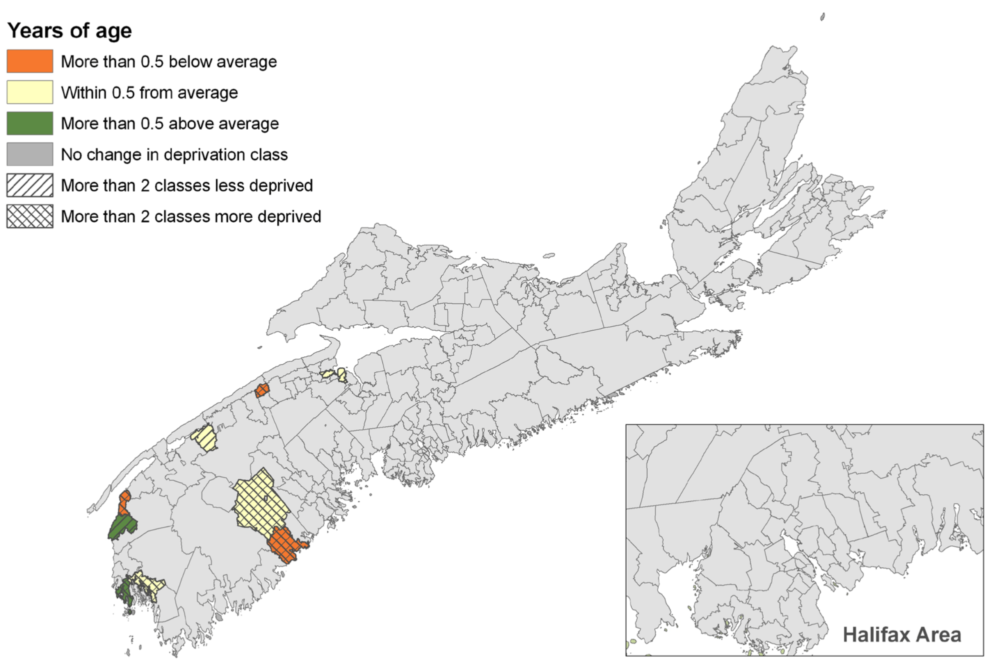
Did the communities experiencing change in deprivation status become worse-off or better-off in health according to their changes? Maps 5-7 (-a to -d) show the levels of LE growths, for females and males respectively, for the communities which experienced more than 2 deciles of class change in deprivation over the 10 years. The stripe pattern shows the communities which became more than 2 classes less deprived (became better-off), and the grid pattern shows those which became more than 2 classes more deprived (became worse-off). Communities in grey experienced 2 or less classes of change in deprivation. As in the previous maps (Maps 5-6-a & -b) showing the LE growths, dark green shows the communities whose LE growth between Time 1 and Time 2 was more than 0.5 years above the Nova Scotia average, and orange shows those with growth that was more than 0.5 years below average.

The names of the communities experiencing change in deprivation status and the growth in LE for these communities are shown in APPENDIX E. For females, only one of the materially or socially better or worse-off communities experienced higher than average LE growth. The one community experiencing higher than average LE growth was one of the materially worse-off communities. Two of the three materially better-off communities had negative growth in LE (while one of the materially worse-off communities also did), and two of the six socially better-off and one of the nine socially worse-off communities also had negative growth in LE. One of the materially worse-off communities and one of the socially worse-off communities experienced LE growth similar to the provincial average, and the LE growths of the rest of the communities was below the provincial average. For males, the results are similar. However, all three materially better-off communities achieved average to above average LE growth, and two of the six materially worse-off communities had average to above average LE growth. But one of the nine socially worse-off communities had LE growth which was below average, while five of six better-off communities experienced below average LE growth. Overall, changes in deprivation classes did not reflect in the patterns of their LE growth.

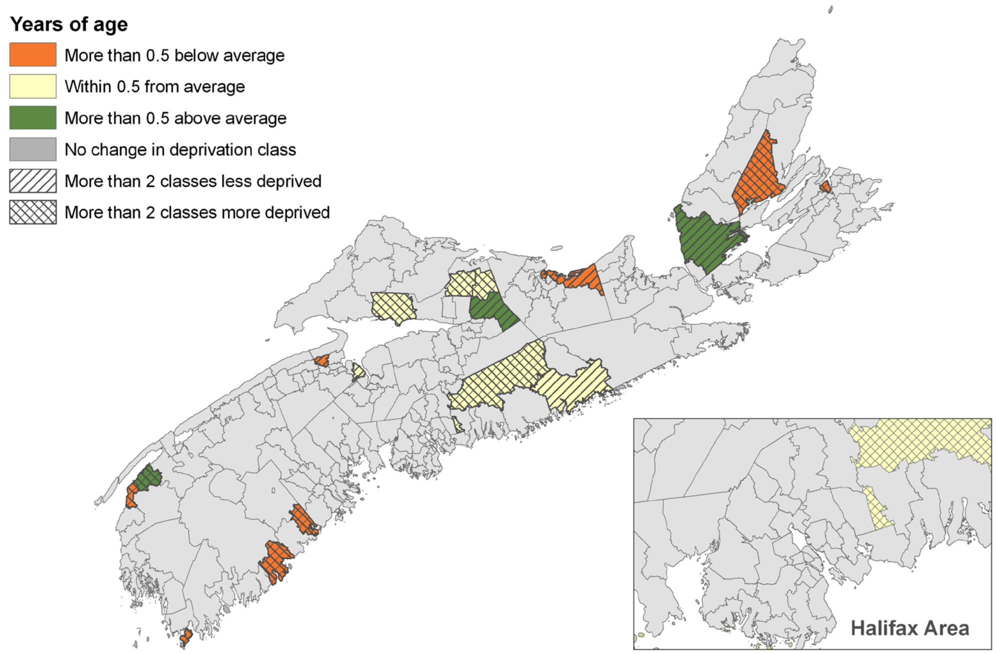
Map 5-7-a. LE Growth and Material Deprivation-Females



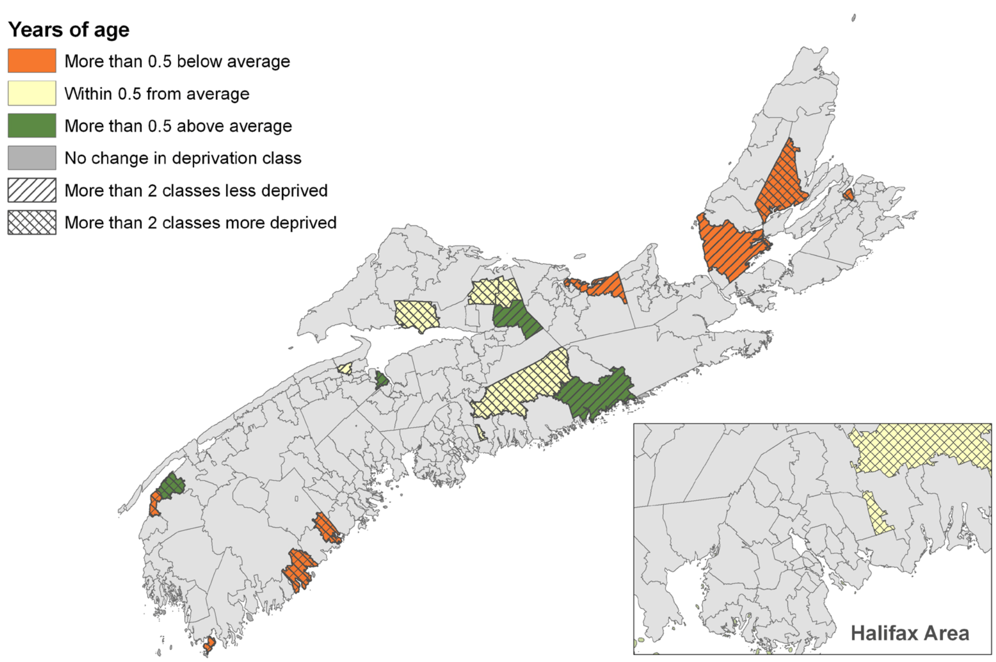
Map 5-7-b. LE Growth and Material Deprivation-Males



Map 5-7-c. LE Growth and Social Deprivation-Females



Map 5-7-d. LE Growth and Social Deprivation-Males



5.7. Unknown Effects

5.7.1. Spatial Distribution of Spatially Correlated and Uncorrelated Residuals

A series of maps below (Maps 5-8-1-a,b,c, to 5-8-4-a,b,c) show how the random effect components in the final regression model are spatially distributed. These random effect components are distinguished into two types: 1) spatially correlated; 2) spatially uncorrelated. Spatially correlated random effect shows to what extent the overall variances unaccounted for by material and social deprivation and their interaction are attributable to 'geographical autocorrelation.' Thus, in the context of this study, a community being similar in health status to nearby communities is considered as a spatial phenomenon, though what kind of likeness is producing similar health status obviously requires investigation. The spatially uncorrelated component shows what is left unaccounted for in the form of residuals in each community.

Mapping the leftover residuals should show—if the spatial inequality in health is sufficiently explained by the explanatory variables employed—no pattern (or random patterns) in distribution. The first (a) of the set of three maps shows the total residuals, showing the spatial distribution of all that was unexplained by the two domains of deprivation and their interaction effect. The second (b) is residuals explained by spatial autocorrelation, it thus shows the clustering in certain values of residuals. It should be noted that communities with no adjacent communities have no value attributed to spatial autocorrelation—these are Dingwall, Boularderie Island, Isle Madame, and Cape Sable Island. The third (c) shows the distribution of what is left unaccounted for after spatial autocorrelation is 'explained away.' The variance ratios of spatially structured random effect to unstructured random effect are, except for males at Time 1 (0.766), small (Females Time 1: 0.133, Females Time 2: 0.064, Males Time 2: 0.082), meaning that unstructured random effects dominate the unexplained variation[15].

Females

Map (a) shows the distribution of overall residuals. The Cape Breton region has a concentration of negative clusters, indicating that there is something else unique to that region contributing to lowering life expectancy that could not be explained by material and social deprivation. However, the concentration of negative residuals is not present for Time 2. Halifax metro and fringe areas have a mix of communities with relatively high positive and negative residuals. There is a clear cluster of spatially correlated negative residuals (b) by region, or even by counties, such as Cape Breton (Inverness, Victoria, Cape Breton and Richmond Counties), and a cluster of spatially correlated positive residuals in the Annapolis Valley (Kings and Annapolis Counties) and Digby County for Time 1. Spatially correlated positive residuals are located in the western tip of the province, namely, Digby, Yarmouth, and Shelburne Counties. Neither spatially correlated positive or negative residuals are present in the metro area for either time points. Likewise, spatially correlated negative residuals are present in the Cape Breton region for Time 2. The remaining residuals maps (c) show that there is still a cluster of positive residuals in the Kings County area for Time 1 and Time 2, and in the northeastern part of the mainland, the Guysborough and Antigonish County areas for Time 2. Negative residuals appear to be distributed fairly randomly for both Time 1 and Time 2.

---

[15] A similar example analysis is shown in Haining (2003). He states that diagnostics for this type of spatial models are still relatively crude and are "currently receiving attention" (p.376).

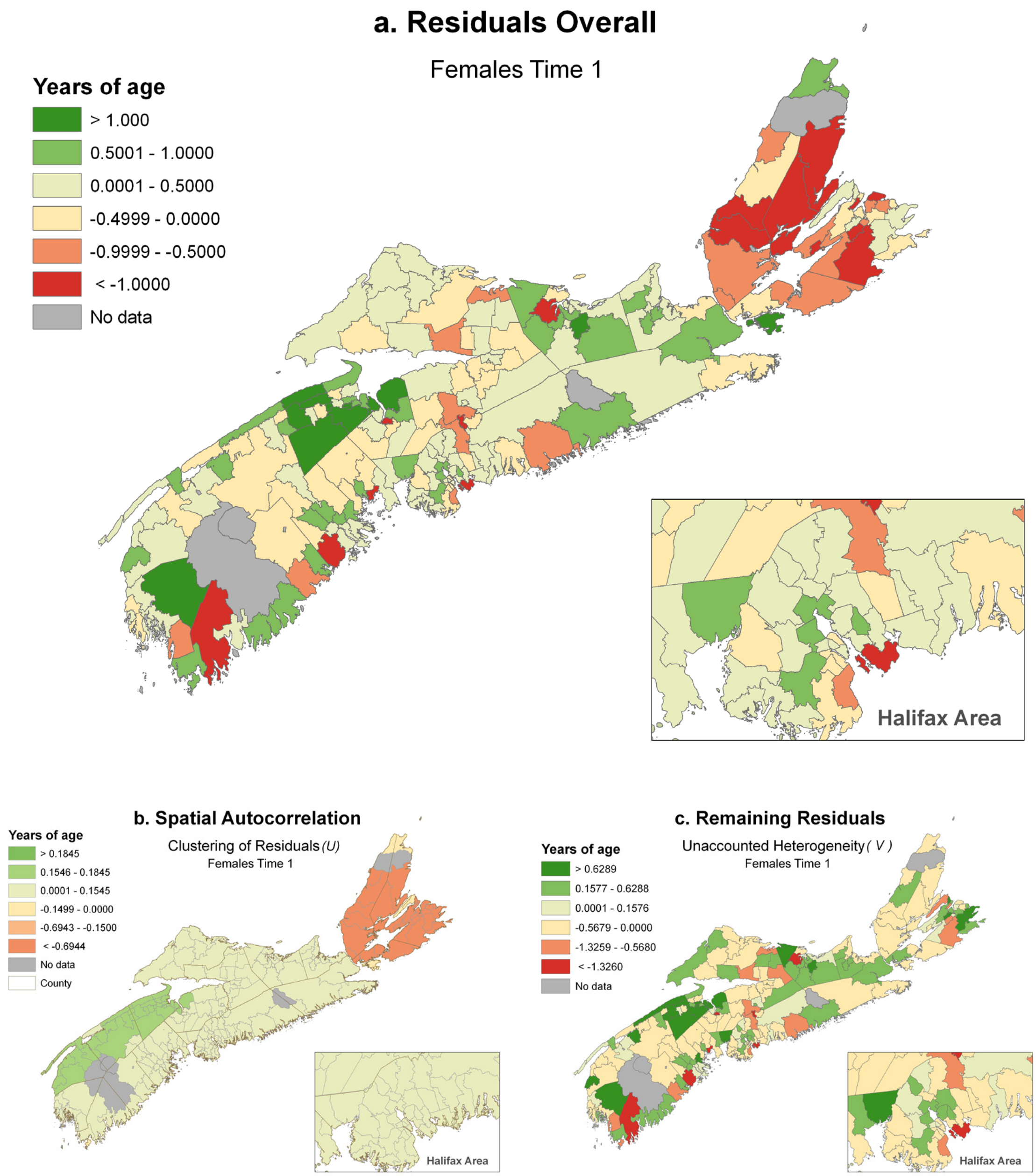
Males

There is a notable cluster of negative residuals in maps (a) for both Time 1 and Time 2, whereas some clusters of positive residuals are seen in the Annapolis Valley, the west side of Colchester, and Yarmouth County regions. The rural side of Halifax County and Guysborough County areas for Time 2 also seem to have a cluster of positive residuals. These patterns are considerably, though not altogether, reflective of the spatially correlated residuals. There is a notable cluster of spatially correlated negative residuals in the Cape Breton region for both Time 1 and Time 2. Other clusters of spatially correlated positive residuals are present in the Hants, east of Colchester, and Kings and Annapolis Counties for Time 1, and in the southeastern half of the province including the Digby, Yarmouth, Shelburne, Queens, Lunenburg, and Kings Counties for Time 2. Like females, spatially correlated negative or positive residuals are not present in the metro area, while there was still a mix of communities with relatively high negative and positive overall residuals. Again, the remaining residuals—after spatial autocorrelation is taken into account—are fairly randomly distributed for both time points, though the western and southwestern regions of the province appear to have a slightly higher concentration of positive residuals than the eastern and northeastern regions.

5.7.2. Residuals by Community Type

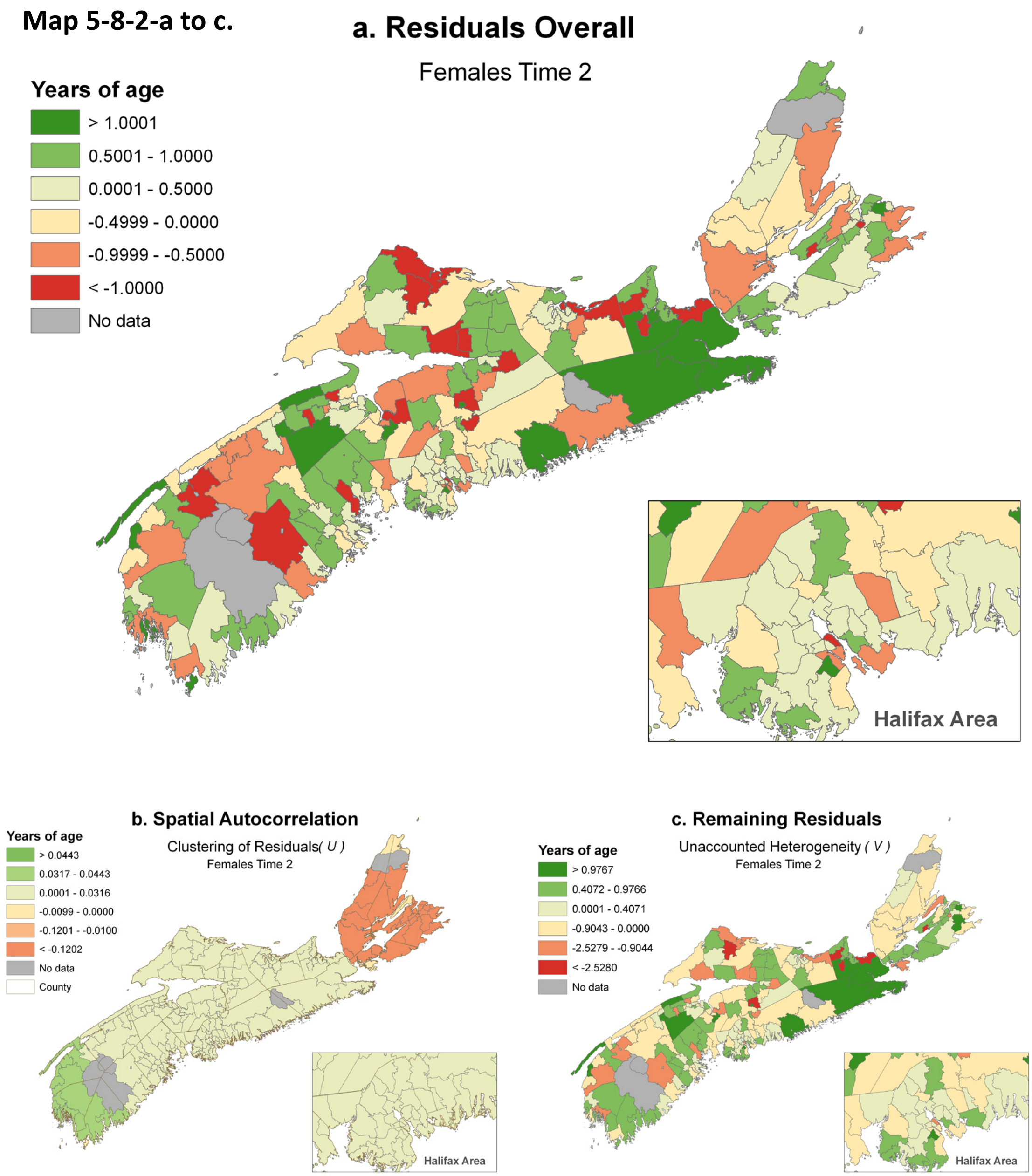
Table 5-11 shows the average overall residuals, spatially correlated residuals and remaining residuals and their confidence intervals (to show the spread) by five community types. Values greater than positive 0.1 were highlighted in blue, and those less than negative 0.1 (-0.1) were highlighted in yellow. Metro fringe & mid-size towns tend to have a large positive residual average, but not a large negative residual average. Sparse settlements tend to have neither, except for uncorrelated residuals for males at Time 2. Spatially correlated residuals tend to be high in metro fringe & and mid-size towns, small towns and villages (those not too urban nor too rural), except for females at Time 2 when the averages of all community types were small. Villages had a large negative average of uncorrelated residuals except for males at Time 1 when the average overall residual was positive and very high. Metro & big towns had large negative spatially correlated residuals except for females at Time 2, though this was also negative. However, the spreads of these values among the same types of communities were wide, and nearly all the confidence intervals included 0. Therefore, it is difficult to determine the patterns of residuals by community type. If there is a pattern, it is a weak one.

Map 5-8-1-a to c.



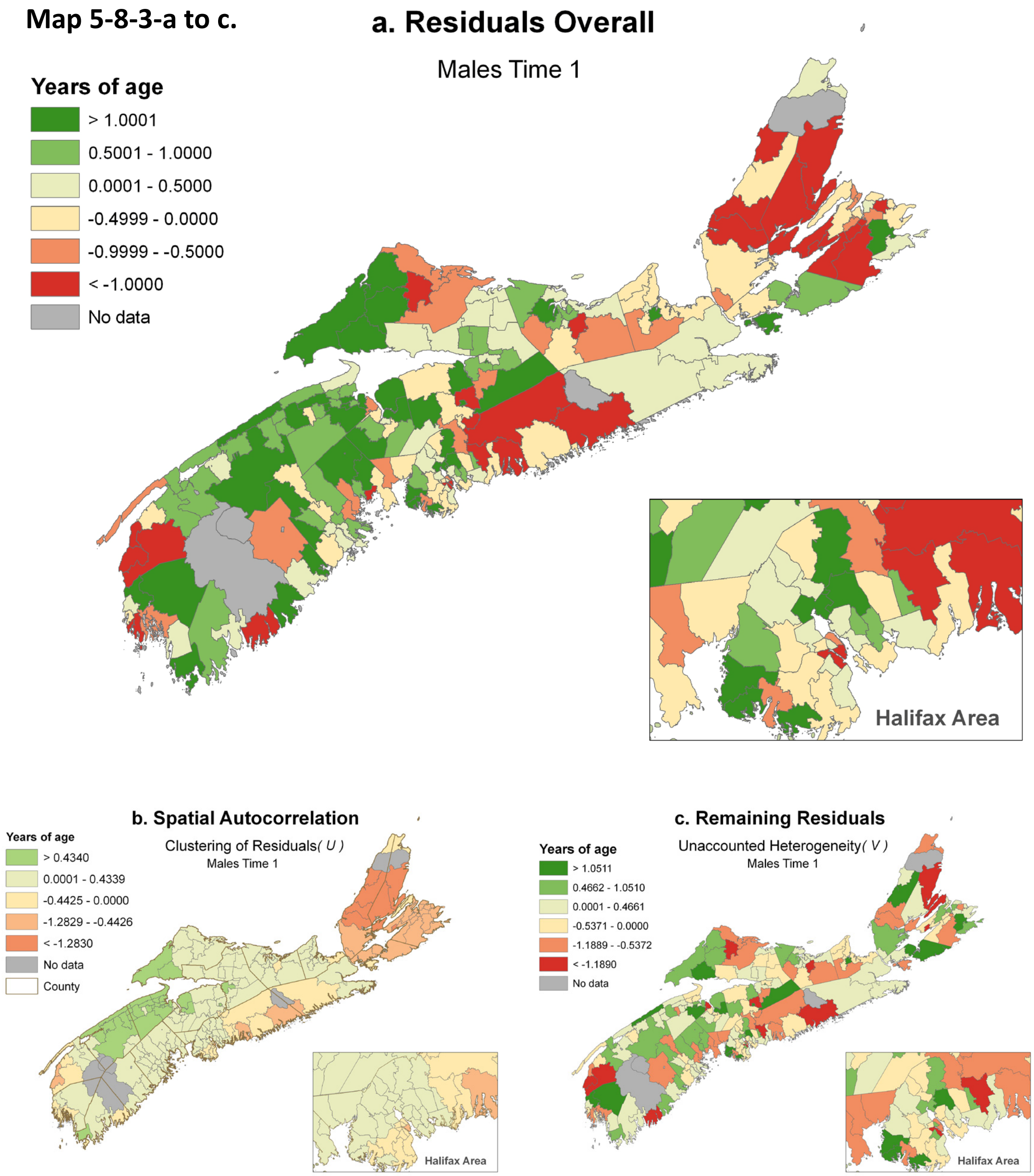
The variance ratio of random effects (spatially correlated/uncorrelated)=0.133

Map 5-8-2-a to c.

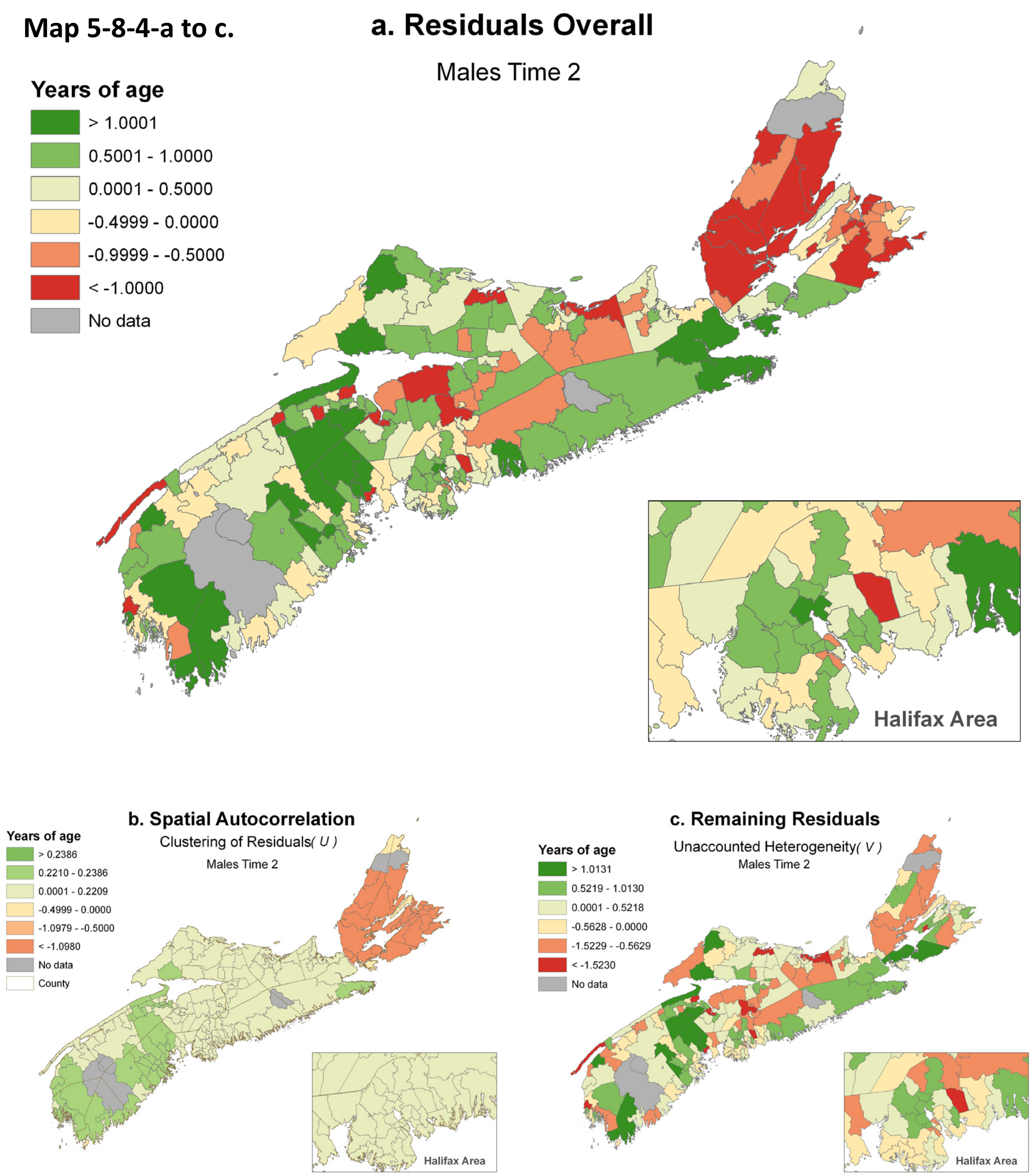


The variance ratio of random effects (spatially correlated/uncorrelated)=0.064

Map 5-8-3-a to c.



The variance ratio of random effects (spatially correlated/uncorrelated)=0.763



The variance ratio of random effects (spatially correlated/uncorrelated)=0.082

Table 5-11. Average Residuals by Community Type

	Metro & big town	Metro fringe & mid-size town	Small town	Village	Sparse settlement
Females					
Time1					
Residual total	-0.044 (-0.249, 0.161)	0.035 (-0.209, 0.279)	0.214 (0.037, 0.391)	0.024 (-0.400, 0.448)	-0.045 (-0.244, 0.155)
Spatially correlated residuals	-0.106 (-0.239, 0.027)	0.100 (-0.029, 0.229)	0.112 (-0.016, 0.239)	0.142 (-0.025, 0.309)	-0.035 (-0.140, 0.071)
Uncorrelated residuals	0.062 (-0.092, 0.216)	-0.065 (-0.293, 0.163)	0.103 (-0.059, 0.264)	-0.118 (-0.529, 0.293)	-0.010 (0.166, 0.146)
Time 2					
Residual total	0.022 (-0.267, 0.311)	0.300 (-0.055, 0.545)	-0.053 (-0.286, 0.179)	-0.417 (-1.100, 0.266)	0.075 (-0.212, 0.363)
Spatially correlated residuals	-0.019 (-0.044, 0.005)	0.060 (-0.042, 0.162)	0.076 (-0.024, 0.176)	0.076 (-0.057, 0.209)	-0.007 (-0.027, 0.012)
Uncorrelated residuals	0.041 (-0.243, 0.325)	0.240 (0.029, 0.452)	-0.129 (-0.371, 0.112)	-0.493(-1.160, 0.174)	0.082 (-0.204, 0.369)
Males					
Time 1					
Residual total	-0.187 (-0.557, 0.182)	0.226 (-0.073, 0.526)	0.0003 (-0.296, 0.297)	0.508 (0.043, 0.972)	-0.091 (-0.466, 0.285)
Spatially correlated residuals	-0.158 (-0.362, 0.046)	0.137 (-0.023, 0.298)	0.145 (-0.033, 0.323)	0.249 (0.046, 0.451)	-0.097 (-0.287, 0.093)
Uncorrelated residuals	-0.029 (-0.242, 0.184)	0.089 (-0.132, 0.310)	-0.145 (-0.363, 0.174)	0.259 (-0.160, 0.674)	0.006 (-0.261, 0.274)
Time 2					
Residual total	0.010 (-0.322, 0.341)	0.063 (-0.249, 0.376)	0.018 (-0.255, 0.291)	-0.017 (-0.506, 0.471)	0.076 (-0.261, 0.412)
Spatially correlated residuals	-0.160 (-0.368, 0.048)	0.128 (-0.033, 0.289)	0.127 (-0.033, 0.286)	0.181 (-0.029, 0.392)	-0.048 (-0.206, 0.114)
Uncorrelated residuals	0.170 (-0.043, 0.382)	-0.065 (-0.348, 0.219)	-0.109 (-0.336, 0.118)	-0.199 (-0.679, 0.281)	0.123 (-0.160, 0.423)

5.8. Relationships Between Deprivation and Health by Rurality

To examine the questions of whether the extent of influence of material and social deprivation differs between urban and rural communities, communities were stratified into two groups: 1) urban—metro & big town/metro fringe & mid-size town; and 2) rural—small town, village, and sparse settlement) and a regression model with a material deprivation score, a social deprivation score, interaction between the two, and an unaccounted effect was run for each group (a spatial autocorrelation term was excluded from Model 5 since the communities are not necessarily adjacent to each other). Tables 5-12-a & -b show the results of the comparisons. As in the earlier regression model comparison tables (Tables 5-6-a & -b), an asterisk shows that the credible intervals are shown at 90%.

Females

For Time 1, the average LE estimated for rural communities was somewhat higher (80.56) than the average LE for urban communities (80.26). Material deprivation was more strongly associated with LEs in urban communities (coefficient:-0.4061; 95%CI [-0.7584, -0.05759]), higher than all-community model (coefficient: -0.312; 95%CI [0.5135, -0.09415]). A strong association of material deprivation was not evidenced in the rural communities-only model (coefficient: -0.3711; 90%CI [-0.7598, 0.01002]). Credible intervals can be understood as those where there is a 95% (or 90% in some calculations in this analysis) probability that the coefficient estimated falls in the intervals. The influence of social deprivation was relatively similar for urban and rural communities (coefficient: -0.492; 95%CI [-0.8189, -0.1727], and coefficient: -0.4489; 90%CI [-8402, -0.0398] respectively). Only the all-community model had credible intervals for the interaction term that did not cross 0. Given the considerably higher unaccounted effects (residuals), health variation in rural communities appears to be explained the least by the two domains of deprivation measured universally across the province.

For Time 2, urban communities were estimated as having the highest LE (81.88). The effect of material deprivation was the strongest in the all-community model (coefficient: -0.4014; 95%CI [-0.6055, -0.1824]). Again, the rural community-only model had the largest unaccounted effect after taking into account material and social deprivation and their interaction. Material deprivation was not strongly associated with LE in rural communities (coefficient: -0.04371; 90%CI [-0.4187, 0.2882]). The effect of social deprivation was the highest in rural communities (coefficient: -0.8042; 95%CI [-1.289, -0.3076]). As in Time 1, the interaction term was only (borrowing the non-Bayesian statistical term) 'statistically significant' in the all-community model (coefficient: -0.2177; 95%CI [-0.4111, -0.0344]).

Males

For Time 1, the estimated average LE was the highest in urban communities (74.21), but the differences between this LE and those of all communities (74.2) and rural communities (74.15) were narrow. Comparing urban and rural communities, both material and social deprivation had somewhat stronger effects on rural communities (material: coefficient: -0.7156; 95%CI [-1.287, -0.1572], social: coefficient: -0.9505; 95%CI [-1.535, -0.3434]) than urban communities (material: coefficient: -0.6783; 95%CI [-1.084, -0.2382], social: coefficient: -0.8331; 95%CI [-1.205, -0.4658]). Unlike comparisons of the three models for females, in the case of males, the interaction term was the strongest and 'statistically significant' in rural communities, though credible intervals did cross 0 at the 95% level (but not at 90%) (coefficient: -0.6271, 90%CI [-1.183, -0.0403]).

For Time 2, estimated average LE was the highest in the all community-model (75.91), though the differences between it and the urban and rural community only models were small (LEs for these models were 75.84 and 75.75, respectively). Unlike Time 1, at which the influence of both material and social deprivation was stronger in rural communities, the influence of material deprivation was stronger in urban communities (coefficient: -0.8274; 95%CI [-1.262, -0.4226]); indeed the coefficient was over twice as high as that of rural communities (coefficient: -0.3831; 90%CI [-0.8037, -0.01332]) and substantially higher than all communities (coefficient: -0.6982; 95%CI [-0.9505, -0.4278]). The influence of social deprivation was strongest in rural communities (coefficient: -0.829; 95%CI [-1.432, -0.276]). The credible intervals of the interaction term did not cross 0 for the urban community only model, but did cross 0 for the rural community only model. For both Time 1 and Time 2, the unaccounted variance was substantially higher for the rural community only model than for the all community or urban community only models.

Table 5-12. Model Comparisons—Females (a) and Males (b), Stratified by Rurality (Urban or Rural in Comparison with All Communities)

"*" = 90% credible intervals. Otherwise 95%

a. Females	All communities (182)	Urban communities (75)	Rural communities (107)
Time 1			
Intercept	80.45 (80.24, 80.67)	80.26 (79.82, 80.7)	80.56 (80.19, 80.94)
Material Deprivation score	-0.312 (-0.5135, -0.09415)	-0.4061 (-0.7584, -0.05759)	-0.3711 (-0.7598, 0.01002)*
Social Deprivation score	-0.5619 (-0.7881, -0.325)	-0.492 (-0.8189, -0.1727)	-0.4489(-8402, -0.0398)*
Material*Social interaction	-0.2221(-0.4133, -0.02542)	-0.147 (-0.3608, 0.04477)*	-0.3768 (-0.817, 0.835)*
Variance-spatial autocorrelation	-	-	-
Variance-unaccounted effects	0.372 (0.01413, 1.547)	0.8154 (0.01666, 1.725)	1.023 (0.01843, 1.633)
DIC	-58575.000	-22279.200	-14761.400
Time 2			
Intercept	81.49 (81.27, 81.71)	81.88 (81.45, 82.31)	81.12 (80.74, 81.48)
Material Deprivation score	-0.4014 (-0.6055, -0.1824)	-0.2968 (-0.5676, -0.0318)*	-0.04371 (-0.4187, 0.2882)*
Social Deprivation score	-0.5913 (-0.6055, -0.1824)	-0.7597 (-1.081, -0.4441)	-0.8042 (-1.289, -0.3076)
Material*Social interaction	-0.2177 (-0.4111, -0.0344)	-0.3098 (-0.5133, 0.1009)*	-0.09523 (-0.4763, 0.2981)*
Variance-spatial autocorrelation	-	-	-
Variance-unaccounted effects	0.6687 (0.01479, 1.629)	0.5268 (0.01561, 1.478)	1.368 (0.02133, 1.829)
DIC	-58932.100	-17784.800	-5385.150

b. Males	All communities (182)	Urban communities (75)	Rural communities (107)
Time 1			
Intercept	74.2 (73.95, 74.44)	74.21 (73.68, 74.79)	74.15 (73.66, 74.6)
Material Deprivation score	-0.7166 (-0.953, -0.4658)	-0.6783 (-1.084, -0.2382)	-0.7156 (-1.287, -0.1572)
Social Deprivation score	-0.8494 (-1.117, -0.5653)	-0.8331 (-1.205, -0.4658)	-0.9505 (-1.535, -0.3434)
Material*Social interaction	-0.5462(-0.7731, -0.3263)	-0.5128 (-0.8199, -0.241)	-0.6271(-1.183, -0.0403)*
Variance-spatial autocorrelation	-	-	-
Variance-unaccounted effects	0.7893 (0.01468, 1.873)	0.6685 (0.01574, 1.833)	1.593 (0.02358, 2.096)
DIC	-72816.100	-31035.800	-6363.460
Time 2			
Intercept	75.91 (75.63, 76.18)	75.84(75.28, 76.41)	75.75(75.27, 76.19)
Material Deprivation score	-0.6982 (-0.9505, -0.4278)	-0.8274 (-1.262, -0.4226)	-0.3831 (-0.8037, -0.01332)*
Social Deprivation score	-0.8086 (-0.9505, -0521)	-0.791(-1.22, -0.3558)	-0.829 (-1.432, -0.276)
Material*Social interaction	-0.2653(-0.4912, -0.03076)	-0.241 (-0.4725, -0.00779)*	-0.2266 (-0.7054, 0.239)*
Variance-spatial autocorrelation	-	-	-
Variance-unaccounted effects	0.3705(0.01409, 1.92)	0.5937 (0.0155, 1.945)	1.606 (0.02164, 2.175)
DIC	-79916.500	-31922.000	-9219.320

Chapter 6. DISCUSSION

6.1. Returning to the Hypotheses—Social and Health Inequalities Across Communities

Hypothesis 1: Health and social inequalities (including temporal trends) have geographical patterns by geographical location or by community type, or both.

Inequalities in relative deprivation—both socioeconomic and social domains measured by the two indices—had some patterns both by community type (rurality) and by space. It is fairly clear that, in this study context, the material deprivation becomes more prominent as 'rurality' increases. However, social deprivation does not seem to reflect on levels of rurality. This is perhaps because of the variables included in the social deprivation index, which, as currently constructed, is a reflection of family structural isolation, rather than a broader indicator of social cohesion or support structures. Other than the most urban metro areas, communities did not exhibit distinctively high or low proportions of single parents, individuals living alone or separated/widowed/divorced. At least in Nova Scotia, which is small in size and populations in any community type still maintain relatively close proximity, there may be little difference in the level of isolation among non-urban, non-densely populated communities compared with some large provinces in which the distance between urban and remote communities as well as distance between any neighbouring communities are larger. As for temporal trends, the 10-year span was probably not sufficient in observing changing patterns in deprivation spatially or by community type.

Inequality in health measured by life expectancy at birth (LE) by relative position of deprivation for communities was clear, even though the growth in years of LE over the given short study period was not so large. There was also a considerable regional pattern, which was persistent after regression smoothing. For both Time 1 and Time 2, Cape Breton region was generally low in LE—particularly so for males—while the LE of areas including the Annapolis Valley, Antigonish, Queens and the west end of Halifax metro region were generally high. There was a mix of high and low LE communities within Halifax metro and its fringes, where communities that are socioeconomically more deprived than surrounding communities had lower than average LEs. Thus, population-based health and health service planning of the province might take into consideration the identified regions and communities with low health status plus high deprivation level as some of the program's priority areas.

There was no clear pattern in the extents of growth in LE for communities spatially or by community type. Neither was there a statistically significant difference in average LEs between rural and urban communities for either gender. The study did not find clear evidence that the temporal change in levels of deprivation led to certain levels of growth in LE given the time span observed. These results are likely, at least partially, due to the fact that the study did not observe the trends in both deprivation and LE for a long enough period. However, observation on LEs within each time point indicates that rurality itself is not a contributing factor for low health status, but rather the condition of deprivation is, and material deprivation tends to be concentrated in rural communities while social deprivation tends to be observed more in urban communities. As such, there would be no clear pattern in the extent of growth in LE by community type where substantial differences in deprivation are not present.

Hypothesis 2: *Both material and social deprivation as measured in this study affect the health status of the community as contextual risk conditions, and the effects differ by gender.*

As this is an ecological level study, it cannot tease out what proportion of the effect of observed health inequalities by the two domains of deprivation measured is attributed to compositions of individuals with the characteristics of deprivation, or to the 'true' contextual effect. As discussed earlier, however, neither the compositions of individuals are random phenomena, nor are they entirely separate from the production of contextual phenomena. Therefore, this study considers both composition and 'true' contextual factors present in communities together as 'contextual' risk conditions. In other words, there is an underlying condition that influences the concentration of certain individuals with certain socioeconomic or social conditions, while the compositions of individuals with these characteristics also determine contextual conditions. Under this premise, both the material and social deprivation of communities were found to be important explanations for inequalities in LEs across communities for both females and males.

The gap in LE for females between the most and least deprived communities was narrower than that for males, which is consistent, though the numbers are not directly comparable, with the study of life expectancy gaps by genders by Auger et al., (2010), the same by Pampalon and Raymond (2000) and gaps in different cancer mortalities in the study by Dupont et al. (2004).

It appears that both material and social deprivation explain the variation of LE for males more than females for both time periods. Residuals—after taking into account the two domains of deprivation in the regression models—are about the same for females and males (Tables 5-6-a & 5-6-b, except for males at Time 1, the residual of which was larger). This seems to suggest that females are less susceptible to the two specific domains of deprivation measured, rather than that the measures are biased. It may be that the deprivation scores are more relevant to situations experienced by males than by females. Past studies (Raleigh &

Kiri, 1997; Singh & Siahpush, 2006) also found that the effect of socioeconomic deprivation on life expectancy is larger for males than females. Raleigh and Kiri (1997) offered possible explanations as: 1) men living in deprived areas of males are in poorer health and thus less likely to migrate; 2) greater gender variation in deprived areas in the incidence of external causes of death such as accidents, suicide and violence, particularly earlier in adult life and 3) deprivation could be a stronger proxy for risky health behaviours in men than in women. The first explanation is supported by a study by Veugelers and Read Guernsey (1999-b), which estimated the out-migration trend of Sydney, Cape Breton, and found that "migration [in the 3 decades they observed] is most apparent in young adults and more prevalent in the periods of economic recession" (p.784), leaving, older, less healthy subgroups behind. The latter two explanations were also suggested as possible factors in what Auger et al.'s (2010) study observed in Quebec. Another possibility may be that the psychosocial stress (through the direct-cognitive path) of material deprivation is often mitigated in females more by having higher levels of some types of social connections that were not reflected by the social deprivation measured in this study.

The statistical models show that an interaction effect between material and social deprivation is present. This is consistent with the finding in the study by Pampalon and Raymond (2000), which showed that "each of these forms of deprivation can have its own distinct impact on health and that this impact is increased when the two forms are found together." Dupont et al.'s study (2004) also found that "(f)or total cancer mortality, the combination of both social and material deprivation increases the risk of mortality in the most disadvantaged men and women." The enhanced impact on health by the two deprivation could mean that, when the so-called psychosocial stress via realization of materialistic reality and stress due to lack of support co-exist, it can accelerate the process of, for instance, allostasis, more quickly reaching a threshold of metabolic regulatory system starting to 'wear out,' escalating the onset of chronic illnesses.

Hypothesis 3: The social inequalities in health between communities (with highest and lowest classes of deprivation) have widened in the last decade.

The gaps in LEs between the least and most deprived seem to have widened over the study period, which is consistent with some other studies—particularly with socioeconomic deprivation—in developed countries (Chaix, et al., 2007-a, Auger et al., 2010, Singh, 2003, Ezzati, Friedman, & Kulkarni et al., 2008). It appears that, for females, the disadvantages of being among the most deprived group of communities have worsened but the advantages of being among the least deprived group communities have remained at the same level between the two time periods. On the other hand, for males, the advantages of materially least deprived became more prominent, whereas the disadvantages of the most deprived did not change substantially. It is unclear what contributed to the difference between genders at this point. It could be that the females are the first to lose jobs or lose the share of financial resources available to the family when the local economy worsens. Hence, there are more females affected by the financial loss in most deprived communities, while females in the least deprived communities did not have the same experience financial loss. In the case of males, since the LE growth of Nova Scotia is comparatively lower than that of Canada (the difference between Nova Scotia and Canada for females is much smaller [data not shown]), the low average growth of Nova Scotia may be making the advantage of health in least deprived group appear to have increased substantially. For both females and males, the gaps between the most and least socially deprived communities have not seen as substantial a change over the time period as the gaps between the most and least materially deprived communities. It could be because the differences in absolute level of isolation across the communities have not changed substantially (data not shown). It could also be that social deprivation measured—or rather, the negative direction of the deprivation measured—is a marker for a 'buffer' against the effects of psychosocial stress from material deprivation (Olstad, Sexton, & Søgaard, 2001). Further investigation of how to comparatively measure the social deprivation between two time periods, as well as clarification of the construct of social deprivation would be desirable. Moreover, as Auger et al. (2010) suggest, the widening or plateau-ing gaps in health between most and least deprived group may be age dependent. This study cannot uncover the differences in the temporal pattern by different age groups. Depending on which groups were particularly affected by the changing socioeconomic and social circumstances observed at the community level, types of potential social and health services to cater these communities might be different. Investigations of trends in health status differentiated by age and sex groups, therefore, would be necessary to help formulate effective social and health programs that cater to specific age and sex groups.

Hypothesis 4: Unaccounted variance measured by spatially correlated and spatially heterogeneous random effect (residuals) have patterns by region or community type, or both.

From the regression models, it appears that the two domains of deprivation explain a substantial portion of the variance in health statuses across communities. After adjusting for spatial autocorrelation, the remaining residuals appeared to be distributed fairly evenly (randomly) across space. However, some persisting clustering of residuals could be observed. For instance, albeit small in number, a cluster of communities with spatially correlated negative residuals was present in the Cape Breton region, and a concentration of spatially correlated positive residuals was considerable in the Annapolis Valley region. The cluster in the Cape Breton region disappears for females once spatially correlated residuals are adjusted, but for males, some communities with negative residuals in the region remain at both time periods.

The clustering of spatially correlated residuals may be partially attributed to how LE was calculated. Because mortality of those 70 years of age and above for each community was replaced by the average of the county in the LE calculation, the variances unexplainable by levels of deprivation among the communities within the county might also be similar to one another. There was no clear pattern as for the clustering of large positive or negative residuals by gradient of rurality (Table 5-11), particularly given the wide intervals of average residuals with almost all of which crossed 0. However, there seem to be tendencies for metro & big towns to have negative average residuals, for metro fringe & mid towns to have positive average residuals, and for most sparse communities to have very small average residuals. These tendencies cannot be explained by the use of county average mortality for older age groups in LE calculation, as different community types exist within the counties exhibiting these tendencies, and community types of those exhibiting high residuals are not always the same.

Albeit small, regional patterns of spatially autocorrelated residuals suggest that there are some regional 'place' effects beyond community level deprivation influencing the health status. Negative residuals in Cape Breton, for instance, suggest that there is something region-wide that negatively affects health of the communities within it beyond their deprivation levels. It could be other aspects of socioeconomic conditions that were not captured by the measures employed. It might be some environmental factors (climate, quality of air and water, or some industrial hazard). Environmental hazards from the steel and mining industries which were active until the early 1990s were suspected as accounting for the higher incidences of cancer and other illnesses in areas such as Sydney and Glace Bay in Cape Breton a decade ago (Read Guernsey et al., 2000; Veugeler & Read Guernsey, 1999-a). There could be remaining effects among former mining and steel-industry employees and residents around sources of the industrial and occupational hazards. There might also be some factors related to lifestyles and cultures that are unique and cannot simply be explained by their relationships with a given socioeconomic position. Similar considerations apply to positive residuals in Annapolis Valley area. There appears to be something in addition to, or despite, the communities' position of deprivation that helps the communities' overall health to be better than expected. It is yet to be investigated what the potential factors might be. However, the results point to a direction in which unique regional characteristics could be identified from sources such as local knowledge, industrial and cultural history, and economic trends over the last few decades. These types of information could help narrow down potential variables to be investigated in a further study—whether they can be found in existing administrative data or they need to be collected.

Hypothesis 5: The strengths in the effects of measured deprivation on, and 'explainability' of variation in health, are not necessarily the same between 'urban' and 'rural' communities.

As in the case of average LEs by community type, there were no clear patterns by a dichotomized rurality (urban or rural) when comparing LEs for females or males, at both time periods. Notable, however, were the large unaccounted variances for the rural community-only model in comparison with the all community and urban community-only models. This appears to suggest that the deprivation measures employed in this study explain the variations within the rural communities to a lesser extent than within urban communities or all communities. A variety of possible explanations for larger variations in the health of rural areas was suggested by Haynes and Gale (1999), which can be echoed here. They include: the small number of deaths leading to greater random variation, the ready-made deprivation indices' insensitivity to uniquely rural disadvantages, and a greater mixture of different characteristics of individuals within a rural area (rich and poor people living close together) (Haynes & Gale, 1999). Pampalon and colleagues' study (Pampalon, Hamel, & Gamache, 2009-b) found that life and disability-free life expectancies were underestimated by their deprivation index measured at an area level to a greater degree in small towns and rural areas than in urban areas. Therefore, the 'explainability' of the deprivation indices employed for this study is also likely lower in rural communities than urban communities.

6.2. Significance of the study

The most important contribution of this research is more to the methodological alternatives it offered, without which the examination of the same relationships studied in a larger province like Quebec would not have been possible in this province. While the health outcome employed was based on general, all-cause mortality rather than cause specific mortality, morbidity or other outcomes of health and well-being, these methodologies now allow us to begin to ask questions about more complex relationships between various 'domains' of deprivation and various health outcomes in Nova Scotia context.

This study takes an advantage of Nova Scotia Community Counts' 'community' units, which are more representative of the areas' homogenous identities than census subdivisions. Particularly, census subdivision (CSD) of Halifax encompasses vast regions with highly urban Halifax Metro as well as sparsely populated settlements. The proportion of commuters to the downtown Halifax area (Halifax Citadel, Needham, Chebucto, Dartmouth, and Bedford etc.) would also vary substantially between communities such as Sheet Harbour, Moser River and Middle and Upper Musquodoboit[16] and communities adjacent to the downtown Halifax area such as Tantallon, Timberlea, and Hammonds Plains. Since about 40% of the province's population reside in this geographically substantial size subdivision, it was crucial that the variability within the subdivision be captured.

Indeed, the levels of deprivation as well as life expectancy at birth varied from 77.4 to 83.14 (Time 1) and 79.04 to 83.86 (Time 2) years of ages for females and 68.65 to 78.66 (Time 1) and 70.09 to 79.66 (Time 2) years of ages for males within the subdivision. All but one (60th percentile) deciles of material deprivation and social deprivation (70th percentile) were represented by at least one of the 39 communities within the CSD. Four communities (10%) fall in the highest half of the material deprivation ranks, and 14 (36%) fall in the highest half of the social deprivation ranks. Eight (20.5%) of the 39 communities were small towns or sparse settlements, while 31 communities were in either metro & big town or metro fringe & mid-size town categories**.** The variations observed here have never been studied before, thus furthering our existing knowledge.

The main technological advantage this research had was that a geodatabase containing nearly 100% complete information of street addresses and town names throughout Nova Scotia was available, which can be connected to a GIS function to assign fairly accurate point locations of health records. Without it, assignment of records to communities outside urban areas would have been too unreliable.

[16] For example, the distance from Sheet Harbour to Halifax is approximately 115-156km, depending on the route.

This study also offers an alternative definition of rurality. Several definitions of 'rurality' exist in Canada. They are mostly based on density and size of the population, with an exception of Metropolitan Influence Zone (MIZ) which takes into account the proportion of commuters to the metro area (du Plessis et al., 2001). However, none of the existing definitions fit into the 'community' unit employed for this research. Therefore, a rurality typology needed to be constructed that fit the unit. The alternative categorization of rurality in this study was based on the population per kilometre density in each community. The five relative levels of rurality were then defined using geometric intervals, which group the values so that the within-group variation is minimum. Unlike rural definitions that use absolute pre-defined number of cut-off population size or density, this ensures that the communities within the category are more similar to each other than with other categories.

A definition such as MIZ is more cognizant of the economic activities related to the urban centre of the province as it measures its influence to the respective areas by measuring the commuters to the urban centre for work. Redefining MIZ at community level would have been useful. However, data pertaining to commuters to the metro were not available, and it was not possible to create a 'MIZ-like' categories. If the data were available, it would also be helpful to categorize community or rurality types based on similarities within the groups, rather than using a pre-defined cut-off number of population or density level, as it was with the rurality categorization used in this study.

There are a few additional contributions to knowledge pertaining to the relationships between place-based deprivation and health inequalities. In Canada, many studies have observed the relationships between socioeconomic deprivation and health outcomes.

However, the adaption of other domains of deprivation than socioeconomic deprivation is relatively new. Researchers in Quebec are spearheading the investigation of socioeconomic and social deprivation and their roles and relationships with various health outcomes as well as the relationships with each other. At least two studies (Pampalon & Raymond, 2000l; Dupont et al., 2004) showed that they together exacerbate health problems. The present study, adopting the same indices recalibrated to Nova Scotia Community Counts' community unit, also found that socioeconomic position and social isolation together exacerbate the health outcome (potentially by not having an immediate support worsens the stress of lacking material resources, for example). The effect of social deprivation is just as strong, if not stronger, as the effect of material deprivation. Thus, the present study supports the previous studies in Quebec as an additional piece of evidence of the combined effects of socioeconomic and social deprivation measured, even in a different provincial context where the population is much smaller, the range of rurality is much narrower, and the historical and cultural make-up of the region is substantially different. This is also an important finding from a policy perspective because it supports the notion that the effort of enhancing health or protecting population from ill-health has to go hand in hand with not only enhancement of socioeconomic means in the individuals, but also enhancement of community level social support systems.

This study also revealed that the deprivation indices did not account for variations in health in rural communities to the same extent as they did for urban communities. This suggests that the existing indices need to be used with care, especially when they are used to predict potential risks of health. The present study 'predicted' the life expectancy, but took into account what were not accounted for by deprivation measured. Moreover, it demonstrated a way to spatially examine where the unaccounted factors are, which would lead to a further hypothesizing of additional contextual risk factors. This has not been done in previous studies reviewed that examined the relationships between deprivation and health inequalities. As Boyle et al. (2004-b) stated, deprivation is also location dependent. Even if two communities have the same deprivation scores or ranks, characteristics of communities surrounding or adjacent to these communities may influence the health outcomes observed.

It is also an indication that not all the important contextual risks 'occur' at community levels but also at a wider local or regional settings. The multiplicity of the contextual levels has been untangled conceptually (Berkman, Glass, & Brissette, et al., 2000; Krieger, 1994; Susser & Susser, 1996; Diez-Roux, 2002, for example), but exactly what sort of contextual factors 'occur' at what levels or scale of social relations is yet to be clearly identified. The present study offers an example research that attempts to connect conceptual understanding of multiplicity of contextual levels, with measured, as well as unmeasured, contextual factors at community and wider (surrounding) area levels.

Relatedly, this study attempted to go a step further on the data availability dilemma by geographically examining what might not have been explained by employed explanatory variables. Clearly, the use of solely inductive reasoning of the phenomena observed makes any evidence of relationships weak, or can lead to under-theorization (Frohlich et al., 2006). The findings with regards to the unaccounted factors will help to identify additional determinants of social and health inequalities, and to deepen our understanding of their potential constructs. This will help make decisions on whether the existing administrative data variables are suitable to measure the determinants suspected.

Finally, this study found that health statuses are not different by community type or rurality. This suggests that it is not rurality *per se* but rather deprivation that produces health inequalities across communities. Low socioeconomic positions are not necessarily inherent in rural communities, though incentives for economic development, employment, and more service oriented job opportunities (which are often higher paying) tend to concentrate in urban centres. These are certainly components of opportunity structures in a place. Without local political will to bring the incentives, rural communities tend to lose out on chances to achieve material wealth, secure and high paying employment and high level of education. Thus, what is more important may be to focus on whether the social, cultural and political factors that do or do not bring the leverage to promote socioeconomic wealth are present—rather than whether the place is rural or urban—in order to advance our understanding of the relationships between rurality and health.

6.3. Limitations

There are several important limitations beside those mentioned above that need to be elaborated. First, this is a population level, ecological study. While this study considers possible pathways between the contextual determinants of health and life expectancy, which is calculated based on mortality, it is unable to 'prove' that in fact deprivation manifests in biophysiology via these potential pathways. It is obvious that there are a number of factors at the individual level that influence the outcomes of those exposed to certain levels of risk conditions at the ecological level. Also, by looking only at the ecological level, intricate interactions between 'structure' and 'agency' (Giddens, 1984, 1991; Bourdieu, 1977, 1986;

Frohlich, 2000)—i.e., how social relationships in a place influence and are influenced by individuals' everyday behavioural and life choices, and what such interaction could mean to health outcomes of individuals or groups—could not be observed.

This thesis does not claim that it reveals anything about individual level health or health inequalities. Instead, it is limited to demonstrating the correlations between ecological level risk factors and ecological level, collective health outcomes of the population. However, the main concern of the study is to be demonstrative of ways to identify target populations, communities, or areas for intervention aimed at removing contextual level obstacles to achieve better health. In other words, this study focuses on social determinants of inequalities in health—rather than on social determinants of health—which is not only equally important as social determinants of health but also necessary to narrow the gap in health inequalities among groups of individuals with different socioeconomic, cultural, and ethnic and other life circumstances (relevant discussion can be found in Frohlich, 2010).

Secondly, while addition of social deprivation is advantageous in examining health inequalities compared with the study that only looks at a socioeconomic dimension, the deprivation indices employed still looked only two domains of a complex social circumstances communities face. Moreover, the indices only measured a limited number and narrow aspects of variables and do not comprehensively reflect social and economic conditions existing in the contexts. Particularly, the social dimension of deprivation measured has a focus on family and household structure, which may or may not translate to a broader, community-wide systems of social support, collective efficacy, or presence of social and community services. As Dupont et al. (2004) suggest, with regards to the social deprivation in Quebec, it is necessary to "clarify the significance of social deprivation by continuing analysis of relationship between it and other measurements, notably social cohesion, the sense of belonging to a local community, and the presence of services in the community." Likewise, material deprivation can be expanded to the community level financial resources such as tax base, property ownership[17], people receiving social assistance, or presence of other kinds of assets within the community. Moreover, other domains of deprivation—such as environmental quality and access to health related services—may contribute substantially to the unaccounted effects observed in this study.

Thirdly, because of the size of the population as well as the counts of deaths per year, a stable calculation of annual life expectancy calculation was not possible. This leads to two shortcomings. First, even with all deaths occurring over a stretch of five years, some communities were too small and needed to be aggregated to achieve the stable calculation. While the area aggregations were conducted based on similar community types, the unique characteristics of those communities were compromised to some degree. However, I expect that the these 'community clusters' will still give us area characteristics of more homogeneous entities which are more conceptually appropriate than other existing administrative area units. The second shortcoming attributed to population size is that, due to the small number of deaths occurring in a given year, community level health outcomes due to specific cause of death could not be calculated. The argument for biosocial mechanisms through which social environments influence specific diseases such as cardiovascular diseases and diabetes has been well accepted (Daniel et al., 2008; Gibbons,

[17] Housing ownership and cost of housing are highly correlated with average income, education and unemployment in Nova Scotia, and adding this variable to the multiple deprivation index did not benefit greatly in the preliminary work in construction of the indices.

Brock, & Alberg et al., 2007). It would have been helpful to demonstrate a clearer pathway between the deprivation and specific causes of death.

In addition, there are a few possibilities that could have led to spurious calculation of the life expectancy. First, the vital statistics records came with fairly well completed location information. However, many of these records—especially rural records—tended to have only town names and not street addresses, though in some cases town names can narrow the location down better than street addresses. Relying on incomplete address information could have led to misallocation of some records. This would probably not have affected the calculation too severely, however, as the towns' (by General Sortation Area) boundaries—albeit the residences were actually located in the recorded towns—are much smaller than the community boundaries and they are nested within community boundaries employed for this study.

Secondly, the assumption was made that the older adults needing some kind of assisted living arrangements are likely to choose nursing home/seniors' home facilities in the same county as the prior residence. Under this assumption, mortality rates of those 70 years of age and older were averaged out based on the county each community belongs. However, it is possible that there could be a shortage of nursing homes/seniors' homes in a county, and many individuals move to different counties. If that is the case, the average county level mortality would be unusually low, raising life expectancies of the communities in the county unusually high. Such could be a case for the 'Valley effect.' The District Health Authority around that region (Annapolis Valley District Health Authority-DHA 3) holds about 8.8% of the bed counts of all nursing homes and seniors' homes registered with the province, the same proportion of the District's population in the entire province. The proportion of age groups 70 years old and above in the District is similar to the average of all DHAs. Based on these simple numbers, it seems unlikely that the method of LE calculation solely explains the relatively high LEs in the region. However, it needs to be further investigated to clarify that the method of calculation of LEs had anything to do with the relatively high LEs in the Annapolis Valley region.

Research that involves a small population, particularly those investigating rural populations, needs to continue its efforts to find ways to get around its predicaments. These efforts should include development of tools and data organization that allow accurate point allocation of records, use of statistical methods (such as Bayesian statistics with Monte Carlo simulation) that would give reliable estimation with limited observation size, and ways to further conceptualize what exactly is in the 'place,' which would help typologize communities to allow meaningful ways to aggregate them when necessary.

Chapter 7. CONCLUSION

This thesis examined the relationships between the geographical distribution of health status and the roles of two types of deprivation in the production of health inequalities across communities in Nova Scotia. It employed geographical epidemiology as a research framework and investigate the relationships between the geographical/spatial distribution of health and deprivation as a contextual risk condition at the ecological level at two different time periods. The study set out to address some of the research gaps and clarify some concepts involved in small-area analysis of variations in social and health conditions across levels of rurality.

Geographical epidemiology as well as 'place and health' research in general still faces many challenges. They include the availability of data for the health and social conditions a study is set to measure, linkability of such data to geographical units that are appropriate to answer their specific research questions, and under-theorization of explanatory variables and their pathways to biophysiological and mental health in individuals. This thesis certainly faced all of these. The population size of this study context added a difficulty to an already hefty load of conundrums. This thesis intended to do the best to produce a piece of empirical evidence lacking in the province by circumventing some of these limitations with available means, rather than discovering new theoretical concepts or methods. It hopefully succeeded in that effort.

Further research efforts must be made to investigate further a few issues found in this thesis, as well as a few things beyond the scope of this thesis. First, this study found some general regional clustering of effects on community level health that were not accounted for by the levels of socioeconomic deprivation or social isolation the indices measured. For example, there is something in the Cape Breton region that could not be explained by deprivation but that seemed to negatively affect the health (mortality) of males (but not females). Some negative effects of environmental hazards on health from the industry in operation until early 1990s were suggested a decade ago (Read Guernsey et al., 2000; Veugeler and Read Guernsey, 1999). How much of the effects observed might still be attributed to them? How much of the observed health status may be attributed to out- (or in-) migration of certain types of population (e.g., young, working age, male)? Both females and males residing in the Annapolis Valley region (Kings and Annapolis Counties) seem to enjoy higher life expectancy despite, or in addition to the benefit of, their levels of socioeconomic and social isolation. What is it in these regions that exacerbates or buffers the contextual risk conditions of health? Did the method of life expectancy affect the result in any way?

Secondly, the two domains of deprivation left unexplained considerable variations in life expectancy at birth in rural community-only models. However, the credible intervals of unaccounted variation in the respective models were wide and overlapping, thus the 'differences' between the degrees of unaccounted variations between urban- and rural community-only models were not statistically proven. How can the research design be improved to add clarity to the 'proof' that the same deprivation indices are or are not insensitive to variations in health in rural communities than in urban communities? Or, should we measure deprivation of urban and rural communities differently? Perhaps the lower income in rural communities compared with the urban average does not mean that residents of rural communities have less purchasing power. Perhaps there are more informal employment opportunities available in rural communities that do not show up in employment rates calculated in the census data. Once these hidden opportunities are measured, would such indicators explain the variances in health equally well between rural and urban communities?

Thirdly, this thesis employed life expectancy at birth as a health outcome, which is an all-cause mortality based health indicator. Different patterns of effect by deprivation are likely to emerge with different types of health outcomes, which would more fully inform policy related to reduction of health and social inequality. Likewise, this thesis could not point to where most disadvantaged individuals are, as the community level average measures like deprivation mask their presence. Therefore, ecological studies such as this should be accompanied with studies that separate out the contextual risks and individual level risks, in order to present a more complete picture of the complex mechanisms through which various social factors 'get under the skin' through different pathways involved.

This study addressed the need to produce evidence of a finer-area level social inequality in health, which helps identify geographical 'hotspots' that call for attention in research and policy aiming at addressing the need to improve health in the most disadvantaged communities. Geographical epidemiological studies such as this can play an important role in this effort of reducing inequalities. They should be employed to assess target areas (e.g., communities, neighbourhoods) for potential policy as well as to better understand the social environmental sources of health inequalities in the population.

BIBLIOGRAPHY:

Adams, J, & White, M. (2006). Removing the health domain from the Index of Multiple Deprivation 2004—effects on measured inequalities in census measure of health. *Journal of Public Health*, 28, 379-387.

Adekola, O.A. (2002). A generalized life-expectancy model for a population. *Journal of the Operational Research Society*, 53, 919-921.

Asada, Y. (2005). A framework for measuring health inequity. *Journal of Epidemiology & Community Health*, 59, 700-705.

Auger, N., Alix, C., Zang, G., & Daniel, M. (2010). Sex, age, deprivation and patterns in life expectancy in Quebec, Canada: a population study. *BMC Public Health*, 10,161.

Auger, N., Authier, M-A, Martines, J., & Daniel, M. (2009). The association between rural-urban continuum, maternal education and adverse birth outcomes in Québec, Canada. *Journal of Rural Health*, Fall, 342-351.

Australian Institute of Health and Welfare. (2007). Rural, regional and remote health: A study on mortality. Rural health series no. 8. Cat. no. PHE 95 (2nd Ed.). Canberra: AIHW.

Bell, N., Schuurman, N., Oliver, L., & Hayes, M.V. (2007). Towards the construction of place-specific measures of deprivation: a case study from the Vancouver Metropolitan area. *Canadian Geographer*, 51, 444-461.

Berkman, L.F., Glass, R., Brisette, I., & Seeman, T.E. (2000). From social integration to health: Durkheim in the new millennium. Social Science & Medicine, 51, 843-857.

Bernard, P., Charafeddine, R., Frohlich, K.L., Daniel, M., Kestens, Y., & Potvin, L. (2007). Health inequalities and place: A theoretical conception of neighbourhood. *Social Science & Medicine*, 65, 1839–1852.

Berthoud, R. (1976). *The Disadvantages of Inequality: A Study of Social Depriv*ation, London: Macdonald and Jane's.

Bithell, J.F. (2005). Geographical Epidemiology, Chapter II.8 in W. Ahrens, & I. Pigeot (Eds.). *Handbook of Epidemiology with 165 Figures and 180 Tables*. Bremen, Germany: Springer.

'Blair calls for quotas on immigrants from 'New Commonwealth', (2004, June 6) *Daily Telegraph*. Available online at http://www.telegraph.co.uk.

Blakely, T., Tobias, M., & Atkinson, J. (2008). Inequalities in mortality during and after restructuring of the New Zealand economy: repeated cohort studies. *British Medical Journal,* 336, 371-375.

Boardman, J.D. (2004). Stress and physical health: the role of neighbourhoods as mediating and moderating mechanisms. *Social Science & Medicine*, 58, 2473-2483.

Bourdieu, P. (1986). The forms of capital. Richardson, J. (Ed.) *Handbook of Theory and Research for Sociology of Education* (pp. 241-258). New York: Greenwood Press

Bourdieu, P. (1977). *Outline of a Theory of Practice*. Cambridge: Cambridge University Press.

Boyle, P., Curtis, S., Graham, E., & Moore, E. (Eds.) (2004-a). *The Geography of Health Inequalities in the Developed World.* Aldershot, UK: Ashgate Publishing Ltd.

Boyle, P. Gatrell, A., & Duke-Williams, O. (2004-b). Limiting long-term illness and locality deprivation in England and Wales: Acknowledging the "socio-spatial context.' Chapter 13 in P. Boyle, S. Curtis, E. Graham, & E. Moore (Eds.), *the Geography of Health Inequalities in the Developed World: Views from Britain and North America.* Aldershot, England: Ashgate Publishing Limited.

Braveman, P. (2006). Health disparities and health inequity: Concepts and measurement. *Annual Review of Public Health*, 27, 167-194.

Brown, M., & Madge, N. (1982). *Despite the Welfare State*. London: Heinemann Educational Books.

Brown, W., Young, A. F., & Byles, J. E. (1999). Tyranny of distance? The health of midage women living in five geographical areas of Australia. *Australian Journal of Rural Health*, 7, 148–154.

Brunner, E. (2002). Stress mechanisms in coronary heart disease. In S.A. Stansfeld, & M.G. Marmot (Eds.), *Stress and the Heart: Psychosocial Pathways to Coronary Heart Disease* (pp. 181-199). London: BMJ Books.

Canadian Population Health Initiative. (2006). *How healthy are rural Canadians? An assessment of their health status and health determinants*. Canadian Institute for Health Information.

Carstairs, V., & Morris, R. (1989). Deprivation: explaining differences in mortality between Scotland and England and Wales, *British Medical Journal*, 299, 886-889.

Chaix, B., Rosvall, M., & Merlo, J. (2007-a). Neighbourhood socioeconomic deprivation and residential instability: Effects on incidence of ischemic heart disease and survival after myocardial infarction. *Epidemiology*, 18, 104-111.

Chaix, B., Rosvall, M., & Merlo, J. (2007-b). Recent Increase of Neighborhood Socioeconomic Effects on Ischemic Heart Disease Mortality: A Multilevel Survival Analysis of Two Large Swedish Cohorts. *American Journal of Epidemiology*, 165, 22-26.

Chiang, C.L. (1984). *The Life Table and Its Applications.* Malabar, FL: Robert E. Krieger Publishing Company.

Chiang, C.L. (1968). *Introduction to Stochastic Processes in Biostatistics*. New York: John Wiley & Sons.

Community and Local Government, UK. (2008). *The English Indices of Deprivation, 2007*. Available online at www.communities.gov.uk.

Cox, M., Boyle, P.J., Davey, P.G., Feng, Z., & Morris, A.D. (2007). Locality deprivation and Type 2 diabetes incidence: A local test of relative inequalities. *Social Science & Medicine*, 65, 1953-1964.

Cox, J. (1999). Poverty in rural areas. *British Medical Journal*, 316, 722.

Cummins, S., Curtis, S., Diez-Roux, A., & Macintyre, S. (2007). Understanding and representing 'place' in health research: A relational approach. *Social Science & Medicine*, 65, 1825–1838

Cummins, S., Macintyre, S., Davidson, S., & Ellaway, A. (2005). Measuring neighbourhood social and material context: generation and interpretation of ecological data from routine and non-routine sources. *Health & Place*, 11, 249-260.

Cummins, S., McKay, L., & Macintyre, S. (2005). McDonald's restaurants and neighbourhood deprivation in Scotland and England. *American Journal of Preventive Medicine*, 29, 308-310.

Curtis, S., & Jones, I.R. (1998). Is there a place for geography in the analysis of health inequality? *Sociology of Health & Illness*, 20, 645-672.

Daniel, M., Moore, S., & Kestens, Y. (2008). Framing the biosocial pathways underlying associations between place and cardiometabolic disease. *Health & Place*, 14, 117-132.

Davey Smith, G. & Gordon, D. (2000). Poverty across the lifecourse and health. In C. Pantazis & D. Gordon (Eds.), *Tackling inequalities: Where are we now and what can be done?* (pp.141-158). Bristol, UK: Policy Press.

Davey Smith, G., Hart, C., Watt, G., Hole, D., & Hawthorne, V. (1998). Individual social class, area-based deprivation, cardiovascular disease risk factors, and mortality: the Renfrew and Paisley study. *Journal of Epidemiology and Community Health*, 52, 399–405.

Department of Health and Social Security. (1980). *Inequalities in health: Report of a research working group chaired by Sir Douglas Black*. London: DHSS.

Diez-Roux, Anna, V. (2002). Invited commentary: places, people and health. *American Journal of Epidemiology*, 155(6):516-519.

Diez-Roux, A. (1998). Brining context back into epidemiology. Variables and fallacies in multilevel analysis. *American Journal of Epidemiology*, 88, 216-222.

Dunn, J.R., Frohlich, K.L., Ross, N., Curtis, L.J., & Sanmartin, C. (2006). Role of geography in inequalities in health and human development. Chapter 9 in Heymann, J., Hertzman, C., Barber M.L., and Evans, R.G. (eds.). Healthier Societies: From Analysis to Action. New York: Oxford University Press.

Dupont, M.A., Pampalon, R., & Hamel, D. (2004). *Deprivation and cancer mortality among Quebec women and men, 1994-1998*. Institut National De Santé Publique Du Québec.

du Plessis, V., Beshiri, R. & Bollman, R.D. (2001). Definitions of Rural. *Rural & Small Town Canada Analysis Bulletin* Vol. 3, No.3 (Catalogue no. 21-006-XIE). Retrieved from http://www.statcan.ca/cgi-bin/downpub/freepub.cgi.

Eberhardt, M. S., & Pamuk, E. R. (2004). The importance of place of residence: examining health in rural and nonrural areas. *American Journal of Public Health*, 94, 1682–1686.

Elliott, P., Wakefield, J., Best, N., & Briggs, D. (Eds.) (2000). *Spatial Epidemiology: Methods and Applications*. Oxford: Oxford University Press.

ESRI (Environmental Systems Resource Institute). (2007). Geometric interval. ArcGIS Desktop Help. Also available online at http://webhelp.esri.com.

ESRI (Environmental Systems Resource Institute). (2009). ArcMap 9.3. ESRI, Redlands, California.

Ezzati, M., Friedman, A.B., Kulkarni, S.C., & Murray, C.J.L. (2008). The reversal of fortunes: Trends in county mortality and cross-county mortality disparities in the United States. *PLoS Med* 5(4), e66. doi:10. 1371/journal.pmed.0050066.

Frohlich, K.L. (2010). Social determinants of what? *International Journal of Public Health*, 55, 235-236.

Frohlich, K.L., & Potvin, L. (2008). The inequality paradox: the population approach and vulnerable populations. *American Journal of Public Health*, 98, 216-221.

Frohlich, K.L. (2000). *Collective Lifestyles Framework: A Contextual Analysis of Social Practices, Social Structure and Disease*. Ph.D. Thesis. Université de Montréal, Canada.

Frohlich, K.L., Dunn, J.R., McLaren, L., Shiell, A., Potvin, L., Hawe, P., Dassa, C., & Thurston, W.E. (2006). Understanding place and health: A heuristic for using administrative data. *Health & Place*, doi:10.1016/j.healthplace.2006.01.007.

Frohlich, K.L., Potvin, L., Chabot, P., & Corin, E. (2002). A theoretical and empirical analysis of context: neighbourhoods, smoking and youth. *Social Science & Medicine*, 54, 1401-1417.

Frohlich N., & Carriere KC. (1997). *Issues in Developing Indicators for Needs-Based Funding.* Winnipeg, MB: Manitoba Centre for Health Policy and Evaluation.

Galea, S., Ahern, J., Nandi, A., Tracy, M., Beard, J., & Vlahov, D. (2007). Urban neighbourhood poverty and the incidence of depression in a population-based cohort study. *Annals of Epidemiology*, 17, 171-179.

Gibbons, M.C., Brock, M., Alberg, A.J., Glass, T., LaVeist, T.A., Baylin, S., Levine, D., & Fox, C.E. (2007). The sociobiologic integrative model (SBIM): enhancing the integration of sociobehavioral, environmental, and biomolecular knowledge in urban health and disparities research. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, 84, 198–211.

Giddens, A. (1991). *Modernity and Self-identity: Self and Society in the Late Modern Age*. Stanford, California: Stanford University Press.

Giddens, A. (1984). *The Constitution of Society: Outline of the Theory of Structuration*. Berkeley and Los Angeles: University of California Press.

Gordon-Larsen, P., Nelson, M.C., Page, P., & Popkin, B.M. (2005). Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*, 117, 417-424.

Haining, R. (2003). *Spatial Data Analysis: Theory and Practice*. Cambridge: Cambridge University Press.

Hayes, M. (2004). From recognition to practice: Gradients, inequality and the social geography of health. Chapter 17 in P. Boyle, S. Curtis, E. Graham, & E. Moore (Eds.), *The Geography of Health Inequalities in the Developed World*: Views from Britain and North America. Aldershot, England: Ashgate Publishing Limited.

Haynes, R., & Gale, S. (1999). Mortality, long-term illness and deprivation in rural and metropolitan wards of England and Wales. *Health & Place*, 5, 301-312.

Haynes, R., & Gale, S. (2000). Deprivation and poor health in rural areas: inequalities hidden by averages. *Health & Place* 6, 275-285.

Jarman, B. (1983). Identification of underprivileged areas. *British Medical Journal,* 289, 1705 – 1709.

Jones, J., Terashima, M., & Rainham, D. (2009). Fast food and deprivation in Nova Scotia. *Canadian Journal of Public Health*, 100, 32-35.

Kawachi, I., & Berkman, L. (Eds.) (2003). Neighbourhoods and Health. New York: Oxford University Press.

Kawachi, I., Subramanian, S.V., & Almedia-Filho, N. (2002). A glossary for health inequalities. Journal of Epidemiology and Community Health, 56, 647-652.

Kearns, R., & Moon, G. (2002). From medical to health geography: novelty, place and theory after a decade of change. *Progress in Human Geography*, 26, 605-625.

Krieger, N. (2001). Theories for social epidemiology in the 21st century: an ecosocial perspective. *International Journal of Epidemiology*, 30, 668-677.

Krieger, N. (2006). Embodiment, inequality, and epidemiology: What are the connections? Introduction in N. Krieger (Ed.) *Embodying Inequality: Epidemiologic Perspectives*. Amityville, New York: Baywood Publishing Company.

Krieger, N. 1994. Epidemiology and the web of causation: has anyone seen the spider? *Social Science and Medicine*, Vol. 39(7): 887-903.

Koch, T. (2009). Social epidemiology as medical geography: Back to the future. *GeoJournal*, 74, 99-106.

Landmark Geographic Solutions. (2009). Nova Scotia Address Locator.

Lang, I.A, Llewellyn, D.J., Langa, K.M., Wallace, R.B., & Melzer, D. (2008). Neighbourhood deprivation and incident mobility disability in older adults. *Age and Ageing,* 37, 403–410.

LaVeist, T. A., Gaskin, D.J., Richard, P. (2009). *The Economic Burden of Health Inequalities in the United States*. Washington DC: Joint Center for Political and Economic Studies. Retrieved online November 2011 at http://www.jointcenter.org/hpi/sites/all/files/Burden_Of_Health_FINAL_0.pdf.

Lee, P., Murie, A., & Gordon, D. (1995). Area measures of deprivation: A study of current mrthods and best practices in the identification of poor areas in Great Britain. Centre for Urban and Regional Studies, University of Birmingham.

Lunn, D.J., Thomas, A., Best, N., & Spiegelhalter, D. (2000). WinBUGS - a Bayesian modelling framework: concepts, structure, and extensibility. *Statistics & Computing*, 10, 325-337.

Lynch, J., & Kaplan, G. (2000). Socioeconomic position. Chapter 2 in L.F. Berkman, & I. Kawachi (Eds.), *Social Epidemiology*. Oxford: Oxford University Press.

Maintyre, S., Ellaway, A., & Cummins, S. (2002). Place effects on health: how can we conceptualise, operationalise and measure them? *Social Science & Medicine*, 55, 125–139.

Macintyre, S. (1997). The Black Report and beyond. What are the issues? *Social Science & Medicine*, 44, 723-745.

Macintyre, S., MacIver, S., & Sooman, A. (1993). Area, class and health: Should we be focusing on places or people? *Journal of Social Policy, 9*3, 213-234.

Mackenbach, J.P., and Kunst, A.E. (1997). Measuring the magnitude of socioeconomic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Social Science & Medicine*, 44, 757-771.

Maheswaran, R., & Elliott, P. (2003). Stroke mortality associated with living near main roads in England and Wales: A Geographical Study. *Stroke*, 34, 2776-2780.

Marx, K. (1844). Economic and Philosophical Manuscripts (First Manuscript) retrieved March 2006 at
http://www.marxists.org/archive/marx/works/1844/manuscripts/preface.htm.

Mercer, S., & Watt, G. (2007). The inverse care law: Clinical primary care encounters in deprived and affluent areas of Scotland. *Annals of Family Medicine*, 5, 503-510.

Moon, G. (1995). (Re)placing research on health and health care. *Health and Place,* 1:1-4.

Moore, L.V., & Diez-Roux, A.V. (2006). Associations of neighbourhood characteristics with the location and type of food stores. *American Journal of Public Health*, 96, 325-331.

Moore, E., Rosenberg, M.W. and Mackenzie, C. (2004). Measuring the geographic effects in a model of depression among the elderly in Canada. Chapter 7 in Boyle, P. Curtis, S., Graham, E., and Moore, E. (eds.) *the Geography of Health Inequalities in the Developed World: Views from Britain and North America*. Aldershot, England: Ashgate Publishing Limited.

Morris, R. & Carstairs, V. (1991). Which deprivation? A comparison of selected deprivation indices. *Journal of Public Health*, 13, 318-326.

Nova Scotia Community Counts (2010). Five-year age group population by province, 1996, 2001, 2006. Retrieved from http://www.gov.ns.ca/finance/communitycounts/
Nova Scotia Department of Health, Continuing Care Branch. (2009-a). *Directory: Nursing homes and homes of the aged.*

Nova Scotia Department of Health, Continuing Care Branch. (2009-b). *Directory: Residential care facilities or seniors.*

Nova Scotia Office of Health Promotion (2005). *Healthy Nova Scotia, Strategic Directions for the Office of Health Promotion*, available online at
http://www.gov.ns.ca/hpp/publications/StrategicPlan_web.pdf.

Nova Scotia Geomatics Centre. (2009). *Nova Scotia Civic Address File User's Guide*. Retrieved online August, 2010 at
http://nscaf1.nsgc.gov.ns.ca/civic_help/Version3/CivicAddressUsersGuide.htm.

O'Campo, P. (2003). Invited commentary: Advancing theory and methods for multilevel models of residential neighbourhoods and health. *American Journal of Epidemiology*, 157, 9-13.

Office of the Deputy Prime Minister. (2004). *The English Indices of Deprivation 2004* (revised). London: ODPM Publications.

Olstad, R., Sexton, H., & Søgaard. A.J. (2001). The Finnmark Study. A prospective population study of the social support buffer hypothesis, specific stressors and mental distress. *Social Psychiatry & Psychiatric Epidemiology*, 36, 582-589.

OPCS: Office of Population Censuses and Surveys (1980). *Classification of Occupations 1980*. London: Her Majesty's Stationery Office.

Ostfeld, R.S., Glass, G.E., & Keesing, F. (2005). Spatial epidemiology: an emerging (or re-emerging) discipline. *TRENDS in Ecology & Evolution*, 20, 328-226.
doi:10.1016/j.tree.2005.03.009

Pampalon, R. Hamel, D., & Gamache, P. (2008). Recent changes in the geography of social disparities in premature mortality in Québec. *Social Science & Medicine*, 67, 1269–1281

Pampalon, R. Hamel, D., & Gamache, P. (2009-a). Health inequalities in urban and rural Canada: Comparing inequalities in survival according to an individual and area-based deprivation index. *Health & Place*, 16, 416-420.

Pampalon, R. Hamel, D., & Gamache, P. (2009-b). A comparison of individual and area-based socio-economic data for monitoring social inequalities in health, *Health Reports*, Vol. 20, no.3, Statistics Canada (Catalogue no. 82-003-XPE)

Pampalon, R., Martinez, J., & Hamel, D. (2006). Does living in rural areas make a difference for health in Québec? *Health & Place*, 12, 421-435.

Pampalon, R., & Raymond, G. (2000). A deprivation index for health and welfare planning in Quebec, *Chronic Diseases in Canada*, Vol. 21 (3), Retrieved October 2005 from http://www.phac-aspc.gc.ca/publicat/cidc-mcc/21-3/b_e.html.

Philibert, M.D., Pampalona, R., Hamel, D., Thouez, J.-P., & Loisell, C.G. (2007). Material and social deprivation and health and social services utilisation in Que´bec: A local-scale evaluation system. *Social Science & Medicine.* 64, 1651–1664

Phillimore, P., and Reading, R. (1992). A rural advantage? Urban-rural health differences in Northern England. *Journal of Public Health Medicine*, 14, 290-299.

Pong, R., DesMeules, M., Heng, D., Lagacé, C., Read Guernsey, J., Kazanjian, A., Manuel, D., Pitlbado, J.R., Bollman, R., Koren, I., Dressler, M.P., Wang, F., & Luo, W. (2010). Patterns of health services utilization in rural Canada. *Chronic Diseases in Canada*, 30 (supp. June), 1-37.

Pong, R., Pitblado, J.R., Irvine, A., Nagarajan, K.V, Sahai, V., Zelmer, J., Dunikowski, L., & Pearson, D.A. (1999). *Assessing Rural Health: Toward Developing Health Indicators for Rural Canada*. Centre for Rural and Northern Health Research

Raleigh, V.S., & Kiri, V. A. (1997). Life expectancy in England: variations and trends by gender, health authority, and level of deprivation. *Journal of Epidemiology & Community Health*, 51, 649-658.

Razaeian, M., Dunn, G., St. Leger, S., & Appleby, L. (2006). Geographical epidemiology, spatial analysis and geographical information systems: a multidisciplinary glossary. *Journal of Epidemiology & Community Health*, 61, 98–102.

Read Guernsey, J., Dewar, R., Weerasinghe, S., Kirkland, S., & Veugelers, P.J. (2000). Incidence of cancer in Sydney and Cape Breton County, Nova Scotia 1979-1997. Canadian Journal of Public Health, 91, 285-292.

Riva, M., Curtis, S., Gauvin, L., & Fagg, J. (2009). Unravelling the extent of inequalities in health across urban and rural areas: Evidence from a national sample in England. Social Science & Medicine, 68, 654–663

Riva, M., Terashima, M., Curtis, S., Shucksmith, J., & Carlebach, S. (2010). Coalfield health effects: variation across former coalmining communities in England. *Health & Place*, Accepted.

Salmond, C., & Crampton, P. (2002). *NZDep2001 Index of Deprivation*. Department of Public Health Wellington School of Medicine and Health Sciences. Available online at http://www.moh.govt.nz.

Sampson, R.J., Morenoff, J.D., & Gannon-Rowley, T. (2002). Assessing "neighbourhood effects": Social process and new directions in research. *Annual Review of Sociology*, 28, 443-78.
Scottish Executive (2006). *Scottish Index of Multiple Deprivation 2006*: General Report.

Scottish Executive (2004). *Scottish Index of Multiple Deprivation 2004*: General Report.

Schwartz A and R Diez-Roux (2001). Commentary: Causes of incidence and causes of cases—a Durkheimian perspective on Rose. International Journal of Epidemiology, 30:435-439.

Sen, A. (2002). Why health equity? Health Economics, 11, 659-666.

Singh, G. (2003). Area deprivation and widening inequalities in US mortality, 1969-1998. *American Journal of Public Health*, 93, 1137-1143.

Shaw, M., Davey Smith, G., & Dorling, D. (2005). Health inequalities and New Labour: how the promises compare with real progress. *BMJ*, 330, 1016-1021.

Singh, G.K., & Siahpush, M. (2006). Widening socioeconomic inequalities in US life expectancy, 1980-2000. *International Journal of Epidemiology*, 35, 969-979.

Spiegelhalter, D.J., Best, N.G., Carlin, B.P., & van der Linde, A. (2002). Bayesian measures of model complexity and fit. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 64, 583-639.

Statistical Analysis Software (SAS). Version 9.1. SAS Institute Inc. Cary, NC, USA.

Susser, M. and Susser, E. (1996). Choosing a future for epidemiology II from black boxes to Chinese boxes and eco-epidemiology. American Journal of Public Health, Vol. 86:674-77.

Susser, M. (1994). The logic in ecological: The logic of analysis. *American Journal of Public Health, 84*, 825-829.

Terashima, M. (2007). *Nova Scotia Deprivation Mapping Project Report*, available online at: http://www/gov.ns.ca/finance/communitycounts/resources.asp.

Tobias, M.I. & Cheung, J. (2003). Monitoring health inequalities: life expectancy and small area deprivation in New Zealand. *Population Health Metrics*, 1. Available online at http://www.pophealthmetrics.com/content/1/1/2.

Tobler, W. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography*, 46, 234-240.

Townsend, P. (1987). Deprivation, *Journal of Social Policy*, 16, 125-146.

Townsend, P., Phillimore, P., & Beattie, A. (1988). *Health and Deprivation: Inequality and the North*. London: Croom Helm.

Townsend, P. (1993). *The International Analysis of Poverty*. London: Harvester Wheatsheaf.

Vaferi, A., Rosenburg, M.W., & Picket, W. (2010). Relationships between income inequality and health: a study on rural and urban regions of Canada. *Rural & Remote Health* 10: 1430-1438.

van Jaarsveld, C.H.M., Miles, A., & Wardle, J. (2007). Pathways from deprivation to health differed between individual and neighbourhood-based indices. *Journal of Clinical Epidemiology*, 60, 712-719.
Veugelers, P., & Read Guernsey, J. (1999). Sensitivity analysis of selective migration in ecological comparisons of health. Letter to the editor. *Epidemiology*, 10, 784-785.

Veugelers, P., & Guernsey, J. (1999). *Health Deficiencies* in Cape Breton County, Nova Scotia, Canada, 1990-1995. *Epidemiology*, 10, 495-499.

Veugelers, P., Kim, A., & Read Guernsey, J. (2000). Inequalities in health. Analytic approaches based on life expectancy and suitable for small area comparisons. *Journal of Epidemiology & Community Health*, 54, 375-380.

Veugelers, P., Yip, A., & Elliott, D. (2003). Geographical variations in health services use in Nova Scotia. *Chronic Diseases in Canada*, 24, available at http://origin.phac-aspc.gc.ca/publicat/cdic-mcc/24-4/f_e.html, retrieved in September, 2010.

Wakefield, J.C., Kelsall, J.E., & Morris, S.E. (2001). Clustering, cluster detection, and spatial variation in risk. Chapter 8 in P. Elliott, J. Wakefield, N. Best, & D. Briggs (Eds.), *Spatial Epidemiology: Methods and Applications*. New York: Oxford University Press.

Weber, M. (1958). The Protestant Sects and the Spirit of Capitalism. In Essays in Sociology (pp. 302-322). New York: Oxford University Press.

Wilkinson, R.G. (2005). *The Impact of Inequality: How to Make Sick Societies Healthier*. New York: New Press.

Wilkinson, R.G. (1996). *Unhealthy Societies: The Afflictions of Inequality*. London & New York: Routeledge.

Woodward, A., & Kawachi, I. (2000). Why reduce health inequalities? *Journal of Epidemiology and Community Health*. 54, 923-929.

Wright, E.G. (1996). *Class counts: comparative studies in class analysis*. New York: Cambridge University Press.

Yen, I.H., & Kaplan, G.A. (1999). Poverty area residence and change in depression and perceived health status. *International Journal of Epidemiology*, 28, 90-94.

APPENDIX A. Community and Community Cluster Names

No	Community/Cluster name	Individual community names
1	Dingwall	Dingwall
2	EnglishIngonish	Englishtown/Ingonish
3	Cheticamp	Cheticamp
4	Margaree	Margaree
5	Baddeck	Baddeck
6	Boularderie Island	Boularderie Island
7	Florence	Florence
8	New Waterford	New Waterford
9	Sydney Mines	Sydney Mines
10	Inverness	Inverness
11	North Sydney	North Sydney
12	Dominion	Dominion
13	FrenchGeorgesRiver	Frenchvale/Georges River
14	Glace Bay	Glace Bay
15	Sydney Northwest	Sydney Northwest
16	Port Morien	Port Morien
17	Point Edward Peninsula	Point Edward Peninsula
18	Sydney Southeast	Sydney Southeast
19	LilNarrowWhyMabou	Little Narrows/Whycocomagh/Mabou
20	EastBayBoisdaleH	East Bay/Boisdale HIlls
21	Coxheath	Coxheath
22	Sydney River	Sydney River
23	Mira East	Mira East
24	Howie Centre	Howie Centre
25	Mira West	Mira West
26	Louisbourg	Louisbourg
27	LongGlenPortHood	Long Point/Glendale/Port Hood
28	Eskasoni IR 3	Eskasoni IR 3
29	TidPugPortHowe	Tidnish/Pugwash/Port Howe
30	Amherst	Amherst
31	MalignantMahoneysPomquet	Malignant Cove/Mahoneys Beach/Pomquet
32	WallaceWentworth	Wallace/Wentworth
33	Oxford	Oxford
34	StPetersLArdoise	St. Peter’s/ L’Ardoise
35	AdvocateRiverHebert	Advocate Harbour/River Hebert
36	Pictou	Pictou
37	River John	River John
38	ClydesdaleSaltA	Clydesdale/Salt Spring (Antigonish)
39	Tatamagouche	Tatamagouche
40	Springhill	Springhill
41	DundeeLouisdale	Dundee/Louisdale

No	Community/Cluster name	Individual community names
42	Port Hawkesbury	Port Hawkesbury
43	LittleMerigoLanding	Little harbor/Merigomish/Pictou Landing
44	HavreBTracadie	Havre Boucher/Tracadie
45	EarltownNewAnnanEconomy	Earltown/New Annan/Economy
46	Scotsburn	Scotsburn
47	Antigonish	Antigonish
48	GuysMulgrave	Guysborough/Mulgrave
49	Trenton	Trenton
50	New Glasgow	New Glasgow
51	Lower South River	Lower South River
52	JamesAndrewsLochaber	James River
53	Westville	Westville
54	Isle Madame	Isle Madame
55	Thorburn	Thorburn
56	BlueMountainSaltP	Blue Mountain/Salt Springs (Pictou)
57	Parrsboro	Parrsboro
58	Glenholme	Glenholme
59	Stellarton	Stellarton
60	East Mountain	East Mountain
61	Hopewell	Hopewell
62	Lower Onslow	Lower Onslow
63	DebertGreenfieldC	Debert/Greenfield (Colchester)
64	MelSherCountry	Melrose/Sherbrooke/Cross Road Country Harbour
65	Bible Hill	Bible Hill
66	WittenUpperStewiacke	Wittenburg/Upper Stewiacke
67	Truro	Turuo
68	CansoLarrysRiver	Canso/Larrys River
69	HildenOldBarns	Hilden/Old Barns
70	IndianMilbrookIRs	Indian Brook IR 13/Millbrook IR 27
71	Blomidon	Blomidon
72	SmithsCRawdonMaitlandH	Smiths Corner/Upper Rawdon/Maitland (Hants)
73	NoelKennetcook	Noel/Kennetcook
74	BrookStewiacke	Brookfield/Stewiacke
75	UpperMiddleMusquodoboit	Upper Musquodoboit/Middle Musquodoboit
76	KemptSummerville	Kempt Shore/Summerville
77	Canning	Canning
78	HarbourGeorge	Harbourville/Lake George
79	Shubenacadie	Shubenacadie
80	Centreville	Centreville
81	NineMileMilStation	Nine Mile River/ Milford Station
82	SheetMoser	Sheet Harbour/ Moser River
83	SomerLakeville	Somerset/Lakeville

No	Community/Cluster name	Individual community names
84	GrandPreWilliams	Grand Pre/Port Williams
85	Hantsport	Hantsport
86	Brooklyn	Brooklyn
87	Kentville	Kentville
88	Wolfville	Wolfville
89	MargaretsPortLorne	Margaretsville/Port Lorne
90	MilvilleAylesford	Milville/Aylesford
91	New Minas	New Minas
92	Coldbrook	Coldbrook
93	CambridgeWaterville	Cambridge/Waterville
94	AltonGaspereau	Alton/Gaspereau
95	Berwick	Berwick
96	Falmouth	Falmouth
97	Kingston	Kingston
98	Lantz	Lantz
99	Elmsdale	Elmsdale
100	NewportWindorForks	Newport Corner/Windsor Forks
101	Windsor	Windsor
102	Enfield	Enfield
103	Middleton	Middleton
104	Three Mile Plains	Three Mile Plains
105	Greenwood	Greenwood
106	Mount Uniacke	Mount Uniacke
107	Ship Harbour	Ship Harbour
108	LawrenceMilford	Lawrencetown (Annapolis)/Milford
109	Fall River	Fall River
110	Beaver Bank	Beaver Bank
111	Bridgetown	Bridgetown
112	SmallLunenComms	Chelsea/Hemford/NewRoss/Windsor Road
113	JeddoreMusquodoboit	Jeddore/Musuodoboit Harbour
114	GranRoyal	Granville Ferry/Port Royal
115	Porters Lake	Porters Lake
116	Chezzetcook	Chezzetcook
117	Sackville North	Sackville North
118	Hammonds Plains	Hammonds Plains
119	Annapolis Royal	Annapolis Royal
120	Lake Echo	Lake Echo
121	Sackville South	Sackville South
122	Preston	Preston
123	Waverley	Waverley
124	St. Margarets Bay	St. Margarets Bay
125	Hubbards	Hubbards

No	Community/Cluster name	Individual community names
126	Bedford	Bedford
127	BlandNewGermany	Blandford/New Germany
128	MapleNewCorn	Maplewood/New Cornwall
129	Tantallon	Tantallon
130	CornwallisBear	Cornwallis Park/Bear River
131	Dartmouth North	Dartmouth North
132	Cole Harbour	Cole Harbour
133	Dartmouth East	Dartmouth East
134	Lawrencetown_H	Lawrencetown (Halifax)
135	Digby	Digby
136	Clayton Park	Clayton Park
137	Timberlea	Timberlea
138	Dartmouth South	Dartmouth South
139	Halifax Needham	Halifax Needham
140	Digby Neck	Digby Neck
141	Fairview	Fairview
142	Halifax Chebucto	Halifax Chebucto
143	Western Shore	Western Shore
144	Eastern Passage	Eastern Passage
145	Chester Basin	Chester Basin
146	SmithBarton	Smith Barton
147	Halifax Citadel	Halifax Citadel
148	Armdale-Northwest Arm	Armdale-Northwest Arm
149	Hatchet Lake	Hatchet Lake
150	HackettsPeggyTerence	Hacketts Cove/ Peggys Cover/Terence Bay
151	Spryfield	Spryfield
152	Chester	Chester
153	Herring Cove	Herring Cove
154	Sambro	Sambro
155	Prospect	Prospect
156	GreenNorthQueens	Greenfield (Queens)/North Queens
157	Mahone Bay	Mahone Bay
158	Northfield	Northfield
159	Weymouth	Weymouth
160	NewcombMaitlandL	Newcombville/Maitland (Lunenburg)
161	Lunenburg	Lunenburg
162	SalmonJoseph	Salmon River/St. Joseph
163	ChurchSaulnier	Church Point/Saulnierville
164	Bridgewater	Bridgewater
165	LaHave	LaHave
166	PetiteItalyBroadCove	Petite Italy/Broad Cove
167	MedwayMouton	Medway/Port Mouton

No	Community/Cluster name	Individual community names
168	Meteghan	Meteghan
169	QuinanCarleton	Quinan/Carleton
170	Liverpool	Liverpool
171	SouthOPortMaitland	South Ohio/Port Maitland
172	ClydeRiverWelsh	Clyde River/Welshtown
173	Hebron	Hebron
174	TusketArgyle	Tusket/Argyle
175	Lockeport	Lockeport
176	Shelburne	Shelburne
177	Yarmouth	Yarmouth
178	Arcadia	Arcadia
179	WedgeAmiraults	Wedgeport/Amiraults Hill
180	Pubnico	Pubnico
181	Barrington	Barrington
182	Cape Sable Island	Cape Sable Island

APPENDIX B. Life Expectancy for Each Community/Community Cluster—Before and After Regression Modeling

No	Community/Cluster	FT1	FT1-PR	FT2	FT2-PR	MT1	MT1-PR	MT2	MT2-PR
1	Dingwall	79.99	80.34	80.5	80.84	72.17	72.68	73.66	74.53
2	EnglishIngonish	77.65	78.24	78.94	79.45	66.19	68.09	70.78	72.02
3	Cheticamp	78.98	79.16	81.35	81.14	72.09	72.07	73.34	73.65
4	Margaree	81.03	80.42	81.88	81.64	75.06	74.28	75.8	75.14
5	Baddeck	79.09	79.52	80.62	80.8	73.41	73.22	72.97	73.69
6	Boularderie Island	79.46	80.53	80.8	81.52	72.23	73.4	75.95	76.52
7	Florence	81.05	79.94	81.65	81.26	72.31	72.16	74.95	74.37
8	New Waterford	77.74	78.34	81.41	80.93	72.06	71.81	73.08	73.18
9	Sydney Mines	79.75	79.09	80.02	80	71.23	71.14	72.51	72.76
10	Inverness	77.77	78.36	79.97	80.09	69.4	70.13	72.92	73.12
11	North Sydney	76.45	77.76	80.04	80.03	71.16	71.2	74.73	73.85
12	Dominion	78.97	79.19	82.75	81.94	70.81	71.57	74.73	74.32
13	FrenchGeorgesRiver	81.09	80.56	80.87	81.3	75.02	74.54	76.15	75.86
14	Glace Bay	79.48	79	80.55	80.37	71.93	71.64	73.45	73.3
15	Sydney Northwest	78.19	78.21	81.01	80.48	72.02	71.29	72.61	72.62
16	Port Morien	82.37	80.75	80.24	80.55	73.71	73.4	75.76	74.98
17	Point Edward Peninsula	80.44	80.19	82.01	81.71	75.18	74.55	75.17	74.91
18	Sydney Southeast	79.79	79.22	80.68	80.5	72.28	72.12	74.41	73.83
19	LilNarrowWhyMabou	79.17	79.62	81.44	81.48	71.1	72.06	73	74.01
20	EastBayBoisdaleH	79.63	79.65	82.73	82.19	72.63	72.78	76.75	75.71
21	Coxheath	82.08	81.12	83.05	82.71	74.09	74.2	75.73	75.87
22	Sydney River	80.25	80.26	80.47	81.13	72.74	73.39	74.4	75.19
23	Mira East	81.94	80.81	83.15	82.45	77.29	75.74	75.77	75.27
24	Howie Centre	77.7	79.15	83.65	83.03	73.37	73.65	77.14	76.47
25	Mira West	77.81	79.07	81.56	81.46	71.89	72.65	72.52	73.64
26	Louisbourg	80.56	79.97	80.13	80.43	74.33	73.7	73.84	73.94
27	LongGlenPortHood	79.19	79.45	81.18	81.46	73.95	73.57	73.81	74.67
28	Eskasoni IR 3	75.82	76.28	72.11	74.56	61.65	63.71	67.26	69.14
29	TidPugPortHowe	80.46	80.56	79.54	80.48	73.18	73.76	77.56	77.11
30	Amherst	80.55	80.04	82.17	81.58	74.46	73.84	77.39	76.2
31	MalignantMahoneysPomquet	81.14	81.21	83.82	83.17	74.88	75.08	77.53	77.3
32	WallaceWentworth	79.06	79.81	80.97	81.1	71.98	72.83	76.26	76.04
33	Oxford	80.07	80.14	76.4	78.25	71.07	72.25	75.25	75.39
34	StPetersLArdoise	78.99	79.43	81.98	81.56	76.11	74.84	77.97	75.97
35	AdvocateRiverHebert	80.41	79.97	80.17	80.39	74.36	73.61	73.84	74.49
36	Pictou	79.46	79.78	82.2	81.86	73.85	73.75	76.83	76.36
37	River John	82.3	81.2	80.97	81.16	75.19	74.72	76.63	76.32
38	ClydesdaleSaltA	82.43	81.63	77.91	79.62	74.37	74.7	75.18	76.2
39	Tatamagouche	77.37	78.73	82.19	81.71	72.84	72.79	69.57	72.64
40	Springhill	79.68	79.78	81.05	80.82	74.49	73.92	74.5	74.67

No	Ncomm	FT1	FT1-PR	FT2	FT2-PR	MT1	MT1-PR	MT2	MT2-PR
41	DundeeLouisdale	80.71	80.16	82.47	81.91	74.15	73.77	76.95	75.59
42	Port Hawkesbury	79.27	79.56	80.14	80.63	74.24	74.02	75.94	75.34
43	LittleMerigoLanding	80.84	80.72	80.1	80.87	74.64	74.6	73.65	75.33
44	HavreBTracadie	79.86	80.4	75.65	78.12	73.98	74.25	75.7	76.11
45	EarltownNewAnnanEconomy	81.35	80.91	82.37	81.78	74.13	74.26	75.98	75.62
46	Scotsburn	76.76	79.27	82.36	82.18	76.8	76.07	77.75	77.18
47	Antigonish	80.85	80.87	82.78	82.34	75.04	75.13	75.48	75.95
48	GuysMulgrave	80.81	80.12	82.78	81.87	72.71	72.6	76.71	75.72
49	Trenton	80.39	80.11	81.05	80.97	73.92	73.62	73.27	74.32
50	New Glasgow	81.13	80.54	81.28	81.17	74.68	74.4	75.65	75.55
51	Lower South River	81.71	80.86	83.96	82.89	76.9	75.6	77.18	76.49
52	JamesAndrewsLochaber	81.9	81.48	85.2	84.12	73.31	74.17	77.62	77.59
53	Westville	81.14	80.41	81.53	81.25	74.17	73.78	74.77	75.02
54	Isle Madame	81.13	81.69	80.64	81.59	73.88	74.56	78.11	77.66
55	Thorburn	83.11	81.69	80.44	80.88	71.47	72.79	76.86	76.49
56	BlueMountainSaltP	81.64	81.05	81.27	81.36	72.92	73.58	73.66	74.92
57	Parrsboro	78.84	79.15	78.85	79.47	75.35	73.94	78.13	76.33
58	Glenholme	78.16	79.4	78.04	79.19	74.21	74.06	76.9	76.07
59	Stellarton	80.7	80.22	79.94	80.21	73.51	73.37	75.59	75.27
60	East Mountain	79.17	79.98	82.98	82.61	74.31	74.33	76.97	76.89
61	Hopewell	81.13	80.81	82.73	82.23	73.84	74.06	74.5	75.33
62	Lower Onslow	80.49	80.59	82.34	81.98	75.52	75.16	76.76	76.4
63	DebertGreenfieldC	80.03	80.37	78.97	80.11	75.31	74.94	74.06	75.35
64	MelSherCountry	79.83	79.92	82.75	82.02	73.32	73.15	76.82	76.01
65	Bible Hill	80.83	80.6	82.67	82.26	75.26	74.95	77.97	77.12
66	WittenUpperStewiacke	81.23	80.89	81.76	81.66	76.91	75.79	76.92	76.48
67	Truro	79.93	80	80.83	80.8	73.85	73.98	75.72	75.42
68	CansoLarrysRiver	79.27	79.89	82.71	81.81	74.12	73.93	76.76	75.67
69	HildenOldBarns	79.92	80.44	83.05	82.62	75.98	75.48	78.37	77.56
70	IndianMilbrookIRs	79.24	78.71	80.29	79.5	73.47	72.07	70.63	71.42
71	Blomidon	82.42	81.71	83.25	82.63	74.94	75.18	79.34	77.77
72	SmithsCRawdonMaitlandH	79.97	80.43	82.37	82.01	76.7	75.8	76.69	76.36
73	NoelKennetcook	79.65	79.84	79.43	79.89	72.64	72.86	72.18	73.58
74	BrookStewiacke	79.22	79.9	80.47	80.92	72.71	73.34	74.68	75.52
75	UpperMiddleMusquodoboit	80.63	80.61	80.59	80.78	71.77	72.83	73.29	74.47
76	KemptSummerville	82.43	80.99	79.66	80.09	74.51	73.93	73.22	74.18
77	Canning	80.31	80.44	81.34	81.39	74.65	74.55	72.84	74.54
78	HarbourGeorge	83.6	81.83	83.84	82.92	75.18	74.83	79.32	77.65
79	Shubenacadie	80.84	80.76	76.62	78.64	72.37	73.37	74.3	75.38
80	Centreville	79.73	80.15	79.68	80.59	74.48	74.39	76.18	76.47
81	NineMileMilStation	79.39	80.42	81.42	81.75	74.78	74.99	73.6	75.45
82	SheetMoser	80.85	80.25	80.61	81.01	68.65	70.36	76.84	76.46

No	Ncomm	FT1	FT1-PR	FT2	FT2-PR	MT1	MT1-PR	MT2	MT2-PR
83	SomerLakeville	84.25	82.51	82.84	82.48	76.82	76.29	78.25	77.43
84	GrandPreWilliams	82.41	81.43	82.35	82.29	76.25	75.62	78.69	77.89
85	Hantsport	83.22	81.68	82.71	82.38	72.23	73.25	78.16	77.37
86	Brooklyn	82.04	81.32	79.68	80.46	77.72	76.46	77.16	76.69
87	Kentville	80.76	80.44	81.02	80.98	75.11	74.8	76.66	75.98
88	Wolfville	82.18	81.42	81.56	81.72	76.51	76.17	76.38	76.55
89	MargaretsPortLorne	82.23	81.15	80.84	80.87	76.62	75.53	75.42	75.38
90	MilvilleAylesford	82.75	81.49	82.85	82.24	76.94	75.88	77.46	76.64
91	New Minas	82.37	81.04	82.47	81.86	77.1	75.71	77.46	76.39
92	Coldbrook	83.64	82.33	81.23	81.73	76.74	76.29	77.44	77.51
93	CambridgeWaterville	78.84	79.53	81.74	81.4	74.59	74.15	72.64	74.04
94	AltonGaspereau	83.46	81.78	82.12	81.95	77.92	76.4	79.38	77.8
95	Berwick	80.62	80.6	79.01	79.92	73.33	73.95	76.03	75.94
96	Falmouth	81.52	81.33	81.68	81.95	74.47	74.86	72.95	75.26
97	Kingston	80.13	80.44	81.64	81.5	75.59	75.32	73.24	74.61
98	Lantz	80.81	81.09	80.29	81.15	73.14	74.11	75.95	76.72
99	Elmsdale	77.39	79.53	83.34	82.94	74.21	74.59	77.36	77.35
100	NewportWindorForks	80.57	80.75	81.84	81.9	75.42	75.2	77.05	76.91
101	Windsor	76.24	78.38	80.21	80.55	73.73	73.69	71.23	73.49
102	Enfield	79.39	80.42	81.95	82.11	73.8	74.43	76.09	76.74
103	Middleton	80.86	80.4	81.45	81.25	74.71	74.31	75.35	75.38
104	Three Mile Plains	79.54	79.99	83.01	82.22	73.37	73.62	76.85	76.14
105	Greenwood	82.84	81.68	83.83	83.02	76.22	75.8	78.31	77.4
106	Mount Uniacke	79.79	80.5	80.75	81.25	74.83	74.94	75.79	76.32
107	Ship Harbour	78.78	79.79	83.81	82.6	73.34	73.57	76.74	75.9
108	LawrenceMilford	79.45	80.03	79.53	80.1	76.24	75.3	75.76	75.55
109	Fall River	81.3	81.36	83.86	83.37	76.82	76.14	79.47	78.75
110	Beaver Bank	81.2	81.15	82.76	82.56	74.83	75.02	76.04	76.68
111	Bridgetown	79.76	80.16	80.22	80.64	75	74.77	74.62	75.25
112	SmallLunenComms	79.9	80.28	81.94	81.57	75.71	75.05	77.94	76.61
113	JeddoreMusquodoboit	79.51	80.18	81.6	81.59	71.95	72.99	78.04	77.11
114	GranRoyal	79.41	80.12	80.88	81.15	75.36	75.03	76.28	76.18
115	Porters Lake	80.88	81	82.36	82.4	72.55	73.67	76.58	77.1
116	Chezzetcook	80.66	80.64	82.23	82	74.22	74.28	76.63	76.47
117	Sackville North	81.83	81.54	82.85	82.76	75.24	75.33	78.19	78.01
118	Hammonds Plains	81.72	81.57	82.83	82.77	75.54	75.5	79.42	78.84
119	Annapolis Royal	81.83	80.68	80.21	80.65	73.42	73.39	75.43	75.66
120	Lake Echo	80.93	81.02	82.55	82.35	76.18	75.75	77.5	77.2
121	Sackville South	80.87	80.92	81.7	81.82	74.92	75.04	78.04	77.41
122	Preston	79.46	80.02	80.07	80.46	73.19	73.53	70.09	72.9
123	Waverley	82.03	81.59	82.89	82.83	78.66	77.32	78.63	78.39
124	St. Margarets Bay	83.14	81.96	83	82.74	74.13	74.64	77.56	77.48

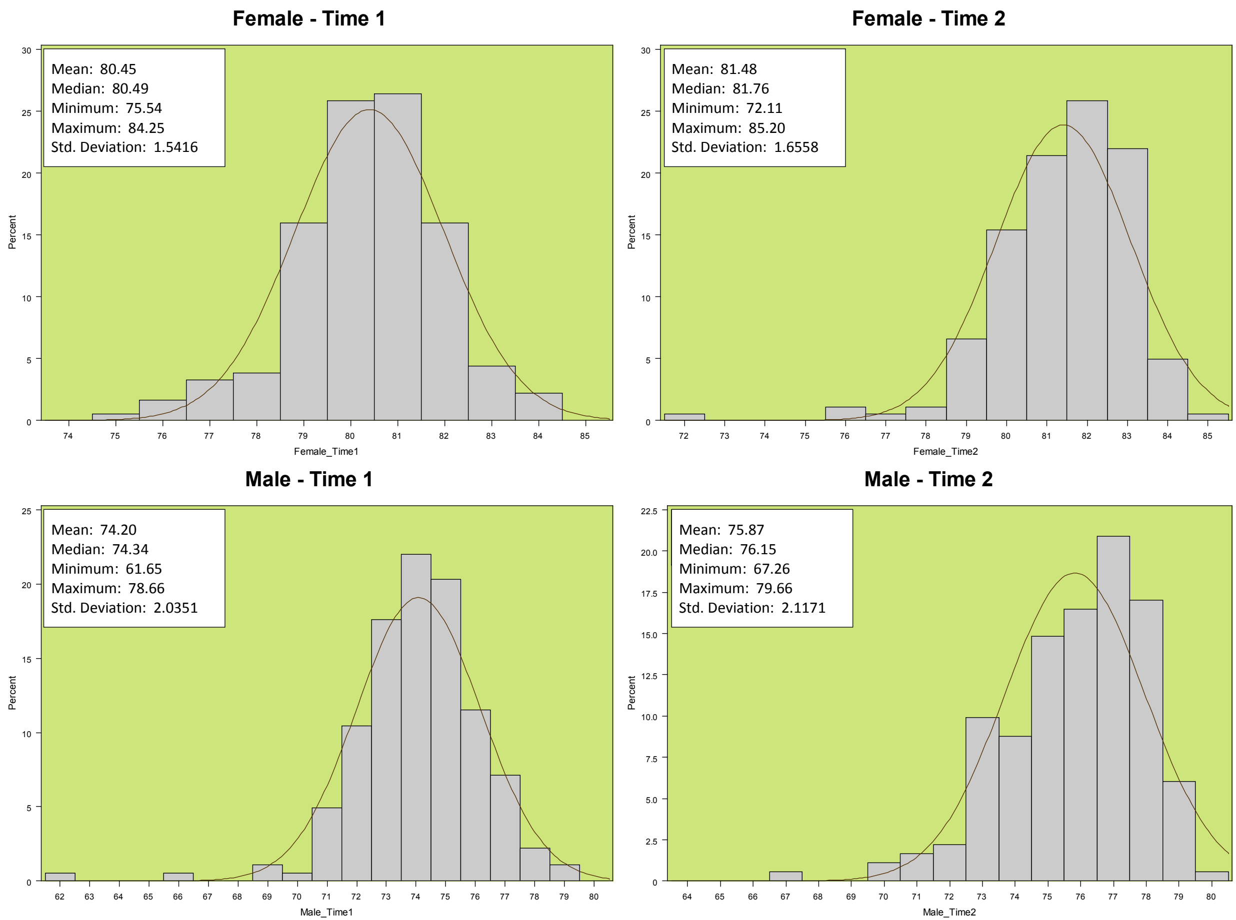
No	Ncomm	FT1	FT1-PR	FT2	FT2-PR	MT1	MT1-PR	MT2	MT2-PR
125	Hubbards	81.1	80.79	80.84	81.24	73.04	73.75	75.19	75.93
126	Bedford	82.71	81.91	82.64	82.61	77.58	76.92	79.66	78.65
127	BlandNewGermany	80.13	80.32	80.14	80.49	73.02	73.5	74.35	74.95
128	MapleNewCorn	80.35	80.66	82.95	82.32	76.06	75.51	77.86	76.82
129	Tantallon	80.75	81.12	82.55	82.62	75.96	75.68	78.85	78.5
130	CornwallisBear	80.12	80.06	78.86	79.6	74.03	73.67	74.12	74.61
131	Dartmouth North	80.09	79.7	81.1	80.92	73.12	73.17	74.62	74.8
132	Cole Harbour	81.02	81.18	82.9	82.71	76.27	75.91	79.03	78.26
133	Dartmouth East	82.26	81.57	82.43	82.36	76.15	75.87	78.11	77.65
134	Lawrencetown_H	81.4	81.47	83.42	83.14	75.4	75.33	77.92	78.02
135	Digby	80.32	79.76	79.58	79.67	72.97	72.59	75.23	74.56
136	Clayton Park	82.24	81.56	82.37	82.29	76.29	76.19	78.37	77.66
137	Timberlea	81.24	81.12	82.48	82.43	74.49	74.8	78.82	78.09
138	Dartmouth South	80.22	80.22	82.44	82.1	74.61	74.67	77.18	76.65
139	Halifax Needham	78.75	79.24	79.04	79.73	71.57	72.22	73.25	74.22
140	Digby Neck	80.38	80.29	83.06	82.16	72.36	72.84	71.57	73.44
141	Fairview	80.45	80.39	81.21	81.13	73.92	74.22	76.88	76.12
142	Halifax Chebucto	81.16	80.94	82.01	81.99	76.33	75.89	77.66	77.17
143	Western Shore	79.69	80.06	78.8	79.6	71.72	72.64	76.14	75.64
144	Eastern Passage	77.4	79.41	81.05	81.44	74.57	74.79	76.2	76.56
145	Chester Basin	82.26	81.36	82.53	82.23	75.76	75.3	79.14	77.78
146	SmithBarton	79.68	80.02	82.38	81.75	74.43	74.02	73.83	74.51
147	Halifax Citadel	81.29	81.34	81.63	82.03	74.72	75.62	77.5	77.57
148	Armdale-Northwest Arm	79.5	80.2	80.88	81.34	72.67	73.82	74.91	75.89
149	Hatchet Lake	82.73	81.95	82.94	82.71	74.18	74.64	76.43	76.93
150	HackettsPeggyTerence	80.75	80.83	83.14	82.61	76.84	75.93	76.48	76.53
151	Spryfield	78.89	79.17	81.84	81.12	73.19	72.87	75.28	74.73
152	Chester	74.54	78.21	81.93	81.94	72.97	73.9	71.92	74.47
153	Herring Cove	79.49	80.4	82.26	82.3	75.14	75.11	77.03	77.23
154	Sambro	80.21	80.76	83.02	82.72	74.34	74.7	77.83	77.48
155	Prospect	81.28	81.31	83	82.79	73.82	74.46	76.82	77.2
156	GreenNorthQueens	79.88	80.45	78.81	79.79	73.31	74	76.67	76.17
157	Mahone Bay	82.13	81.16	82.13	81.88	72.51	73.31	75.52	75.85
158	Northfield	82.35	81.83	82.83	82.79	75.38	75.57	76.83	77.26
159	Weymouth	80.25	80.26	79.4	79.72	72.94	73.14	76.62	75.45
160	NewcombMaitlandL	82.12	81.58	83.62	83.09	76.03	75.74	78.32	77.66
161	Lunenburg	80.67	80.61	81.86	81.71	75.07	74.79	75.31	75.73
162	SalmonJoseph	80.28	80.43	79.09	79.78	70.99	72.28	76.14	75.59
163	ChurchSaulnier	80.46	80.64	82.39	81.65	72.32	73.16	72.9	73.9
164	Bridgewater	80.59	80.23	81.52	81.32	73.61	73.68	77.18	76.31
165	LaHave	81.16	81.08	80.96	81.26	75.36	75.25	77.26	76.81
166	PetiteItalyBroadCove	77.24	79.31	82.49	82.12	74.04	74.33	77.68	76.87

No	Ncomm	FT1	FT1-PR	FT2	FT2-PR	MT1	MT1-PR	MT2	MT2-PR
167	MedwayMouton	81.79	81.13	81.37	81.24	76.31	75.48	75.47	75.48
168	Meteghan	82.42	81.26	80.95	81.16	70.2	71.65	76.63	76.33
169	QuinanCarleton	83.73	81.96	83.36	82.79	77.68	76.28	78.34	77.43
170	Liverpool	78.51	79.67	80.02	80.44	74.86	74.67	74.53	75.06
171	SouthOPortMaitland	81.03	80.83	81.88	81.76	78.62	76.78	75.36	75.78
172	ClydeRiverWelsh	77.09	79	81.79	81.51	74.76	74.4	78.36	76.86
173	Hebron	79.79	80.2	82.67	82.1	74.07	74.1	72.2	74.08
174	TusketArgyle	80.69	80.73	79.58	80.2	72.6	73.47	74.01	74.81
175	Lockeport	81.36	80.71	82.36	81.88	70.71	71.92	74.26	74.94
176	Shelburne	80.41	79.97	81.4	80.91	72.72	72.72	74.55	74.47
177	Yarmouth	79.21	79.39	81.08	80.62	71.87	72.13	76.14	75.07
178	Arcadia	79.8	80.18	80	80.41	71.38	72.46	74.66	75.02
179	WedgeAmiraults	81.75	81.43	83.18	82.55	73.91	74.44	77.53	76.79
180	Pubnico	79.41	80.56	83.62	83.35	75.78	75.71	75.9	76.94
181	Barrington	81.06	80.54	78.92	79.41	75.38	74.62	77.62	75.9
182	Cape Sable Island	79.57	81.1	82.84	82.38	75.58	75.55	75.44	75.49

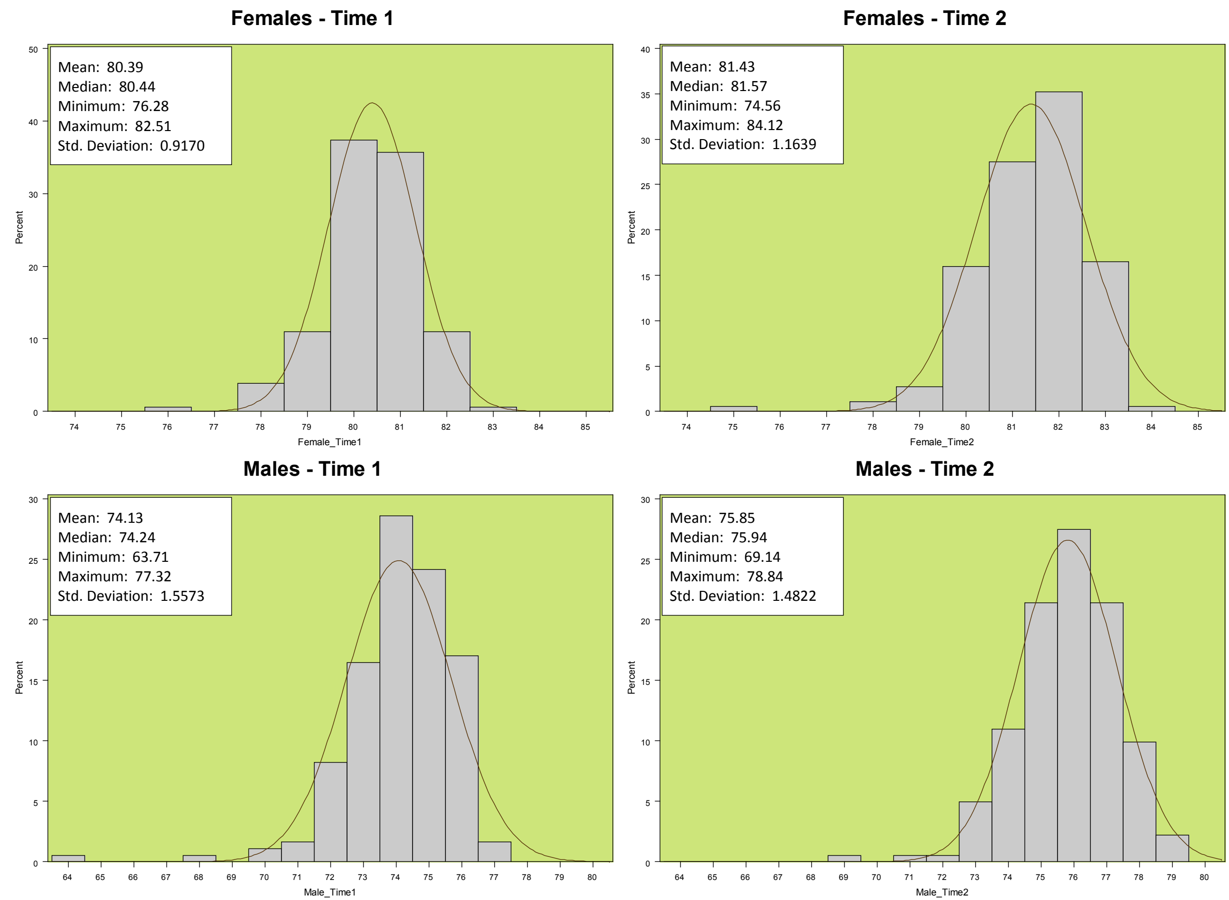
Note:

FT1: Females at Time 1 (pre-regression)
FT2: Females at Time 2 (pre-regression)
MT1: Males at Time 1 (pre-regression)
MT2: Males at Time 2 (pre-regression)
FT1-PR: Females at Time 1 (post-regression)
FT2-PR: Females at Time 2 (post-regression)
MT1-PR: Males at Time 1 (post-regression)
MT2-PR: Males at Time 2 (post-regression)

APPENDIX C. Distribition (Histogram) of Life Expectancy at Birth by Community—Before Regression Modeling



APPENDIX C. Distribution (Histogram) of Life Expectancy at Birth by Community—After Regression Modeling



APPENDIX D. Regression Model with Six Individual Variables in Deprivation Indices (Centered)-Results

Time 1	Females	Males
Intercept	80.06 (79.69, 80.51)	74.13 (73.82, 74.44)
Average income	-0.2498 (-0.6597, 0.162)*	0.1342 (-0.3199, 0.577)*
Unemployment	-0.1153 (-0.5662, 0.3626)*	0.01094 (-0.3966, 0.4156)*
Less than high school	-0.3598 (0.7455, 0.07338)*	**-0.5212 (-1.03, -0.01632)**
Living alone	-0.3212 (-0.9143, 0.1737)*	-0.4299 (-0.9128, 0.06094)*
Single parents	**-0.5503 (-0.9958, -0.07558)**	**-0.8596 (-0.286, -0.4444)**
Separated/widowed/divorced	0.2462 (-0.3334, 1.06)*	0.1913 (-0.3768, -0.5195)*
Spatial autocorrelation variance	0.04804 (0.01252, 0.1875)	0.2173 (0.01312, 1.83)
Unaccounted factors variance	0.9557 (0.01511, 2.523)	0.4114 (0.01425, 2.242)
DIC	-3625.550	-70374.100

Time 2	Females	Males
Intercept	81.24 (80.97, 81.5)	75.87 (75.55, 76.3)
Average income	0.9594 (0.4949, 1.436)*	0.6021 (0.1176, 1.111)
Unemployment	0.1674 (-0.1871, 0.5174)*	**-0.5006 (-0.9758, -0.05607)**
Less than high school	0.2516 (-0.1871, 0.6174)*	0.2759 (-0.1321, 0.6987)*
Living alone	-0.04896 (-0.416, 0.3032)*	-0.05969 (-0.494, 0.3368)*
Single parents	-0.2072 (-0.4714, 0.05484)*	**-0.5077 (-0.8543, -0.1498)**
Separated/widowed/divorced	-0.09289 (-0.4771, 0.309)*	-0.09502 (-0.5166, 0.4023)*
Spatial autocorrelation variance	0.04825 (0.01282, 0.1801)	0.04906 (0.01253, 0.2059)
Unaccounted factors variance	0.4055 (0.01425, 1.894)	0.9176 (0.01513, 2.238)
DIC	-50549.000	-112876.000

Red: the credible intervals do not cross 0—or 'statistically significant'
Asterisk: 90% credible intervals (otherwise they are 95%)

APPENDIX E. Growth in Life Expectancy at Birth (LE) from Time 1 to Time 2 for Communities Experiencing More Than 2 Decile Classes of Deprivation

Communities that are more deprived (became worse-off)

Community/Community cluster	Females	Growth	Males	Growth
Material deprivation ↑				
Church Point/Saulnierville	1.01	Low	0.74	Low
Centreville	0.44	Low	2.08	Low
East Mountain	2.63	High	2.56	Normal
Hantsport	0.7	Low	4.12	High
Social deprivation ↑				
Church Point/Saulnierville	1.01	Low	0.74	Low
Baddeck	1.28	Low	0.47	Low
Cape Sable Island	1.28	Low	-0.06	Low
Earltown/New Annan/Economy	0.87	Low	1.36	Low
Lake Echo	1.33	Low	1.45	Low
MedwayMouton	0.11	Low	0	Low

Communities that are less deprived (became better-off)

Community/Community cluster	Females	Growth	Males	Growth
Material deprivation ↓				
Little Harbour/ Merigomish Pictou Landing	0.15	Low	0.73	Low
Long Point/Glendale/PortHood	2.01	Normal	1.1	Low
Annapolis Royal	-0.03	Low	2.27	Normal
GrandPre/ Port Williams	0.86	Low	2.27	Normal
Meteghan	-0.1	Low	4.68	High
Social deprivation ↓				
Point Edward Peninsula	1.52	Normal	0.36	Low
UpperMusquidoboit/ MiddleMusquodoboit	0.17	Low	1.64	Low
Weymouth	-0.54	Low	2.31	Normal
Arcadia	0.23	Low	2.56	Normal
Greenfield/North Queens	-0.66	Low	2.17	Low
Kingston	1.06	Low	-0.71	Low
Liverpool	0.77	Low	0.39	Low
Tusket/Argyle	-0.53	Low	1.34	Low

The level of growth was considered to be high if it was 0.5 years above Nova Scotia average, low if it was 0.5 years below average, and normal if it is in between the 0.5 years range from the average.

APPENDIX F. WinBUGS Codes for the Final Multivariate Linear Regression Model (Model 5)

Females at Time 1. Females at Time 2, males at Time 1 and Time 2 follow the same code

-Explanatory variables:

1. Material deprivation
2. Social deprivation
3. Interaction between material and social deprivation
4. Spatially correlated unaccounted effect
5. Heterogeneous unaccounted effect

-Outcome/dependent variable

Life expectancy at birth

```
#Multivariate linear regression model in WinBUGS
#For Females Time 1 (1995-1999)

model{
	for (i in 1 : N) {
		# Observed LE are normally distributed with some residuals that are randomly distributed
		(stochastic)
		O[i]  ~ dnorm(mu[i], tau.z)
		mu[i] <- alpha + beta1 * Mat[i] + beta2 * Soc[i] + beta3 * Mat[i] * Soc[i] + b[i] + h[i]
		LE[i] <- alpha + beta1 * Mat[i] + beta2 * Soc[i] + beta3 * Mat[i] * Soc[i] + b[i] + h[i]
		LERes[i] <- b[i] + h[i]     #Calculate overall residuals for each community
		LESp[i] <-b[i]              #Calculate spatially correlated residuals for each community
		LENonSp[i] <- h[i]          #Calculate spatially uncorrelated residuals for each community


# Variance ratio of the spatially structured random effect to the spatially unstructured random effect=tau.h/tau.b

		# Prior on unstructured random effects
		h[i] ~ dnorm(0, tau.h)
	}

	# CAR (normal) prior distribution for spatial random effects.
	# b is U in Methodology section.  It is calculated as the equally weighted average residuals of the
	surrounding
	# communities

	b[1:N] ~ car.normal(adj[], weights[], num[], tau.b)
	for(k in 1:sumNumNeigh) {
		weights[k] <- 1
	}

	# Other priors.  They are set to be very flat because we do not have any prior knowledge about the
	#distribution of these parameters.  'Sigma.' represents the overall variance for each parameter; or
	#tau=1/variance.

	alpha  ~ dflat()
	beta1 ~ dnorm(0.0, 1.0E-5)
	beta2 ~ dnorm(0.0, 1.0E-5)
	beta3 ~ dnorm(0.0, 1.0E-5)
	tau.b  ~ dgamma(0.5, 0.0005)
	sigma.b <- sqrt(1 / tau.b)
	tau.z  ~ dgamma(0.5, 0.0005)
	sigma.z <- sqrt(1/tau.z)
	tau.h  ~ dgamma(0.5, 0.0005)
	sigma.h <- sqrt(1 / tau.h)

}
```

Data

```
list(N = 182

O = c(79.99,77.65,78.98,81.03,79.09,79.46,81.05,77.74,79.75,77.77,76.45,78.97,  # LE calculated with Chiang method
81.09,79.48,78.19,82.37,80.44,79.79,79.17,79.63,82.08,80.25,81.94,77.7,          # for each community
77.81,80.56,79.19,75.82,80.46,80.55,81.14,79.06,80.07,78.99,80.41,79.46,         # These communities are ordered
                                                                                 # by appearance of the north east
82.3,82.43,77.37,79.68,80.71,79.27,80.84,79.86,81.35,76.76,80.85,80.81,80.39,    # point of the polygon
81.13,81.71,81.9,81.14,81.13,83.11,81.64,78.84,78.16,80.7,79.17,81.13,80.49,
80.03,79.83,80.83,81.23,79.93,79.27,79.92,79.24,82.42,79.97,79.65,79.22,80.63,
82.43,80.31,83.6,80.84,79.73,79.39,80.85,84.25,82.41,83.22,82.04,80.76,82.18,
82.23,82.75,82.37,83.64,78.84,83.46,80.62,81.52,80.13,80.81,77.39,80.57,
76.24,79.39,80.86,79.54,82.84,79.79,78.78,79.45,81.3,81.2,79.76,79.9,79.51,
79.41,80.88,80.66,81.83,81.72,81.83,80.93,80.87,79.46,82.03,83.14,81.1,82.71,
80.13,80.35,80.75,80.12,80.09,81.02,82.26,81.4,80.32,82.24,81.24,80.22,
78.75,80.38,80.45,81.16,79.69,77.4,82.26,79.68,81.29,79.5,82.73,80.75,
78.89,74.54,79.49,80.21,81.28,79.88,82.13,82.35,80.25,82.12,80.67,80.28,
80.46,80.59,81.16,77.24,81.79,82.42,83.73,78.51,81.03,77.09,79.79,80.69,
81.36,80.41,79.21,79.8,81.75,79.41,81.06,79.57
),

Mat = c(2.164,1.701,1.464,0.947,0.762,0.726,1.393,0.844,1.118,0.95,0.822,0.759,   #Score of material deprivation
-0.103,0.822,1.216,0.887,-0.349,0.034,0.186,0.317,-1.396,-1.252,0.57,
-0.934,0.54,1.411,0.021,1.654,-0.137,0.106,-0.807,0.779,0.221,0.83,
1.77,-0.016,0.563,-0.758,0.955,0.559,0.917,-0.996,-0.544,0.244,1.47,-0.032,
-1.495,0.955,0.254,-0.688,-0.193,-0.698,0.124,1.115,0.33,0.493,1.476,0.689,
0.171,0.404,0.091,-0.332,0.402,1.609,-0.732,0.498,-0.712,1.837,-0.043,
0.885,0.331,0.103,1.551,0.029,0.508,1.45,0.039,1.064,0.013,0.187,
-0.106,1.283,-0.159,-0.204,-0.351,-0.119,-0.723,-1.69,0.698,0.267,-0.14,
-1.22,0.196,0.222,-0.6,-0.46,-0.836,-0.517,-1.076,-0.1,-0.348,-0.712,0.002,
0.515,-1.117,-0.366,0.74,0.87,-2.448,-0.953,-0.352,0.959,-0.328,0.46,
-0.947,-0.347,-0.971,-1.601,0.165,-1.206,-1.217,1.029,-2.262,-1.185,-0.732,
-2.876,0.66,0.437,-2.626,1.189,-0.603,-1.919,-1.73,-1.869,0.662,-2.335,
-1.205,-1.234,-0.564,1.356,-1.258,-1.815,0.655,-1.064,-0.484,1.299,-3.04,
-1.723,-2.019,-0.056,-0.089,-1.255,-1.181,-0.569,-1.375,-0.127,-0.347,
0.28,1.126,0.441,-0.171,1.508,0.496,-0.49,-0.369,0.179,0.967,0.89,0.597,
-0.383,0.308,0.669,-0.099,0.021,1.253,0.383,0.136,0.529,0.463,-0.036,
0.955,1.326
),

Soc = c(0.222,0.647,-0.059,-0.877,-0.594,-0.124,0.258,1.124,1.129,0.912,1.249,   #Score of social deprivation
0.29,-0.853,1.32,1.628,-0.165,-0.371,1.768,-0.597,-0.043,-1.081,-0.565,
-0.678,-0.449,-0.608,-0.266,0.081,3.306,-0.176,1.496,-1.284,-0.078,
0.458,-0.39,0.425,0.982,-0.14,-0.806,0.792,0.807,-0.498,0.586,0.119,
-0.577,-0.677,-0.988,0.29,0.899,0.989,1.499,0.683,-1.146,1.107,0.009,
-0.444,-0.435,0.939,0.042,1.106,-0.263,-0.172,-0.15,-0.362,0.097,
0.721,-0.461,1.647,-0.395,-0.545,2.887,-1.267,-0.472,0.155,0.238,-0.378,
0.213,0.093,-0.477,-0.376,0.161,-1.195,0.432,-1.361,-0.2,0.185,-0.507,
1.459,0.782,-0.056,-0.181,1.062,-1.541,0.919,-0.165,0.38,-1.131,
0.384,-1.481,-0.684,-0.618,1.613,-1.083,0.953,0.133,0.096,-0.823,
-0.32,-0.195,-1.874,-0.88,0.486,-0.417,-0.118,-0.333,-0.853,-0.051,-1.496,
-1.951,1.167,-0.776,-0.269,-0.292,-0.847,-0.81,0.429,-0.277,-0.16,-0.769,
-1.591,0.288,3.018,-1.276,-0.383,-2.395,1.605,0.912,-0.544,2.043,2.551,
-0.082,1.731,1.173,0.057,-0.135,-0.118,-0.092,1.169,1.301,-1.787,-0.688,
2.315,0.26,-0.636,-1.142,-1.523,-0.557,0.36,-1.769,-0.051,-1.31,0.056,
-0.518,-0.578,1.603,-0.822,-0.528,-0.609,-0.187,-0.566,0.332,-0.409,
-0.006,0.154,-0.442,-0.089,1.325,1.803,-0.09,-1.329,-1.595,0.136,-0.195
),
```

#Adjacent matrix. First it describes the number of adjacent communities for each community. Then it list what numbers of these communities are adjacent. Normally adjacent matrix can automatically be made with GeoBUGS. However, due to some polygon having too many nodes, the adjacent communities needed to be identified manually.

```
num = c(0,2,1,4,4,0,3,2,2,3,
3,5,6,2,3,4,3,6,3,5,
4,5,4,5,7,2,3,1,3,4,
6,6,4,3,3,2,6,5,3,6,
3,2,7,3,9,5,4,4,2,6,
4,9,5,0,5,10,3,4,4,7,
6,6,9,7,4,9,5,2,4,4,
```

```
4,13,4,5,10,2,3,14,5,5,  #80
9,3,8,7,3,6,6,3,6,5,
4,4,5,11,4,3,5,4,4,9,
3,9,4,4,5,8,3,10,6,4,
4,15,3,2,5,4,4,7,3,4,
5,5,6,5,5,7,7,7,4,4,
4,6,4,5,3,4,6,4,3,2,  #140
5,3,4,2,3,5,2,4,8,5,
4,3,3,4,2,4,4,5,3,7,
3,6,3,5,4,4,5,2,5,2,
4,4,4,6,2,2,2,4,2,4,
2,0
),

adj=c(

5,4,
4,
10,5,3,2,
19,10,4,2,

13,11,9,
15,12,
11,7,
19,5,4,    #10
13,9,7,
18,16,15,14,8,
24,21,20,17,11,7,
16,12,
18,12,8,
23,18,14,12,
22,21,13,
25,23,22,16,15,12,
27,10,5,
34,28,25,24,13,   #20
24,22,17,13,
25,24,21,18,17,
26,25,18,16,
25,22,21,20,13,
34,26,24,23,22,20,18,
25,23,
42,41,19,
20,
33,32,30,
40,35,33,29,  #30
52,51,47,44,43,38,
58,45,40,39,33,29,
40,32,30,29,
41,25,20,
57,40,30,
46,37,
60,56,46,45,39,36,
52,51,47,43,31,
45,37,32,
57,45,35,33,32,30,   #40
42,34,27,
41,27,
56,55,52,50,49,38,31,
52,48,31,
63,62,60,58,57,40,39,37,32,
56,53,50,37,36,
52,51,38,31,
68,64,52,44,
50,43,
59,55,53,49,46,43,  #50
52,47,38,31,
64,56,51,48,47,44,43,38,31,
61,59,56,50,46,

61,59,56,50,43,
```

66,64,61,60,55,53,52,46,43,37,
45,40,35,
63,62,45,32,
61,55,53,50,
66,65,63,62,56,45,37, #60
66,64,59,56,55,53,
67,65,63,60,58,45,
74,69,67,66,65,62,60,58,45,
82,75,68,61,56,52,48,
67,63,62,60,
98,81,79,75,74,63,61,60,56,
70,65,69,63,62,
64,48,
74,70,67,63,
81,79,69,67, #70
83,80,78,77,
125,112,106,104,102,100,94,86,81,79,78,74,73,
86,81,76,72,
79,72,69,66,63,
116,115,113,107,102,99,98,82,66,64,
86,73,
84,80,71,
128,127,112,108,105,97,95,94,93,90,89,83,72,71,
81,74,72,70,66,
87,84,83,77,71, #80
102,99,98,81,79,73,72,70,66,
107,75,64,
95,93,92,90,87,80,78,71,
94,91,88,87,85,80,77,
96,94,84,
104,101,100,76,73,72,
94,92,91,84,83,80,
94,91,84,
114,111,108,103,97,78,
105,97,95,83,78, #90
94,88,87,84,
94,93,87,83,
95,94,92,83,78,
100,96,93,92,91,88,87,85,84,78,72,
93,90,83,78,
100,94,85,
105,103,90,89,78,
99,81,75,66,
102,98,81,75,
125,124,106,104,101,96,94,86,72, #100
104,100,86,
122,120,115,109,106,99,81,75,72,
108,105,97,89,
101,100,86,72,
108,103,97,90,78,
124,118,117,110,109,102,100,72,
113,82,75,
156,130,127,119,112,111,105,103,89,78,
126,123,121,110,106,102,
121,117,109,106, #110
119,114,108,89,
167,166,164,160,158,156,152,145,143,128,127,125,108,78,72,
116,107,75,
111,89,
134,120,116,102,75,
134,115,113,75,
121,118,110,106,
137,129,126,124,121,117,106,
130,111,108,
134,122,115,102, #120
126,118,117,110,109,
134,132,123,120,102,
133,132,131,126,122,109,
129,125,118,106,100,
127,124,112,100,72,

```
137,136,131,123,121,118,109,
158,152,128,125,112,108,78,
160,158,157,143,127,112,78,
150,137,124,118,
146,135,119,108,  #130
138,133,126,123,
144,138,134,133,123,122,
138,132,131,123,
132,122,120,116,115,
146,140,130,
149,141,137,126,
150,149,136,129,126,118,
144,133,132,131,
147,142,141,
135,146,   #140
149,148,142,139,136,
147,141,139,
157,145,128,112,
138,132,
152,143,112,
162,159,140,135,130,
142,139,
153,151,149,141,
155,154,151,150,148,141,137,136,
155,154,149,137,129,   #150
154,153,149,148,
145,127,112,
154,151,148,
153,151,150,149,
150,149,
170,167,112,108,
161,160,143,128,
164,160,128,127,112,
163,162,146,
165,164,161,158,157,128,112,   #160
165,160,157,
171,169,168,163,159,146,
168,162,159,
166,165,160,158,112,
166,164,161,160,
167,165,164,112,
175,170,166,156,112,
163,162,
180,174,172,171,162,
167,156,  #170
174,173,169,162,
181,180,176,169,
178,177,174,171,
180,179,178,173,171,169,
176,167,
175,172,
178,173,
179,177,174,173,
178,174,
181,174,172,169,
180,172
),
sumNumNeigh = 827)

Inits    # Initial values to feed for Marko Chain Monte Carlo sampling process.
list(tau.z=1, tau.b = 0.5, tau.h = 0.2, alpha=0.2, beta1=-0.1, beta2=0.3, beta3=0.1,
h = c(1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
1,1,1,1,1,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
1,2,1,2,1,2,1,2,1,2,
2,2,2,2,2,1,1,1,1,1,
```

```
1,1,1,1,1,1,1,1,1,2,
2,1,2,2,2,1,2,2,1,2,
2,2,2,2,2,2,2,2,2,1,
1,1,1,1,1,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,1,
2,2,2,1,1,1,2,2,2,1,
1,1,1,1,1,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
2,2
),

b = c(1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
1,1,1,1,1,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
1,2,1,2,1,2,1,2,1,2,
2,2,2,2,2,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,2,
2,1,2,2,2,1,2,2,1,2,
2,2,2,2,2,2,2,2,2,1,
1,1,1,1,1,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,1,
2,2,2,1,1,1,2,2,2,1,
1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
1,1,1,1,1,1,1,1,1,1,
1,1,1,1,1,1,1,1,1,1,
2,2,2,2,2,2,2,2,2,2,
2,2
))
```