SOCIOECONOMIC POSITION, GENDER AND HYPERTENSION IN A RURAL CANADIAN POPULATION

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ABSTRACT

Background: High blood pressure is the leading risk factor for disease burden world-wide, contributing to more than 9 million deaths each year. Some research suggests that the prevalence of hypertension increases as individual/household socioeconomic position (SEP) decreases. The results of multilevel studies also suggest an association between poorer neighborhood socioeconomic circumstances and hypertension. Further, at both the individual/household- and area-level, high blood pressure may be more strongly related to SEP among women than men. Most research, however, has been restricted to urban populations. There has not been much research which examines risk factors for hypertension in rural Canada and, in particular, socioeconomic risk factors.

Objectives: To examine the relationship between individual/household- and area- level socioeconomic circumstances, gender, and high blood pressure in a rural Saskatchewan population.

Methods: There were two data sources for this study. Individual/household-level data were from the Saskatchewan Rural Health Study (SRHS). Analyses focused on adults (n=8,261) who completed the cross-sectional baseline questionnaire. Census subdivisions were used to link SRHS data with area-level data from the 2006 Canadian census. The dependent variable was self-reported diagnosed high blood pressure. The primary independent variables were gender and four measures of socioeconomic circumstances: household income, educational attainment, area-level material deprivation, and area-level social deprivation. Principal components analysis was used to derive the area-level measures of deprivation. Multilevel logistic regression was the primary method of analysis.

Results: Four main findings emerged: 1) low educational attainment was associated with a greater odds of high blood pressure; 2) the relationship between low household income and high blood pressure was more pronounced among women than men; 3) the relationship between higher area-level social deprivation and high blood pressure was more pronounced among men than women; and 4) area-level material deprivation was not associated with high blood pressure.

Conclusion: Study results revealed complex relationships between SEP, gender, and high blood pressure in this rural Saskatchewan population. Future research applying a longitudinal design is needed to advance understanding of the relationship between SEP and incident hypertension in rural Canada, including the identification of vulnerable subgroups. Also needed is research examining the factors which explain (i.e. mediate) associations between SEP and hypertension in rural settings, particularly at the area-level.

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CHAPTER 1: INTRODUCTION

Worldwide, approximately 970 million people have high blood pressure.[1] In Canada, 22% of 20 to 70 year olds (more than 5 million people) have hypertension, and among 60-79 year olds, the prevalence increases to 52%.[2-4] Of those Canadians with high blood pressure, approximately one-third have uncontrolled hypertension.[2][5] Uncontrolled hypertension is a major risk factor for the development of numerous chronic conditions, including coronary heart disease, stroke, dementia and kidney failure, among others.[1][3][6][7] High blood pressure is the number one risk factor for disease burden worldwide, contributing to more than 9 million deaths each year in 2010.[8][9]

Lifestyle characteristics, such as smoking, physical inactivity, obesity, and high sodium intake, have been identified as important proximal risk factors for the development of high blood pressure.[6][10-17] Research has also examined the risk of high blood pressure in relation to socioeconomic position (SEP).[18-20] Often measured at the individual/household level in terms of educational attainment and income, indicators of SEP are considered to be markers of one's degree of access to health-enhancing psychosocial, material, and behavioral resources.[21] Most studies carried out in developed countries, including Canada, have found the prevalence and incidence of hypertension increases as SEP decreases.[18] Several studies also suggest that the relationship between SEP and high blood pressure may be stronger in women than in men.[22][23]

Some recent research also suggests an association between area-level indicators of SEP (e.g. neighborhood social and material deprivation) and prevalent high blood pressure, even after adjustment for individual/household SEP.[24-27] Similar to that observed at the individual / household level, research suggests that the relationship between area-level SEP and high blood pressure may be more pronounced among women than men.[28-30] For example, Matheson and colleagues, using data from three waves of the Canadian Community Health Survey (CCHSA) found that, only among women, the prevalence of hypertension increased as the level of neighborhood deprivation increased. The extent to which gender differences in the relationship between SEP and high blood pressure may arise from differences in the psychosocial exposures of men and women, differences in biological vulnerability, or some combination of the two, is not well understood.[31]

An important limitation in the aforementioned studies is that the majority of this research, particularly in developed countries, has been restricted to urban populations. The published rural health literature continues to be dominated by studies of health service accessibility.[32] Research examining socioeconomic conditions as risk factors for high blood pressure in rural populations is limited. Due to urban/rural differences in population density, age structure, educational opportunities, and employment practices, commonly used measures of SEP may be less telling of actual access to health enhancing resources in rural contexts.[32-34] The use of area-level measures of SEP in rural settings can be particularly challenging.[35-37]

Previous research using data from the Saskatchewan Rural Health Study (SRHS)[38][39] showed associations between the prevalence of hypertension and various individual/household indicators of SEP, especially for women.[40] However, the potential relationship between area-level socioeconomic circumstances and hypertension, independently and in concert with individual/household level SEP, has yet to be explored in this rural population.

Drawing upon individual/household-level data from the SRHS, combined with area-level data from the 2006 Canada Census, the primary objective of this research was to examine the relationship between individual/household- and area-level SEP, gender, and high blood pressure in a rural Canadian population. Three research questions guided the analyses:

1. Is hypertension associated with individual/household SEP? Is gender an effect modifier in the relationship between individual/household SEP and hypertension?

2. Is hypertension associated with area-level SEP? Is gender an effect modifier in the relationship between area-level SEP and hypertension?

3. Does individual/household SEP interact with area-level SEP to influence hypertension? Is gender an effect modifier in the relationship between individual/household SEP, area-level SEP and hypertension?

CHAPTER 2: LITERATURE REVIEW

Nearly one billion people worldwide have high blood pressure,[1, 2] and by 2025, it is expected that the number will increase to 1.6 billion.(6)(9)(41) Globally, hypertension is the leading cause of mortality and the second leading cause of disability-adjusted life-years.(9) Hypertension is also costly.(42)(43) Approximately 10% of health care costs world-wide in 2001, equaling $370 billion, were attributed to high blood pressure.(44) In Canada in 2007, nearly $2.4 billion dollars was spent on medical care related to hypertension.(17)

2.1 Epidemiology of high blood pressure in Canada

Estimates of the prevalence of high blood pressure in Canada vary depending on the data source.(2)(23)(45) National-level information about hypertension in Canada comes from one of three sources, each with their own particular strengths and weaknesses: 1) the Canadian Chronic Disease Surveillance System (CCDSS); 2) the Canadian Community Health Survey (CCHS); and 3) the Canadian Health Measures Survey (CHMS). The CCDSS is a population-based surveillance system and assesses diagnosed hypertension based on physician reimbursement claims and hospital stays.(46) The CCHS measures diagnosed hypertension based on study participants' self-report of having received a diagnosis or of using medication for high blood pressure.(47) Estimates of hypertension using the CHMS are based on physical blood pressure readings combined with self-reported use of blood pressure medication.(48) The CCDSS covers almost the entire population in Canada, whereas both the CCHS and the CHMS excluded certain populations (e.g. those in institutions, on Indian Reserve). The CHMS is the only source which provides estimates of physically measured hypertension; neither the CCHS nor the CCDSS will

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[1] Blood pressure is a measure of the pressure or force of blood against the walls of blood vessels. Generally, blood pressure is estimated in the brachial artery of the arm and is depicted as two numbers: systolic blood pressure (SBP), the pressure of the squeezing heart and diastolic blood pressure (DBP), the pressure of the relaxing heart. Blood pressure is considered optimal when SBP is no more than 120 mmHg and DBP is no more than 80 mmHg. Hypertension, or high blood pressure, is usually defined as blood pressure which is consistently more than 140/90 mmHg when measured in the doctor's office or 135/85 mmHg when measured at home. Blood pressure which is consistently slightly raised (ie., SBP 120 to 139 mm Hg or DBP 80 to 89 mm Hg) is called pre-hypertension.(2)

[2] The terms hypertension and high blood pressure will be used interchangeably in this thesis.

capture hypertension that has not been diagnosed by a health professional. Only the CCDSS can provide information on the incidence of diagnosed hypertension.

In 2007-2008, 418,000 Canadians 20 years of age and older were newly diagnosed with hypertension; the age standardized incidence was 2.0 per 100 per year. Estimates of the crude prevalence of high blood pressure among 20-79 year olds, by source of data, were: 20.3% (CCDSS), 18.2% (CCHS), and 19.5% (CHMS). According to results from the 2009-2011 CHMS, of 20-79 year olds with hypertension, 64% had controlled hypertension (ie., hypertension was being successfully treated), 15% had uncontrolled hypertension (ie., hypertension was being treated but blood pressure remained elevated) and 17% were unaware of their condition.[45][50]

Based on CCDSS data,[23] Figure 2.1 shows that the age-standardized prevalence of hypertension among Canadian adults increased from 12.5% in 1998-99 to 19.6% in 2007-08, whereas the incidence decreased from 2.7 per 100 to 2.4 per 100. The authors attribute the increase in prevalence to greater awareness and thus diagnosis of hypertension by health professionals, along with declining mortality rates among those with cardiovascular diseases, including high blood pressure.

Shown in Figure 2.2 are estimates of the prevalence and incidence of hypertension among Canadians by age.[23] Both prevalence and incidence (up to 80 years) increase with age. Starting at age 65, the majority of Canadian adults had received a diagnosis of hypertension.

In 2007-2008, the crude incidence of hypertension was higher among men (2.1%) than among women (1.9%), whereas the opposite was true when crude prevalence was considered (24.3% versus 21.7%). However, observed sex/gender differences in the crude prevalence of high blood pressure depends on the data source.[49] Hypertension is slightly more common among women than men when the CCDSS or CCHS is used, but more common among men when assessed by the CHMS. As mentioned previously, the CCDS and CCHS measures diagnosed high blood pressure; women, on average, may be more likely than men to see their family doctor, resulting in a greater probability of being diagnosed.

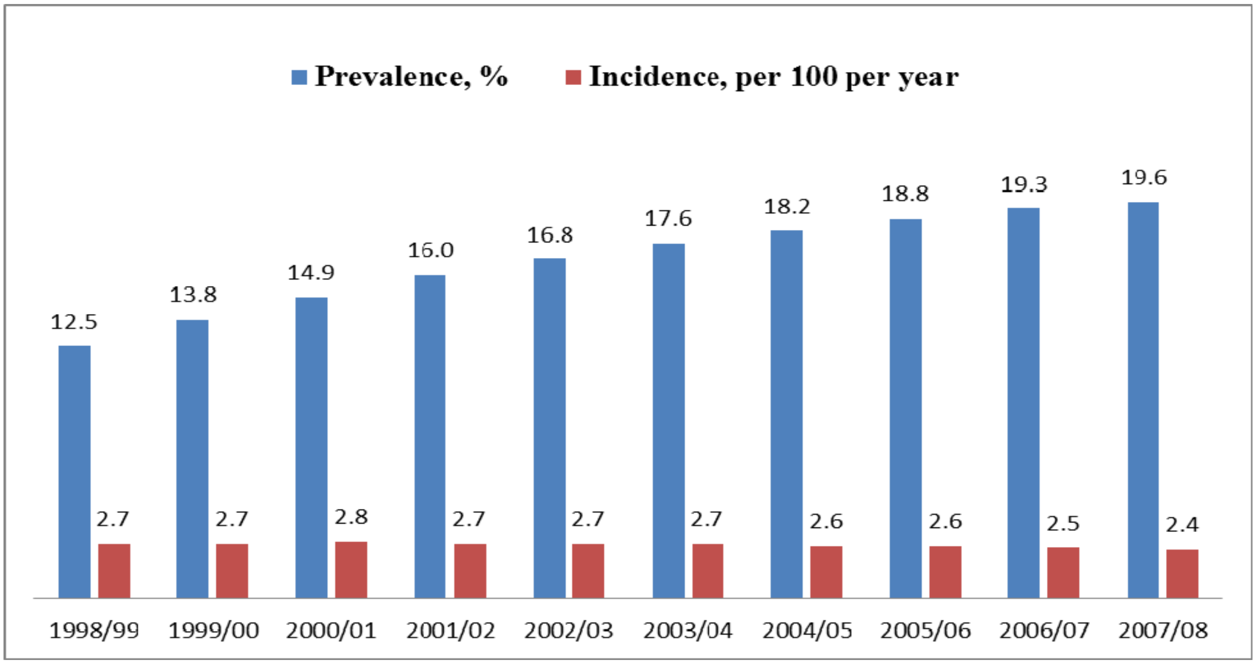

Figure 2.1: Age-adjusted prevalence and incidence of hypertension among Canadian adults over time[23]

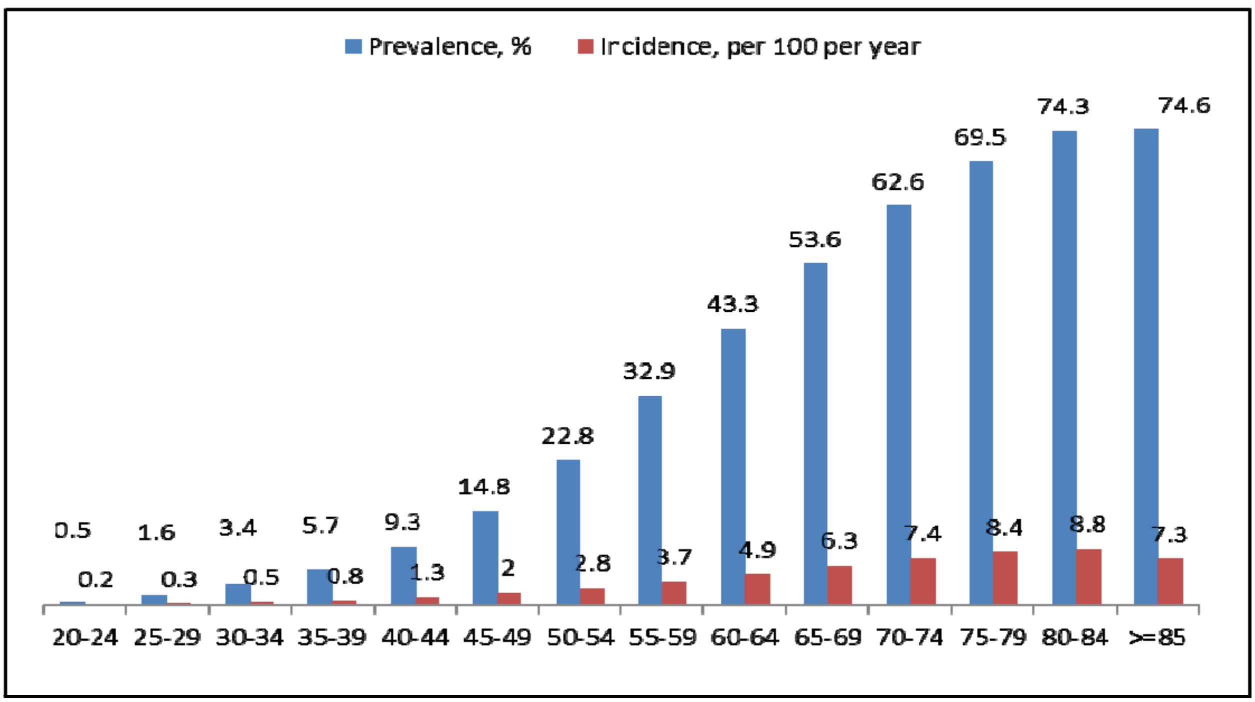

Figure 2.2: Prevalence and incidence of hypertension among Canadian adults by age, 2007/2008[23]

The relationship between hypertension prevalence/incidence and sex/gender also depends on age. As shown in Table 2.1,[23] the age-standardized prevalence of high blood pressure in 2007-2008 was similar for women and men less than 60 years of age. With increasing age however, hypertension became more prevalent in women than men. The incidence of high blood pressure also became higher among women than men starting at 75 years of age.

Table 2.1: Prevalence and incidence of hypertension among Canadian adults by age and gender[23]

	Prevalence, %		Incidence, per 100 per year	
Age, yr	**Women**	**Men**	**Women**	**Men**
20-24	0.5	0.6	0.2	0.2
25-29	1.6	1.7	0.3	0.3
30-34	3.2	3.6	0.4	0.6
35-39	5.2	6.2	0.7	0.9
40-44	8.7	9.9	1.2	1.4
45-49	14.2	15.4	1.9	2.1
50-54	22.6	23.1	2.7	3.0
55-59	32.8	32.9	3.4	4.0
60-64	43.6	43.0	4.6	5.2
65-69	54.8	52.3	6.1	6.4
70-74	64.5	60.4	7.5	7.4
75-79	71.8	66.7	8.6	8.2
80-84	77.0	70.3	9.2	8.4
>=85	77.5	68.3	7.6	6.9

Age-sex patterns observed are likely the result of a complex interplay between factors related to both biological sex (e.g. the influence of sex hormones on renal sodium handling and/or vascular resistance) and gender (e.g. help-seeking behavior, awareness of hypertension). It is also important to note that among older people with hypertension that is being treated, women are more likely than men to have hypertension that is uncontrolled. For example, Wilkins and colleagues, using CHMS data, found the rate of hypertension control was 83% among 60-79 year old men taking hypertensive medication, compared to 70% among like women – a difference which remained after statistical control for socio-demographics characteristics, medication type, co-morbidities, and body mass index.(49)

In addition to age and gender, the prevalence of high blood pressure varies by ethnic group. In Canada, compared to Caucasian people, the prevalence of hypertension is higher in Black, Filipino and Aboriginal people.(51)(52) Hypertension rates may be particularly high among First Nations People living on reserve.(53)

Regional differences in the prevalence and incidence of hypertension within Canada are also present. The geographic patterning of hypertension is generally consistent with the east-to-west gradient observed with cardiovascular diseases and other risk factors, with prevalence highest in Newfoundland/Labrador and lowest in British Columbia. (23) In Saskatchewan in 2007-2008, the age standardized prevalence (women: 21%, men: 20.4%) and incidence (women: 2.6%, men: 2.7%) of hypertension is higher than the Canadian average.

Only limited information is available about the patterning of high blood pressure in Canada according to urban/rural location. Based on data from the CCHS, Mitura and Bollman reported no differences in prevalent diagnosed hypertension by metropolitan or non-metropolitan region compared to Canada as a whole with one exception: northern Canadian residents had a significantly higher age-standardized prevalence of diagnosed hypertension compared to national figures.(54) In another Canadian study using the same data source but a different measure of urban/rural, no differences in hypertension prevalence by region were reported for men. (32) For women, however, a higher prevalence of high blood pressure was found among those living in the most remote areas of Canada compared to those residing in urban areas.

A recent study in Quebec using CCDSS data reported a higher incidence of hypertension in Montreal compared to rural regions when applying the standard definition of hypertension (ie., combining physician billing and hospitalization stays) or when using only physician billing; however, no association was found by region using hospitalization records alone to identify hypertension cases.(26) Salvadori and colleagues, in their study of 4–17 year olds in Walkerton, Canada reported an aggregate prevalence of measured pre-hypertension and hypertension of 15.0%, which they compared to the results of a study of similar age youth in Quebec, which reported a prevalence of hypertension ranging between 12% and 23%.(36)

2.2 Risk factors for hypertension

2.2.1 Proximate risk factors

A large body of epidemiological research has identified lifestyle characteristics as important proximal risk factors for the development of high blood pressure. According to results from the most recent cycle of the CHMS,(50) prevalent hypertension is more than two times as likely to be present among overweight or obese Canadians (29%), compared to those in the normal weight range (12%). Overweight and obesity were also related to hypertension and pre-hypertension in children.(36) In a ten year follow-up study of middle-age women and men in the United States, the incidence of hypertension increased as BMI increased.(55) A similar dose-response relationship between degree of overweight and risk of high blood pressure was reported in a Finnish cohort study of 45-64 year old men and women.(12) Closely related to weight is physical activity. The results of a recent critical review of the scientific evidence for Canada's physical activity guidelines showed that 58% of the studies reviewed reported an inverse and dose-response relationship between high blood pressure and physical activity.(56) Katzmarzyk and Janssen estimated that physical inactivity and obesity explained 13.8% and 34% of the burden of high blood pressure in the Canadian population, respectively.(57)

Higher than recommended sodium intake has also been linked to the development of high blood pressure through various lines of evidence, including animal studies, observational epidemiological studies, and clinical trials.(58) Based on the results of clinical trials, 1840 mg per day less sodium intake would led to a reduction of 5.06 mmHg in systolic blood pressure and 2.7 mmHg in diastolic blood pressure.[17][59] It is estimated that lessening dietary sodium would reduce hypertension frequency by 30% in Canada, resulting in one million fewer hypertensive Canadians.[60]

Alcohol use has a complex relationship with many chronic conditions, including high blood pressure. While heavy alcohol use has quite consistently been associated with an increased risk of hypertension, contradictory associations have been reported for moderate alcohol use.[61-63] The relationship between cigarette smoking and high blood pressure is also unclear, despite its strong relationship to cardiovascular disease risk. Although some longitudinal research has suggested an increased risk of hypertension among smokers compared to non-smokers, [64][65] or a reduction in blood pressure following smoking cessation,[66] others have failed to found such associations, or that blood pressure actually increased after quitting smoking.[67-69]

Stress has been identified as another potential proximal risk factor for hypertension,[70] defined here as "*a process in which environmental demands exceed the adaptive capacity of an organism, resulting in psychological and biological changes that place persons at risk for disease*.[71] The relationship between blood pressure and exposure to workplace-related chronic stressors have received the most recent attention, with a number of longitudinal studies indicating increased blood pressure or an increased risk of hypertension associated with high-demand, low- control work environments.[72][73] Other chronic stressors that have been linked with high blood pressure in the literature, though less consistently, include racial discrimination, marital stress, social isolation, housing instability and poor sleep quality.[74][75]

2.2.2 Distal risk factors

Considerable evidence suggests that many of the proximal risk factors for hypertension identified in the previous section are patterned according to socioeconomic position (SEP). SEP can be defined as "the social and economic factors that influence what positions individuals or groups hold within the structure of a society".[76] Figure 2.3 shows the conceptual framework developed for the Commission on Social Determinants of Health (CSDH), depicting how distal political, social and economic characteristics lead to the development of power hierarchies based on socioeconomic factors.[77] Fixed to their stratified position in society, individuals and populations are differentially exposed and/or vulnerable to myriad life stressors and have varied access to potentially health enhancing material, social, behavioral and psychological resources.

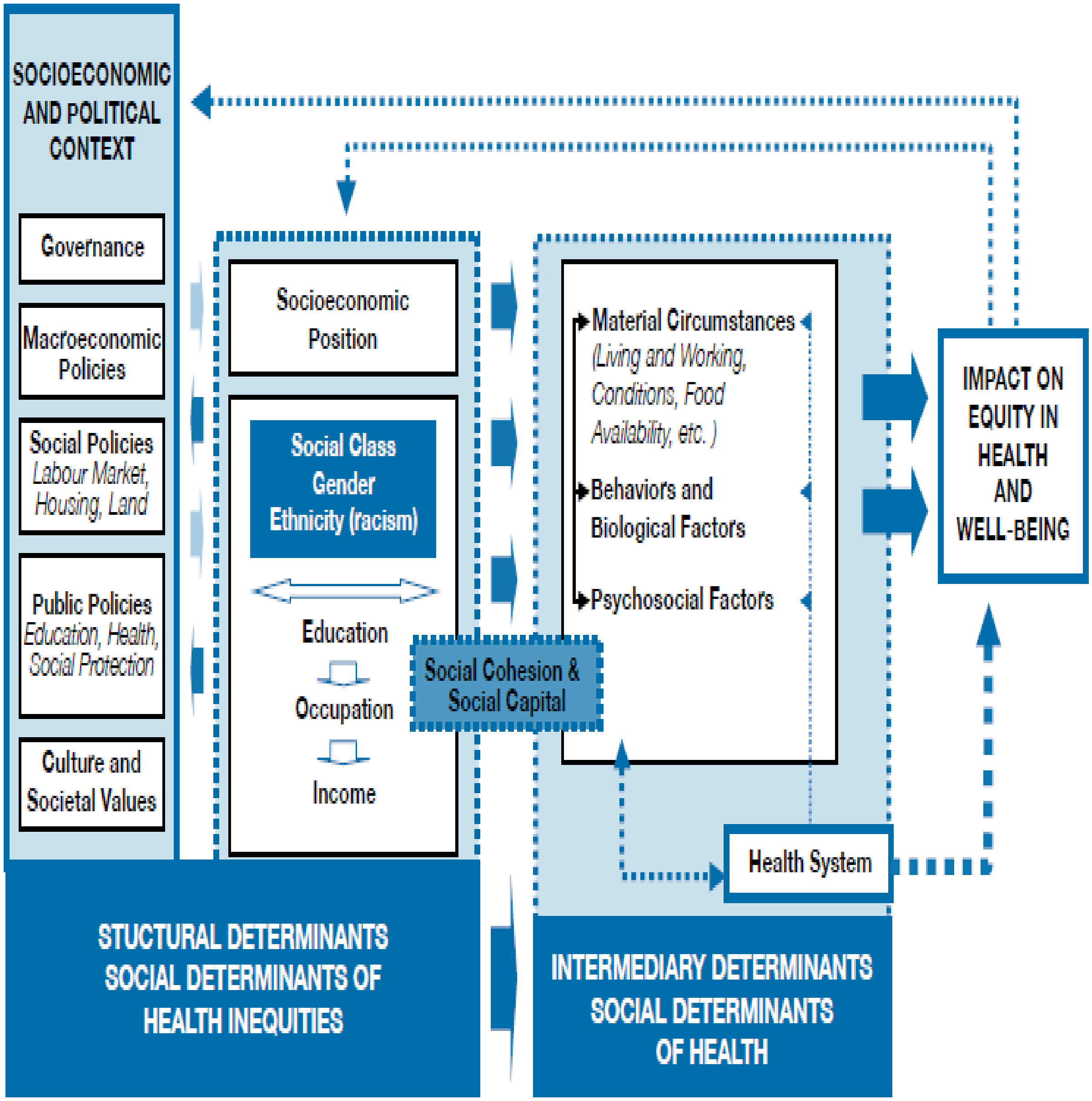

Figure 2.3: Commission on Social Determinants of Health (CSDH) conceptual framework

SEP can be measured at the level of the individual, the household, and the community.(78) In North America, the most common indicators of individual/household SEP are educational attainment and income. Although conceptually overlapping (and often used interchangeably), these indicators are believed to highlight different aspects of the mechanisms hypothesized as underlying SEP-health associations. For example, educational attainment reflects the capacity to apply knowledge in ways which enhance health, whereas income may be a better indicator of access to material resources, such as safe housing and healthy food.

Community- or area-level measures of SEP try to capture the socioeconomic circumstances of geographic areas within which individuals and families reside.(79) To this end, researchers often draw upon data from their country's census. These area-level data are sometimes considered as proxy measures for individual/household-level SEP. Alternatively, use of area-level indicators can be viewed as an attempt to move beyond the individual- or household-level to capture contextual or place influences on health.

Great Britain was one of the first countries to use area-level indictors to better understand social inequalities in health.(80) Deprivation, according to Peter Townsend, is "a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which the individual, family or group belongs". According to Townsend, there are two types of deprivation, material and social. As the labels imply, material deprivation focuses on area-level availability of tangible resources such as car and home ownership, whereas social deprivation highlights potential deficits in community cohesiveness, trust, and sense of belonging.

In Canada, area-level measures of SEP take on various forms.(81) One of the most commonly used is a deprivation index developed by Roger Pampalon and colleagues.(35)(79)(82)(83) Drawing largely on the British tradition, this Canadian index consists of six census indicators grouped, through principal components analysis, according to material (% without high school diploma, % employed, average income) and social (% living alone, % separated/divorced/widowed, and % of single parents).

2.2.3 SEP and hypertension

A large body of research has reported inverse, dose-response associations between common indicators of individual/household SEP and a variety of morbidity and mortality outcomes, including high blood pressure.(18) A large number of studies have reported associations between SEP and prevalent hypertension. In Canada, using data from the CCHS, Matheson and colleagues found lower educational attainment to be associated with increased odds of high blood pressure.(31) Another recent study combined data from two health surveys to examine the relationship between hypertension and household income over time.(84) These authors found that hypertension was related in an inverse and graded manner with household income adequacy in 2005. In addition, the difference in the prevalence of high blood pressure in the lowest versus the highest income group was wider in 2005 than it was in 1994. Other studies in North America and beyond have reported similar findings.(12)(21)(85)

Compared to prevalent hypertension, less evidence is available documenting SEP as a risk factor for incident high blood pressure. In a recent study in the Unites States, the relationship between several measures of SEP and incident hypertension were examined using data from the Women's Health Study.(22) The results showed that educational attainment, but not income, was significantly related to incident hypertension. The findings of several other prospective studies in the United States similarly suggested that educational attainment may be more strongly associated with incident hypertension than other individual-level SEP indicators.(86)(87) However, a recent cohort study of young adults revealed no significant relationship between income or education and the development of high blood pressure.(88)

A growing body of research is examining the relationship between high blood pressure and area-level indicators of SEP, including several recent Canadian studies. Menec and colleagues,(89) in a study of adults 65 years of age and older in Winnipeg, reported an inverse and graded association between prevalent hypertension (measured with provincial administrative data) and neighborhood income quintile, with the odds of hypertension increasing as one moved down from the richest to the poorest neighborhood income quintile. Also using administrative data,(84) a prospective study of adults 20 years of age and older in Ontario found few differences in the incidence of hypertension between neighborhood income quintiles. Most recently, Aube-

Maurice et al.[26] examined relationships between incident hypertension and measures of material and social deprivation among adults in Quebec. The results of their study were complex and sometimes contradictory, with the relationship between deprivation and incident hypertension dependent upon the method used to identify people with hypertension (ie., physician billing, hospitalization records, or both). Although there was also some variation in results according to gender and type of deprivation, in general, there was a trend toward positive associations between deprivation and incident hypertension when using hospitalization records (ie., greater deprivation = higher risk). In contrast, when physician billing or the standard definition (combining methods) was applied, negative associations between deprivation and hypertension emerged (ie., greater deprivation = lower risk). For women, higher levels of material deprivation were consistently associated with an increased risk of hypertension.

Due to the reliance on administrative data sources, a limitation of the Canadian studies reviewed above was a lack of information concerning individual-level SEP, precluding the authors being able to confidently attribute observed variation in prevalent or incident hypertension to area-level socioeconomic circumstances (as opposed to individual/household-level effects). One notable exception was a study by Matheson (described in more detail below) who,[31] using CCHS data combined with census data, reported a positive association between prevalent hypertension and neighborhood-level deprivation in urban Canada, even after adjusting for individual/household level SEP.

A number of multilevel studies have been conducted in the United States and Europe which examine the relationship between SEP and hypertension. At the area-level, the majority of these studies have focused on the material dimension of SEP in relation to hypertension, such as neighborhood educational attainment, relative poverty, and average income.[24][25][90] Most of these studies report higher prevalent blood pressure with decreasing in area-level SEP, even after taking into account individual/household-level SEP. Similar findings are emerging for multilevel studies highlighting the social aspects of communities, such as neighborhood-level social standing, chronic stressors, and social capital.[91-93]

2.2.4 Gender as an effect modifier in the relationship between SEP and hypertension

In addition to SEP, the CSDH conceptual framework (Figure 2.3) includes gender as an important structural determinant of access to the material, psychosocial, behavioral and biological factors which impact health. Gender is “a social construct regarding culture-bound conventions, roles, and behaviors for, as well as relations between and among, women and men and boys and girls”.[(94)] Gender is different that sex which is “a biological construct premised upon biological characteristics enabling sexual reproduction.” Disentangling the effects of gender versus sex in health research is challenging.

The results of several of the studies reviewed in previous sections of this thesis (ie., those having to do with age-related changes in the prevalence/incidence of hypertension, and hypertension control in older women and men) do suggest a relationship between hypertension and sex/gender.[(23)] The main question posed in this thesis, however, is whether sex/gender modifies associations between SEP and hypertension.

To date, most research examining the potential modifying effects of sex/gender has focused on the relationship between cardiovascular disease and SEP, rather than hypertension per se.[(95)] From this broader literature, two patterns emerge: 1) low SEP is more consistently associated with cardiovascular disease among women than men; and 2) when SEP associations of a similar nature emerge for both genders, they are typically weaker for men than women.[(95)] These patterns have been reported in studies using both individual/household-level[(29)(96)] and area-level indicators of SEP.[(97)(98)]

To explain these findings, recent studies have examined gender differences in the socioeconomic patterning of physical activity, BMI, smoking, and psychosocial stress – characteristics associated with an increased risk of cardiovascular diseases.[(95)] Some research suggests that these risk factors may be more strongly associated with SEP among women than men, which in turn may explain, in part, weaker associations between SEP and cardiovascular outcomes among men. [(29)(96)] To explain observed gender differences in the health effects of area-level SEP, researchers have speculated that women and men may live in their environments differently, "Put simply, women may be more likely to spend more time in the local area as they spend more time at home with children, are more likely to work part-time, conduct more of the domestic work including activities such as shopping and are more likely to be primary careers for elderly or disabled relatives. In addition, it is possible that women may be more vulnerable to the health effects of local environments. For example, if neighborhoods have poor reputations and are less safe, this may affect women's locally based activities (for example, leisure time physical activity)".[(99)]

Some limited research suggests that the relationship between SEP and hypertension may also vary by sex/gender. For example, several studies have found low educational attainment to be more strongly associated with prevalent hypertension among women than men.[(21)(95)(100-102)] Several longitudinal studies have examined incident hypertension in relation to SEP based on occupational position. In one recent study from the United States, female blue collar workers exhibited a greater probability of developing hypertension compared to male workers in the same occupational class.[(103)] In contrast, results from an earlier American cohort study reported a more pronounced negative effect of low occupational status on the development of incident hypertension in men than women.[(104)]

Gender as a potential modifier in the relationship SEP and hypertension has been examined in several studies using area-level indicators of SEP. Matheson et al.,[(31)] using an aggregate, continuous measure of area-level deprivation, found that Canadian women in high deprived urban neighborhoods were 10% more likely to have prevalent hypertension than men who lived in the same area, even after adjusting for individual/household-level SEP. In an earlier multilevel study in the United States examining multiple risk factors for cardiovascular disease in relation to state-level income inequality, greater inequality was associated with higher prevalent hypertension in women but not men.[(105)]

CHAPTER 3: METHODOLOGY

3.1 Data sources

There were two data sources used in this study: the Saskatchewan Rural Health Study (SRHS).[38] and the 2006 Canadian Census. Both of these data sources are described below.

Individual-level and household-level variables for this study are from the 2010 baseline (cross-sectional) component of the Saskatchewan Rural Health Study (SRHS). [38] The study base for the SRHS was tax-paying households in rural municipalities (RMs) and small towns located in one of four geographical quadrants (Southeast, Southwest, Northeast, and Northwest) in the southern part of the province of Saskatchewan (Figure 3.1). In each quadrant, a sector was identified for possible inclusion if it was located a minimum of 60 kilometers from an urban centre.[106] Twelve adjacent RMs in each quadrant were selected, and a random sample of 9 RMs from each quadrant chosen. The councils for each of these communities were approached and most (32/36 RMs and 15/16 towns) agreed to participate and provided residents' addresses. A variation on Dillman's mail survey methodology was utilized to recruit study participants 18 years of age and older. [38] [107] A key informant in each household was asked to provide household-level information and individual-level information for each adult in the household. The questionnaire, which included questions on sociodemographic characteristics, health status, and respiratory health-related exposures, was developed by the SRHS research team with input from community members.[38] The study was approved by the University of Saskatchewan Biomedical Ethics Review Board.

The source of area-level socioeconomic data for the present study was the 2006 Canadian census. Census subdivision (CSD) is the general term for municipalities (as determined by provincial/territorial legislation) or areas treated as municipal equivalents for statistical purposes.[108] Each RM and town participating in the SRHS is governed by an elected council representing one CSD. SRHS data were linked to the 2006 Canadian census by CSD name and code. There were 47 CSDs in the catchment area for this study.

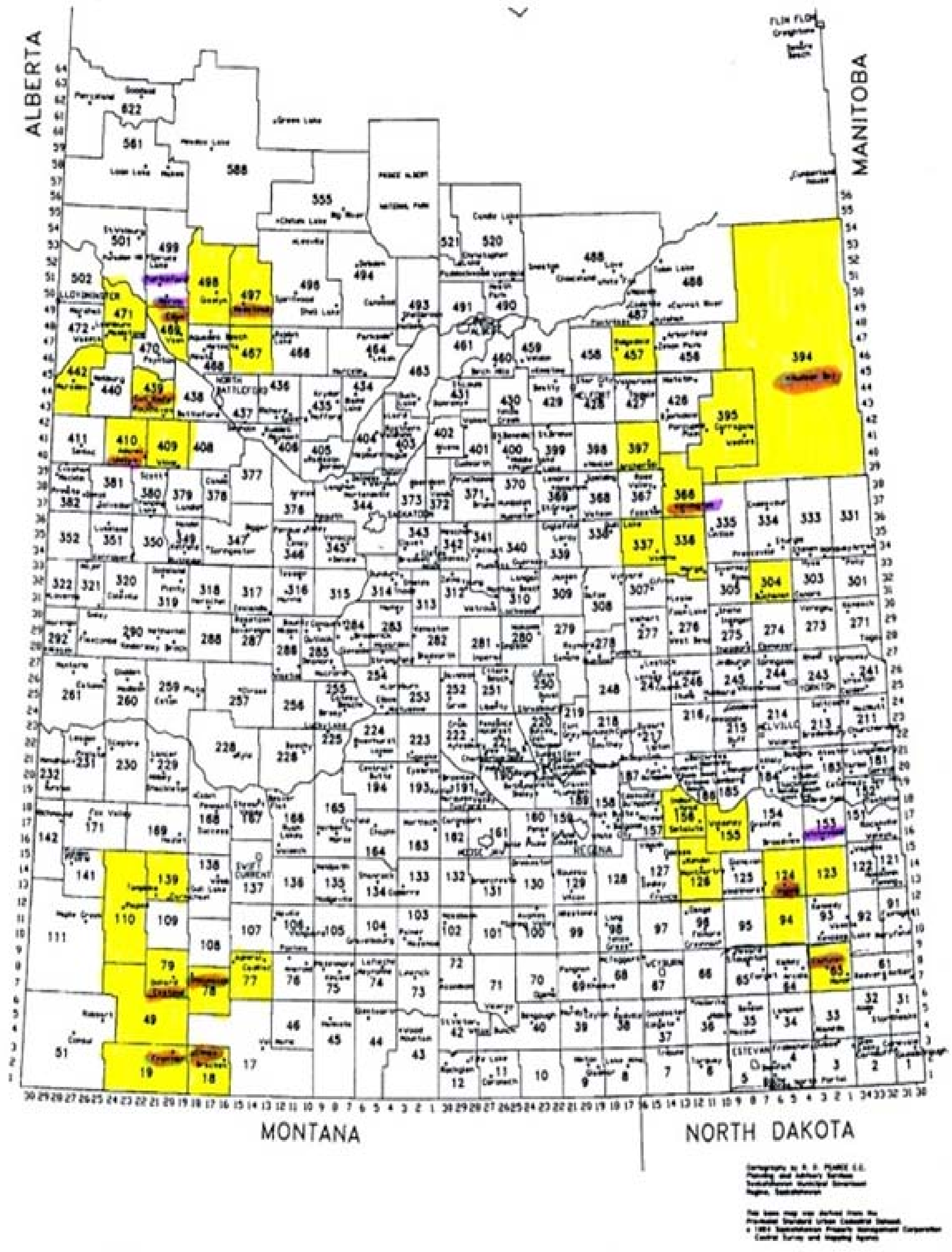

Figure 3.1: Study quadrants, rural municipalities, and small towns in the Saskatchewan Rural Health Study

3.2 Variables

The source of data for the variables described below was the SRHS, with the exception of social and material deprivation, which were from the 2006 census. See Appendix A for the SRHS survey questions.

3.2.1 Dependent variable

The dependent variable was self-reported hypertension (yes/no) based on participants answer to the question: "*Has a doctor or primary care giver ever said you have: … high blood pressure*?"

3.2.2 Independent variables

3.2.2.1 Primary independent variables

In addition to gender (male, female), there were four measures of socioeconomic circumstances: household income, educational attainment, material deprivation, and social deprivation. Household income was based on respondents' estimate of their total household income (all household members), prior to taxes and deductions. Participants' were provided with eight income categories which were subsequently collapsed for this study into three broader groupings: <$40,000, $40,000-$79,999, ≥$80,000. Similarly, educational attainment, originally assessed with four categories, was collapsed into three groupings: 1) less than high school; 2) high school graduate; and 3) more than high school. Educational attainment was considered an individual-level variable and household income, a household-level variable.

Informed by the work of Pampalon and colleagues,[79][83] two community-level socioeconomic variables were developed for this study based on questions from the 2006 census. Initially, six census items were considered for inclusion: the proportion of people who did not graduate high school, the proportion of employed, average (median) income, the proportion of separated/divorced/widowed, the proportion of living alone and the proportion of single parent families. However, Statistics Canada will not release data for some CSDs which yield too few cases to meet confidentiality requirements. Six out of 47 CSDs (Lone tree No.18, Climax, Wise creek No.77, Gull lake No.139, Medstead, Mervin) were without any income data, leading to the decision to impute income values from the 2001 census. In addition, the proportion of single parents was excluded from further analysis, given that 19 out of 47 CSDs did not have this information.

Principle components analysis (PCA) using orthogonal varimax rotation was then conducted with the five remaining census variables.[109] PCA is a statistical technique used to transform a larger number of variables into a smaller, more coherent set of linearly uncorrelated factors called principal components. In PCA, factors are used to reflect the variables measured and the relative importance of them for that particular factor, represented by the value of b. Original variables (n=p), which represent total system variability, can be expressed by a smaller number (i) of principal components. The components often provide as much information as the original p variables.[110] The mathematical representation of factor (i) is shown as:

$$\text{Factor}_i = b_1\text{var}_1 + b_2\text{var}_2 + \ldots + b_i\text{var}_i + \varepsilon_i$$

Two of the variables (proportion living alone and separated/divorced/widowed) were not normally distributed (Table 3.1) and thus transformed to meet PCA data requirements (Table 3.2).

Table 3.1: Normality test results for the five area-level socioeconomic indicators

Area level socioeconomic position indicator	Shapiro-Wilk		
	Statistic	df	Sig.
Median income	.981	47	.620
% employment rate	.976	47	.426
% unfinished high school	.980	47	.613
% separated, divorced, widow	.893	47	.000
% living alone	.899	47	.001

Table 3.2: Normality test result for the two transformed indicators

	Shapiro-Wilk		
	Statistic	df	Sig.
Log transformed ratio of separated, divorced, widowed	0.975	47	.418
Log transformed ratio of living alone	0.965	47	.174

Based on the results of the scree plot (Figure 3.2) and the ‘eigenvalues greater than 1’ criterion,[(111)(112)] two components were identified, explaining 79.87% of the variance (Table 3.3). Inspection of the items which loaded on the two factors suggested the following groupings, labeled social deprivation and material deprivation, respectively: 1) % living alone, % employed, % separated/divorced/widowed; and 2) % less than high school, median income (Table 3.4). The continuous factor scores derived from the PCA, which were used to represent social and material deprivation in subsequent analyses, were divided into tertiles, each representing approximately one-third of the population: low material (social) deprivation, medium material (social) deprivation, and high material (social) deprivation. It is important to note however, the resulting measures of social and material deprivation in this study, though similarly named, did not contain the same items as Pampalon and colleagues’ measures. More specifically, in addition to being unable to use the proportion of single parents as an indicator in this study, the proportion employed variable loaded strongly on the social deprivation factor, compared to its inclusion as a component of material deprivation in Pampalon's measures. [113]

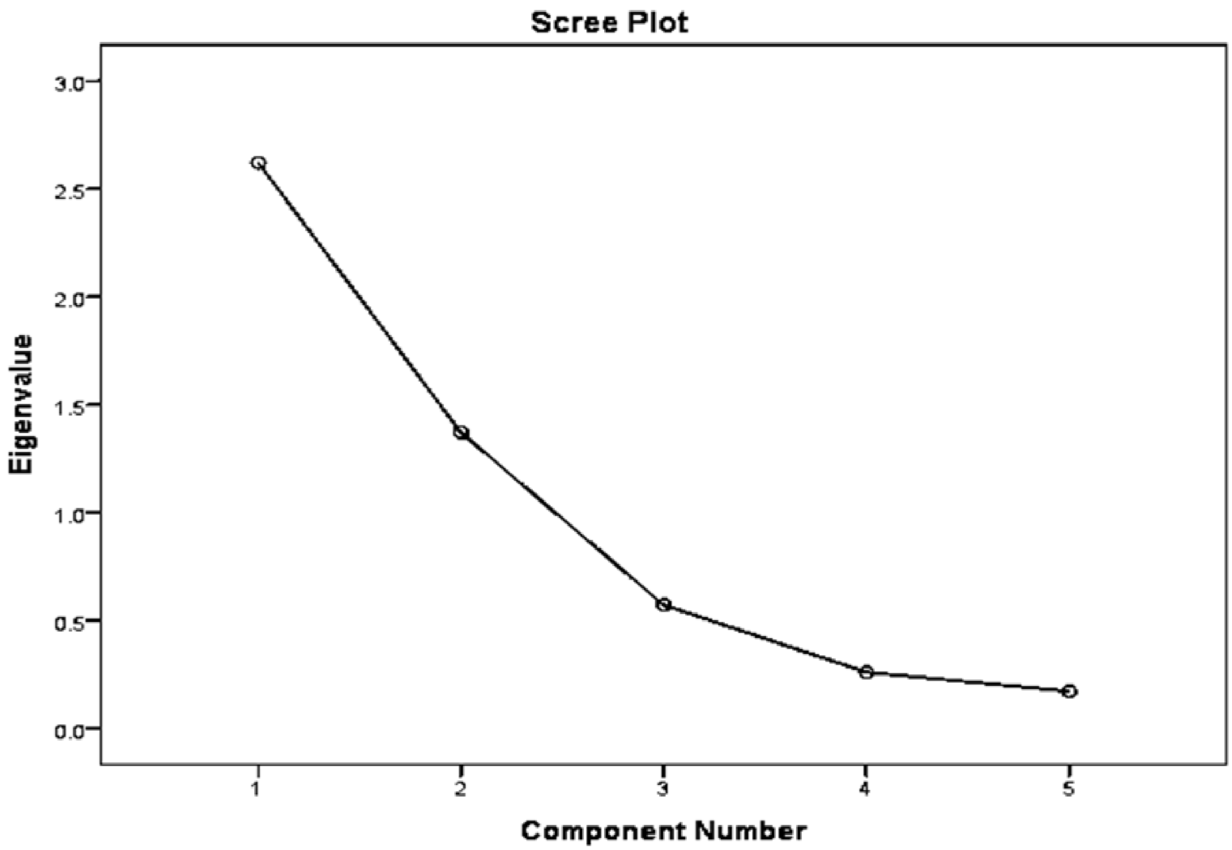

Figure 3.2: Scree plot of principal component analysis

Table 3.3: Total variance explained in principal component analysis

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.622	52.431	52.431	2.622	52.431	52.431
2	1.372	27.439	79.870	1.372	27.439	79.870
3	.573	11.451	91.321			
4	.261	5.225	96.546			
5	.173	3.454	100.000			

Table 3.4: Principal component loadings for social and material deprivation using the 2006 Canadian census

	Component	
	Social	Material
% living alone (transformed)	.924	.158
% employment rate	-.864	.114
% separated, divorced, widow (transformed)	.843	.386
% unfinished high school	.041	-.907
Median income	-.556	.603

3.2.2.2 Covariates

Additional variables assessed include demographic and housing characteristics, location, health behaviors and family history of disease. Demographic characteristics included participants' age (<40 years, 40-59 years, 60+ years) and marital status (married/common-law, single/separated/divorced/widowed). Quadrant location within the province was also assessed (Northwest, Northeast, Southwest, Southeast), as was location of primary residence (farm, town/acreage), and degree of accessibility to urban areas, using the Metropolitan Influence Zones (MIZ) approach: moderate MIZ (a CSD where at least 5% but less than 30% of residents commute to work in an urban core and excludes those with fewer than 40 persons in their resident employed labour force), weak MIZ (a CSD where more than 0% but less than 5% of residents commute to work in an urban core and excludes CSDs with fewer than 40 persons in their resident employed labour force), and no MIZ (a CSD where fewer than 40 persons or none commute to work in an urban core). [114] An indicator of crowding within the home was a derived variable based on the number of people living in the home and the number of bedrooms: 1) less than 1 person per bedroom and 2) 1 or more persons per bedroom. Health behavior measures included smoking status (never-smoker, ex-smoker, current smoker), alcohol use (none or less than once a month, once a month to 2 to 3 times a week, 4 or more times a week) [115] and weekly physical activity (none, less than 15 minutes, 15-30 minutes, more than 30 minutes). Based on height and weight, three categories of body mass index (BMI) were calculated: normal (BMI<25), overweight (BMI=25-30), and obesity (BMI>30). Four variables assessed family history of disease: 1) heart disease (ie., heart disease, heart attack, hardening of the arteries, or stroke) on the mother's side (yes, no), heart disease (ie., heart disease, heart attack, hardening of the arteries, or stroke) on fathers' side (yes, no), hypertension on the mothers' side (yes, no) and hypertension on fathers' side (yes, no).

3.3 Analysis

Given that a random-coefficient logistic regression model was not appropriate for this study, two-level and three-level random-intercept logistic regression models were used. [116] [117] Random intercepts at the area-level and household-level were applied to assess unobserved heterogeneity between areas and between households within areas. The area-level random intercept generates dependence among households in the same RMs or towns, while the random household-level intercept generates extra dependence among participants in the same household. The individual-level comprised the first hierarchy of the model, household-level the second, and rural municipalities/towns the third. According to Rabe-Hesketh and Skrondal[117], a_{ijk} are covariates at level 1, x_{jk} are for level 2, and w_k for level 3. The first level model can be shown as:

$$logit\{Pr(y_{ijk}=1 \mid \pi_{ijk}, a_{ijk})\} = \pi_{0jk} + \pi_1 a_{1ijk} + ... + \pi_i a_{iijk} + \varepsilon_{ijk}$$

Where the intercept π_{0jk}, which is random effect in the model, varies between household j and municipality k. ε_{ijk} is a level-1 random effect. Denoting covariates at the household level as x_{1jk} to x_{jjk}, the model can be written as:

$$\pi_{0jk} = \beta_{00k} + \beta_{01}X_{1jk} + ... + \beta_{0j}X_{jjk} + \gamma_{0jk}$$

In the formula, γ_{0jk} is a random household effect, while the coefficient with a k subscript is the intercept β_{00k}, therefore it compose a municipality level model:

$$\beta_{00k} = \gamma_{000} + \gamma_{001}W_{1k} + \ldots + \gamma_{00k}W_{kk} + \mu_{0k}$$

Here W_{kk} are the covariates at level 3. Therefore the three-level model can show as:

$$logit\{Pr(y_{ijk}=1 \mid x_{ijk}, \gamma_{0jk}, \mu_{0k})\} = \gamma_{000} + \pi_1 a_{1ijk} + ... + \pi_i a_{iijk} + \beta_{01}X_{1jk} + ... + \beta_{0j}X_{jjk} + \gamma_{001}W_{1k} + \ldots + \gamma_{00k}W_{kk} + \varepsilon_{ijk} + \gamma_{0jk} + \mu_{0k}$$

The reduced-formula can also be written in the following single equation:

$$Y_{ijk} = \beta_1 + \zeta^{(2)}_{jk} + \zeta^{(3)}_{k} + \varepsilon_{ijk}$$

Where $\varsigma^{(2)}_{jk}$ ~ N (0, σ^2_2) is the random intercept for household j, municipality k and $\varsigma^{(3)}_{k}$ ~ N (0, σ^2_3) is the random intercept for municipality k and ε_{ijk} ~ N (0, σ^2_1) is the random effect across the individuals.

For the same municipality k but different households, residual intra-class correlations (ICC) are obtained:

$$\frac{\sigma^2_3}{\sigma^2_3 + \sigma^2_2 + \sigma^2_1}$$

While intra-class correlation coefficients between individuals (within the same household and same municipality) equals:

$$\frac{\sigma^2_3 + \sigma^2_2}{\sigma^2_3 + \sigma^2_2 + \sigma^2_1}$$

3.3.1 Descriptive analysis

Initial descriptive analysis involved calculating the frequency distributions (number and percentages) of all study variables for the total sample and then by gender. The prevalence of high blood pressure (observed/total and percentage) by each study variable was calculated, separately for men and women, followed by multilevel, bivariate logistic regression models to provide estimates of odds ratios and 95% confidence intervals.

3.3.2 Multivariable modeling approach

A series of multilevel logistic regression models were fit to address the research questions. Socioeconomic variables were considered of primary importance in this study, as was gender, as a potential effect modifier in the relationship between SEP and high blood pressure. Covariates were variables of theoretical/clinical significance or that were associated with high blood pressure ($p<0.20$) in the bivariate analysis (men and women combined). To address the first two research questions, the following hierarchical modeling building strategy was followed: model 1 (gender, education, income, age), model 2 (model 1 + covariates), model 3 (model 2 + gender X education + gender X income), model 4 (model 3 + material deprivation + social deprivation), model 5 (model 4 + gender X material deprivation + gender X social deprivation). The final model included main effects and statistically significant interaction terms. To address the third research question, a series of multilevel logistic regression models were conducted, separately for social and material deprivation and by gender. Model 1 included educational attainment, household income, social (material) deprivation, and covariates. In model 2, cross-level interaction terms between social (material) deprivation and education and between social (material) deprivation and income were introduced.

Both the likelihood-ratio test and predicted probability graphs were used to understand interactions between variables in this study. The likelihood-ratio test was used to confirm the existence of interactions. There were two competing models (the model with and without interaction) which were fitted separately to the data and the log-likelihood recorded. The test statistic was calculated as two times the difference in the log-likelihoods with a probability distribution that fits a chi-squared distribution with the degrees of freedom of interaction terms. The p-value of the test statistic was used to determine statistical significance.[118] Mean predicted probabilities were used to display interactions from the final multilevel logistic regression model. These probabilities consist of the fixed and random parts of the random intercept model.

Statistical analyses were performed using SPSS (version 21; SPSS, Chicago, IL) and Stata (version 11.1; College Station, TX). All tests were two-tailed and statistical significance was specified as a p-value of less than 0.05. Area-level cartographic manipulation and displays were done using ArcGIS 10.21.[119]

CHAPTER 4: RESULTS

4.1 Descriptive analysis

Of the 11,004 eligible households to which surveys were sent, responses were obtained from 4,624 (42%) households, representing 8,261 adults.

The overall percentage of respondents who reported high blood pressure was 33.1%. Figure 4.1 shows the prevalence of hypertension according to CSD, with a more detailed view by quadrant and CSD in Figure 4.2. The highest prevalence of hypertension (51%) was reported in the Southwest part of the study area and the lowest (23%) in the Northwest.

Displayed in Table 4.1 are the frequency distributions of study variables for the total sample. Similar proportions of men and women participated in the study, with the majority coupled (82.1%) and under 60 years of age. Nearly 42% of respondents reported their primary residence as located on a farm. The vast majority (83.4%) of respondents lived in weak or no MIZs, and a lower proportion of participants were from the south study regions (40.3%) compared to the north (59.7%).

Just over one-quarter of respondents reported an annual household income of less than $40,000, and 25.7% did not graduate high school. Similar proportions were in the low, medium, and high categories for material and social deprivation. The spatial distribution of social deprivation and material deprivation, according to CSD, are shown in Figures 4.3 and 4.4, respectively. High levels of social deprivation were restricted to small town communities.

Nearly one-half of the participants were ex-smokers or current smokers and one-in-ten consumed alcohol at least four times a week (Table 4.1). Over one-half did not engage in any regular physical activity and over 70% were considered overweight or obese. Just over 60% of respondents reported a family history of hypertension on their mothers' or fathers' side and 71% a family history of cardiovascular disease.

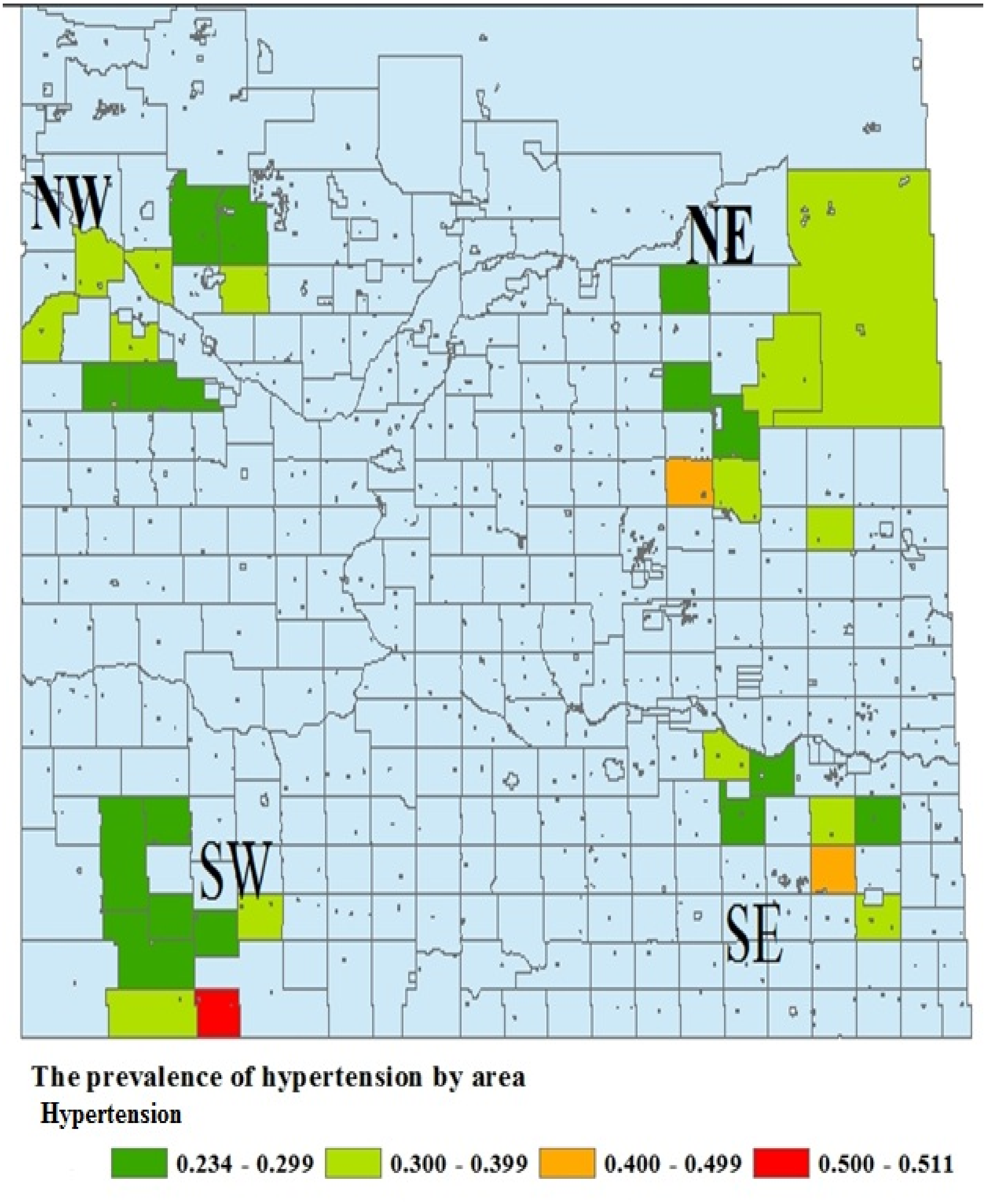

Figure 4.1: Proportion of study participants with high blood pressure by census subdivision (CSD)

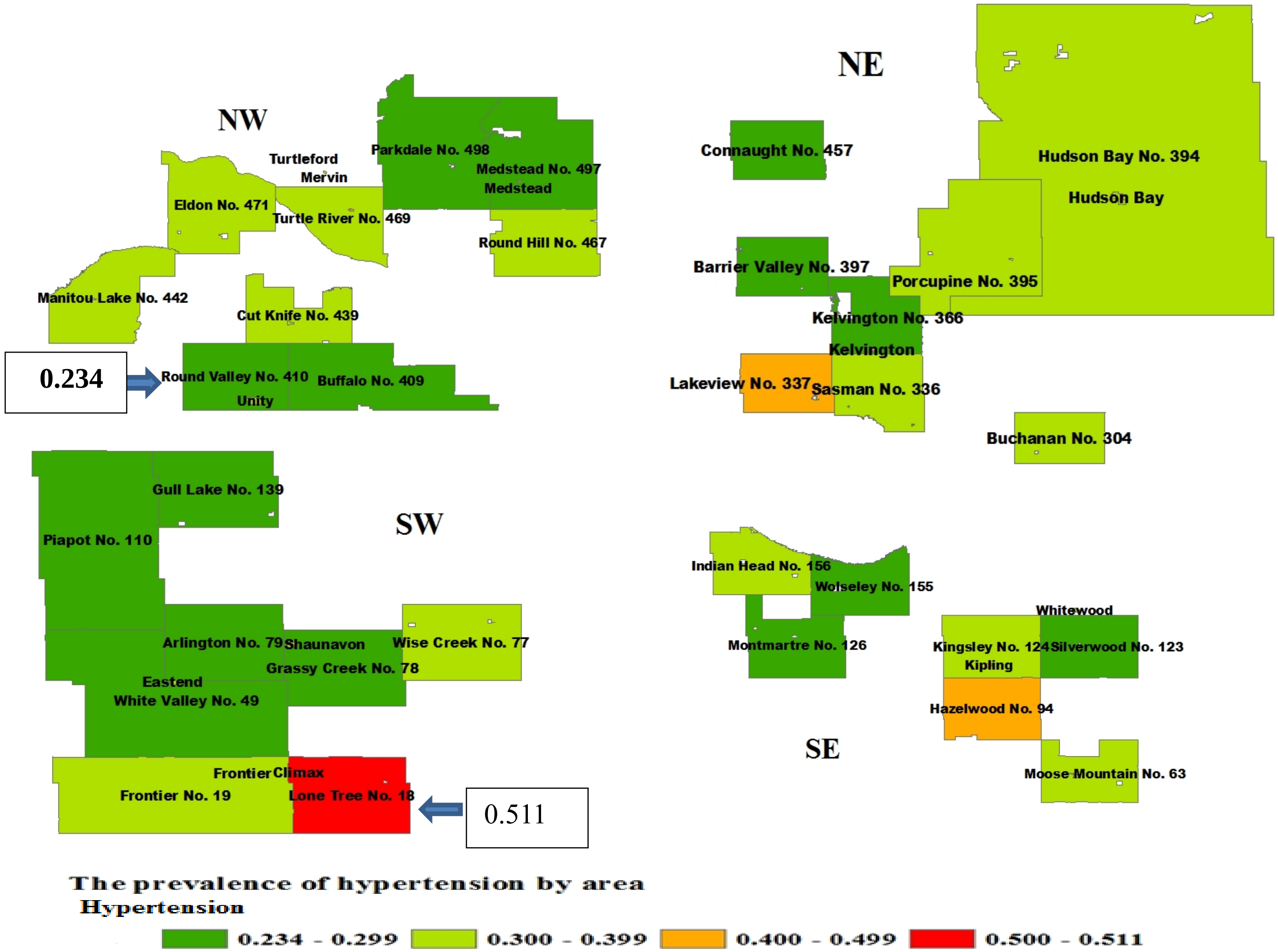

Figure 4.2: Proportion of study participants with high blood pressure by census subdivision (CSD): Detailed view

Table 4.1: Distribution of study variables, total sample

	Number (%)
Demographics	
Gender	
Women	4188 (50.7)
Men	4068 (49.3)
Age	
60 years and older	3467 (41.99)
40 to 59 years	3514 (42.56)
<40 years	1275 (15.44)
Marital status	
Widow/divorced/separated	877 (10.66)
Single	569 (6.92)
Married/common-in-law	6780 (82.42)
Socioeconomic position	
Educational attainment	
Less than high school	2126 (26.06)
High school	2814 (34.49)
More than high school	3219 (39.45)
Household income (annual)	
<$40,000	2063 (29.31)
$40,000-$79,999	2452 (34.83)
>= $80,000	2524 (35.86)

	Number (%)
Area-level material deprivation	
High	2929 (35.47)
Medium	2629 (31.84)
Low	2699 (32.69)
Area-level social deprivation	
High	3256 (39.43)
Medium	2280 (27.61)
Low	2721 (32.95)
Place	
Crowding	
One or more person per bedroom	2609 (31.98)
Less than one person per bedroom	5550 (68.02)
Home location	
Non-farm	4763 (58.30)
Farm	3445 (41.70)
Quadrant	
Northwest	2527 (30.60)
Northeast	2400 (29.07)
Southeast	1792 (21.70)
Southwest	1538 (18.63)
Metropolitan influence zone (MIZ)	
Moderate MIZ	1370 (16.59)
Weak MIZ	4573 (55.38)
No MIZ	2314 (28.02)

	Number (%)
Lifestyle	
Body Mass Index (BMI)	
Obese	2290 (29.20)
Overweight	3207 (40.90)
Normal	2345 (29.90)
Physical activity (weekly)	
More than 30 minutes	1887 (23.86)
30 minutes or less	2600 (32.87)
None	3422 (43.27)
Smoking status	
Current smoker	968 (11.78)
Ex-smoker	2923 (35.57)
Never smoker	4326 (52.65)
Alcohol use	
Four or more times a week	866 (10.53)
Once a month to 2/3 times a week	4148 (50.43)
Never or less than once a month	3211 (39.04)
Family history of disease	
Cardiovascular disease (father)	
Yes	3448 (41.74)
No	4813 (58.26)

	Number (%)
Cardiovascular disease (mother)	
Yes	2455 (29.72)
No	5806 (70.28)
High blood pressure (father)	
Yes	2175 (28.96)
No	5355 (71.04)
High blood pressure (mother)	
Yes	2897 (38.25)
No	4677 (61.75)

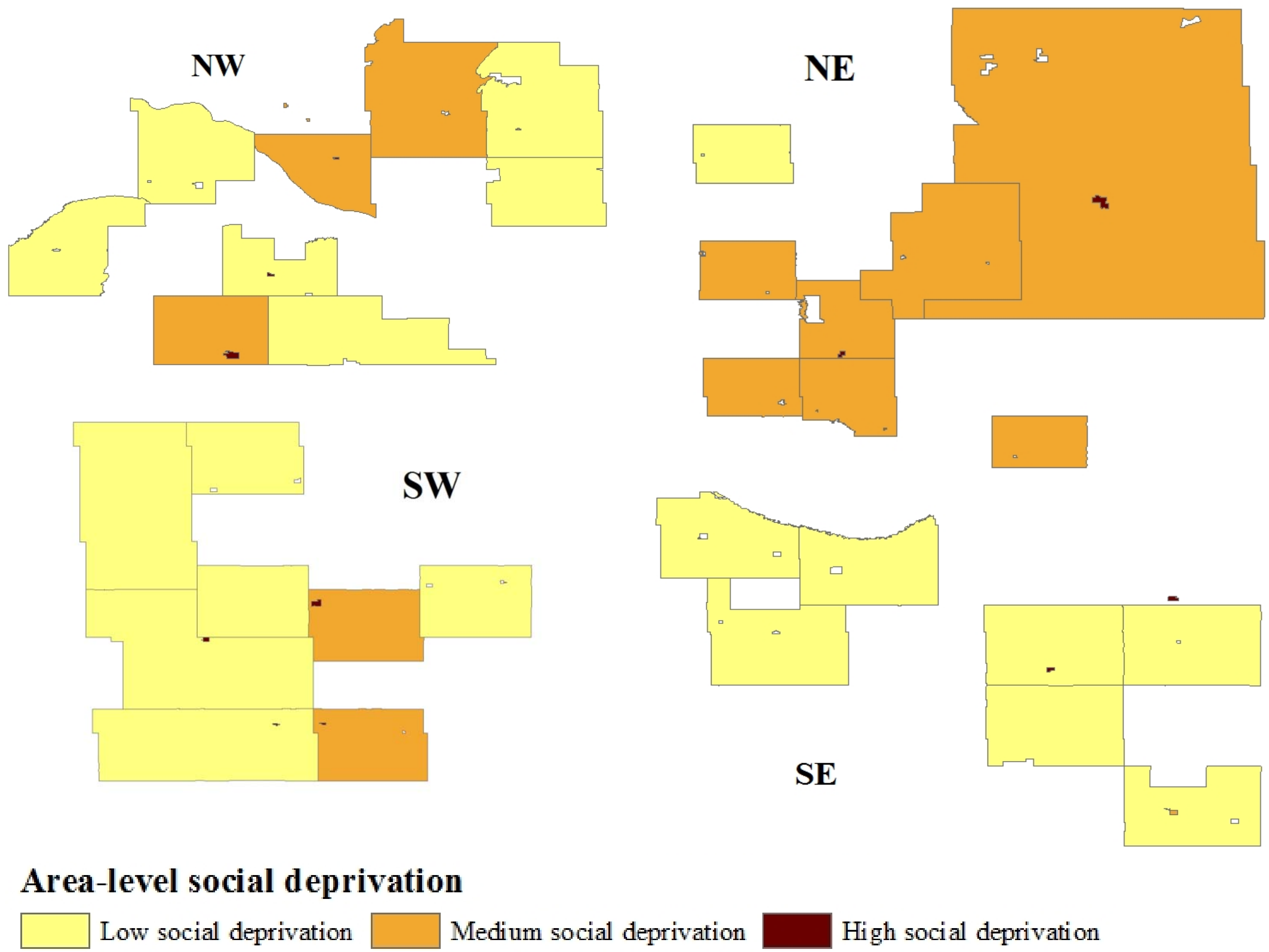

Figure 4.3: Area-level Social deprivation by Census Subdivision (CSD)

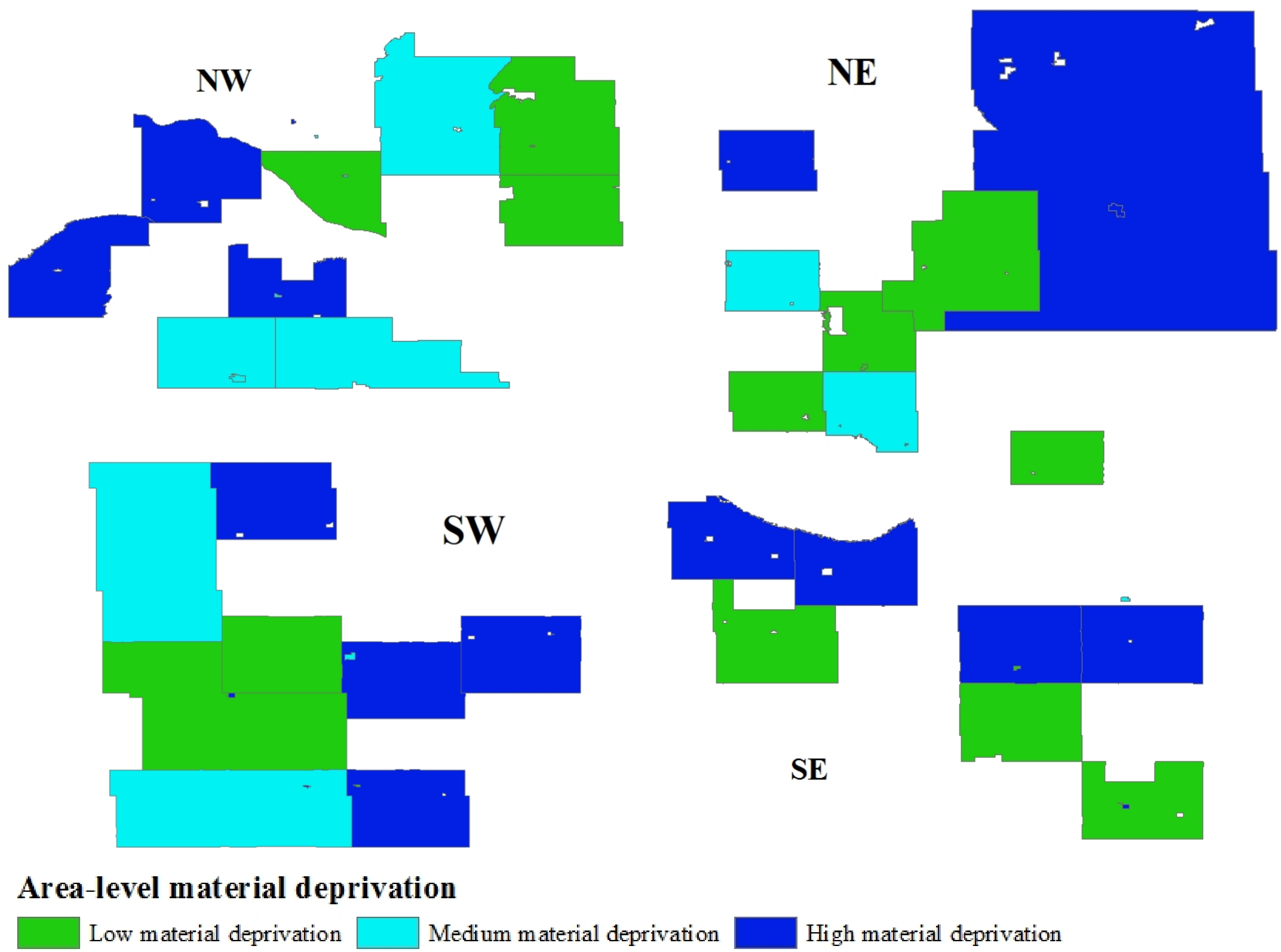

Figure 4.4: Area-level Material deprivation by Census Subdivision (CSD)

Table 4.2 displays the distribution of study variables according to gender. Similar proportions of men and women, approximately 33%, reported having been diagnosed with high blood pressure by a health professional. The average age in this study was 56.74 for men and 56.06 for women. A greater proportion of men than women were partnered or single, though no gender differences emerged by age. Although a greater proportion of women than men were in the lowest household income grouping, a higher percentage of men did not graduate high school. A greater proportion of women than men lived in a high social deprivation CSD, though no gender difference emerged for material deprivation. Although the proportions of men and women did not differ significantly for crowding, quadrant location of dwelling, or MIZ, a significantly higher percentage of men than women lived on a farm. Regarding health behaviors, while women were less likely to be physically active compared to men, men were more likely to be obese, a current or ex-smoker, and to drink alcohol once a month or more. With the exception of a family history of high blood pressure on the fathers' side, a significantly higher percentage of women than men reported a history of heart disease (mothers' and fathers' side) and high blood pressure on the mothers' side.

Table 4.2: Distribution of study variables by gender

	Men	Women	p-value
	Number (%)		
High blood pressure			
Yes	1343 (33.6)	1390 (33.7)	0.910
No	2657 (66.4)	2736 (66.3)	
Demography			
Age			
60 years and older	1757 (43.2)	1709 (40.8)	0.088
40 to 59 years	1700 (41.8)	1813 (43.3)	
<40 years	610 (15.0)	664 (15.9)	
Marital status			
Widow/divorced/separated	266 (6.6)	610 (14.6)	0.000
Single	375 (9.3)	193 (4.6)	
Married/common-in-law	3412 (84.2)	3365 (80.7)	
Socioeconomic position			
Educational attainment			
Less than high school	1384 (34.5)	740 (17.9)	0.000
High school	1389 (34.6)	1423 (34.4)	
More than high school	1242 (30.9)	1977 (47.8)	
Household income			
<$40,000	934 (26.9)	1127 (31.6)	0.000
$40,000-$79,999	1255 (36.1)	1197 (33.6)	
>= $80,000	1285 (37.0)	1237 (34.7)	

	Men	Women	p-value
	Number (%)		
Material deprivation			
High	1451 (35.7)	1477 (35.3)	0.623
Medium	1273 (31.3)	1352 (32.3)	
Low	1342 (33.0)	1357 (32.4)	
Social deprivation			
High	1518 (37.3)	1734 (41.4)	0.001
Medium	1156 (28.4)	1124 (26.9)	
Low	1392 (34.2)	1328 (31.7)	
Place			
Crowding			
One and more person per bedroom	1309 (32.6)	1298 (31.4)	0.238
Less than one person per bedroom	2708 (67.4)	2840 (68.6)	
Home location			
Non-farm	2246 (55.6)	2514 (60.4)	0.010
Farm	1794 (44.4)	1650 (39.6)	
Quadrant			
Northwest	1229 (30.2)	1293 (30.9)	0.791
Northeast	1201 (29.5)	1199 (28.6)	
Southeast	886 (21.8)	906 (21.6)	
Southwest	750 (18.4)	788 (18.8)	

	Men	Women	p-value
	Number (%)		
Metropolitan influence zone (MIZ)			
Moderate MIZ	677 (16.7)	692 (16.5)	0.829
Weak MIZ	2238 (55.0)	2331 (55.7)	
No MIZ	1151 (28.3)	1163 (27.8)	
Life style			
Body Mass Index			
Obese	1256 (32.1)	1032 (26.3)	0.000
Overweight	1856 (47.4)	1350 (34.4)	
Normal	803 (20.5)	1541 (39.3)	
Physical activity			
More than 30 min	848 (21.8)	1037 (25.8)	0.000
30 min or Less	1019 (26.2)	1580 (39.3)	
None	2021 (52.0)	1400 (34.9)	
Smoking status			
Current smoking	495 (12.2)	472 (11.3)	0.000
Ex-smoking	1614 (39.8)	1308 (31.4)	
Never smoking	1943 (48.0)	2381 (57.2)	
Alcohol drinking			
Four or more times a week	582 (14.4)	282 (6.8)	0.000
Once a month to 2 to 3 times a week	2247 (55.4)	1900 (45.6)	
Never or less than once a month	1225 (30.2)	1984 (47.6)	

	Men	Women	p-value
	Number (%)		
Family history of disease			
Cardiovascular disease (father)			
Yes	1629 (40.0)	1817 (43.4)	0.002
No	2439 (60.0)	2371 (56.6)	
Cardiovascular disease (mother)			
Yes	1119 (27.5)	1335 (31.9)	0.000
No	2949 (72.5)	2853 (68.1)	
High blood pressure (father)			
Yes	1038 (28.0)	1135 (29.9)	0.062
No	2674 (72.0)	2659 (70.1)	
High blood pressure (mother)			
Yes	1318 (35.5)	1577 (40.9)	0.000
No	2398 (64.5)	2277 (59.1)	

Table 4.3 displays the prevalence of high blood pressure according to study variables, along with crude odds ratios, separately for women and men. The overall pattern of associations between high blood pressure and the independent variables were generally similar for both genders. The prevalence of high blood pressure increased with age, lower education, lower household income and living in an area of high social deprivation. Area-level material deprivation was not associated with high blood pressure for men or women. Although being widowed /separated /divorced was associated with an increased odds of high blood pressure for women, the relationship was not statistically significant for men. Living in a more densely populated home was associated with a lower odds of high blood pressure for both women and

men. MIZ was not associated with high blood pressure; living in the Northwest quadrant was associated with an increased prevalence of hypertension for men and a decreased prevalence for women. Regarding health behaviors, for both women and men, the odds of high blood pressure generally increased with higher body mass index, less exercise and being an ex-smoker. A family history of heart disease or hypertension (mothers' and fathers' side) was also associated with a greater likelihood of high blood pressure for both genders.

Table 4.3: Percentage of respondents with high blood pressure and crude odds ratios by study variables and gender

	Men		**Women**	
	% with hypertension	**OR (95% CI)**	**% with hypertension**	**OR (95% CI)**
Demographics				
Age				
60 years and older	48.2	14.40 (6.04-34.35)	55.5	19.90 (9.35-42.36)
40 to 59 years	27.5	4.73 (2.74-8.16)	23.7	4.86 (3.18-7.43)
<40 years	9.1	1.00	6.1	1.00
Marital status				
Widow/divorced/separated	40.4	1.39 (0.99-1.95)	54.2	2.98 (2.04-4.36)
Single	22.5	0.49 (0.34-0.71)	16.6	0.41 (0.25-0.66)
Married/common-in-law	34.2	1.00	31.0	1.00
Socioeconomic position				
Educational attainment				
Less than high school	42.0	2.08 (1.60-2.71)	50.9	3.23 (2.27-4.61)
High school	29.6	1.08 (0.88-1.33)	33.3	1.37 (1.14-1.65)
More than high school	28.4	1.00	27.5	1.00
Household income (annual)				
<$40,000	39.7	1.75(1.35-2.27)	48.7	4.46(2.83-7.04)
$40,000 -$79,999	33.3	1.25(1.01-1.55)	28.2	1.46(1.14-1.87)
>= $80,000	29.3	1.00	22.4	1.00

	Men		Women	
	% with hypertension	OR (95% CI)	% with hypertension	OR (95% CI)
Area-level material deprivation				
High	35.9	0.87(0.66-1.15)	32.0	0.82(0.63-1.06)
Medium	34.6	0.81(0.60-1.11)	32.5	0.80(0.60-1.05)
Low	30.2	1.00	36.8	1.00
Area-level social deprivation				
High	35.9	1.36(1.02-1.81)	37.6	1.64(1.27-2.11)
Medium	34.6	1.26(0.95-1.66)	33.3	1.24(0.98-1.58)
Low	30.2	1.00	28.9	1.00
Place				
Crowding				
One or more person per bedroom	25.1	0.50(0.39-0.63)	23.7	0.45(0.34-0.58)
Less than one person per bedroom	37.6	1.00	38.1	1.00
Home location				
Non-farm	35.4	1.18 (1.06-1.34)	36.7	1.17 (1.05-1.32)
Farm	31.1	1.00	29.3	1.00
Quadrant				
Northwest	34.8	1.31 (1.02-1.69)	30.1	0.75 (0.60-0.95)
Northeast	33.9	1.25 (0.97-1.61)	36.2	1.04 (0.83-1.31)
Southeast	34.4	1.28 (0.98-1.67)	34.2	0.94 (0.74-1.19)
Southwest	30.1	1.00	35.4	1.00
Metropolitan influence zone (MIZ)				
Moderate MIZ	34.9	1.11 (0.86-1.43)	30.7	0.79 (0.62-1.01)
Weak MIZ	33.5	1.02 (0.84-1.23)	33.9	0.93 (0.78-1.11)
No MIZ	33.0	1.00	35.1	1.00

	Men		Women	
	% with hypertension	OR (95% CI)	% with hypertension	OR (95% CI)
Lifestyle				
Body Mass Index (BMI)				
Obesity	45.1	4.53 (2.78-7.39)	49.4	4.56 (2.79-7.44)
Overweight	31.1	2.06 (1.51-2.83)	33.7	2.06 (1.55-2.74)
Normal	20.4	1.00	21.7	1.00
Physical activity (weekly)				
More than 30 minutes	26.2	0.60 (0.47-0.78)	21.7	0.44 (0.33-0.59)
30 minutes or less	37.7	1.20 (0.97-1.48)	37.7	1.06 (0.89-1.26)
None	34.4	1.00	36.5	1.00
Smoking status				
Current smoker	27.8	1.01 (0.77-1.34)	28.5	0.77 (0.60-1.00)
Ex-smoker	42.6	2.35 (1.77-3.12)	35.9	1.14 (0.97-1.35)
Never smoker	27.4	1.00	33.3	1.00
Alcohol use				
Four or more times a week	40.1	1.24 (0.96-1.59)	31.1	0.64 (0.47-0.87)
Once a month to 2/3 times a week	30.6	0.75 (0.62-0.91)	27.0	0.51 (0.41-0.63)
Never or less than once a month	35.8	1.00	40.6	1.00
Family history of disease				
Cardiovascular disease (father)				
Yes	40.3	1.80 (1.47-2.21)	40.2	1.76 (1.45-2.13)
No	29.0	1.00	28.7	1.00
Cardiovascular disease (mother)				
Yes	43.6	2.04 (1.60-2.60)	45.0	2.33 (1.78-3.05)
No	29.8	1.00	28.4	1.00
High blood pressure (father)				
Yes	46.4	2.51 (1.91-3.29)	36.3	1.39 (1.15-1.69)
No	27.4	1.00	30.1	1.00

	Men		Women	
	% with hypertension	OR (95% CI)	% with hypertension	OR (95% CI)
High blood pressure (mother)				
Yes	40.7	1.99 (1.54-2.55)	41.4	2.00 (1.74-2.29)
No	28.6	1.00	26.2	1.00

4.2 Multivariable results

Prior to conducting multilevel modeling, bivariate analyses examining crude associations between hypertension and each independent variable were conducted to reduce the number of covariates.[3] Of the covariates under consideration, only three variables (gender, MIZ and quadrant location within the province) did not meet the statistical criteria set for retention ($p < 0.20$) (see Appendix 3 for results). Due to its theoretical importance in this study, gender was retained in subsequent analyses. The multivariable results are presented below, according to research question.

4.2.1 Research questions 1 and 2

Is hypertension associated with individual/household SEP? Is gender an effect modifier in the relationship between individual/household SEP and hypertension?

Is hypertension associated with area-level SEP? Is gender an effect modifier in the relationship between area-level SEP and hypertension?

Table 4.4 provides a summary of the multilevel modeling results addressing research questions 1 and 2.[3] In model 1, gender, education, and household income were entered into the model, adjusting for age. Gender was not associated with high blood pressure. However, high school graduates and those not graduating high school had a significantly higher odds of high

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[3]See Appendix B for detailed table of results.

blood pressure than those with post-secondary education, as did the lowest income group compared to the highest (ICC=5%). In model 2, with the addition of all covariates, having less than high school remained associated with an increased probability of high blood pressure, though household income was no longer associated. Model 3, with the entry of two interaction terms between gender and individual/household SEP indicators, showed a statistically significant interaction between income and gender but not between education and gender. In model 4, with the entry of area-level indicators of SEP, the interaction between gender and household income remained statistically significant. While material deprivation was not associated with high blood pressure, those living in high socially deprived areas were at an increased odds of hypertension compared to those residing in low socially deprived areas (ICC =0.1%). Model 5 introduced interaction terms between gender and area-level indicators and showed a borderline statistically significant interaction between gender and social deprivation (p=0.054). The interaction between gender and household income also remained statistically significant (p=0.001). The final model includes the primary independent variables and statistically significant interaction terms, adjusting for all covariates. Compared to those with more than high school education, not graduating high school was associated with a significantly higher odds of high blood pressure (OR=1.24, 1.03-1.48). In addition, gender was a statistically significant effect modifier in the relationship between high blood pressure and household income (OR=1.33, 1.12-1.56) and was of borderline significance in relation to social deprivation (OR=0.86, 0.73-1.00, p=0.045). Figure 4.5 displays the predicted probability of reporting hypertension by gender and household income (χ^2 of likelihood–ratio test =11.11, p =0.001, degree of freedom=1). For medium and high income groups, the probability of hypertension was higher among men than women; among the lowest income groups, women were at a greater risk of hypertension than men. Shown in Figure 4.6 is the predicted probability of hypertension by gender and social deprivation. The χ^2 of the likelihood-ratio test was 4.00 (p=0.045, df=1). For those living in low socially deprived areas women and men shared a similar probability of hypertension; among those residing in medium and high socially deprived areas, the probability of hypertension was higher among men than women.

Table 4.4: Multilevel logistic regression models of hypertension by gender, individual /household socioeconomic position, and area-level social and material deprivation

	Model 1[a]		Model 2[b]		Model 3[c]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Gender						
Women	1.02 (0.91-1.15)	0.691	1.01 (0.88-1.16)	0.862	0.56 (0.37-0.85)	0.007
Men	1.00		1.00		1.00	
Education attainment						
Less than high school	1.26 (1.08-1.46)	0.003	1.22 (1.02-1.46)	0.031	1.05 (0.62-1.78)	0.856
High school	1.15 (1.01-1.31)	0.042	1.12 (0.96-1.30)	0.142	1.02 (0.96-1.30)	0.918
More than high school	1.00		1.00		1.00	
Household income						
<$40,000	1.23 (1.06-1.43)	0.008	1.09 (0.90-1.31)	0.371	0.51 (0.30-0.87)	0.013
$40,000-79,999	0.99 (0.86-1.14)	0.876	0.97 (0.83-1.13)	0.674	0.67 (0.50-0.89)	0.006
>=$80,000	1.00		1.00		1.00	
Area-level social deprivation						
High						
Medium						
Low						
Area-level material deprivation						
High						
Medium						
Low						
Interaction						
Education* gender					1.06 (0.89-1.26)	0.542
Income* gender					1.29 (1.09-1.52)	0.003
Material * gender						
Social * gender						

[a]model 1: adjusted for age

[b]model 2: model 1 + crowding, home location, BMI, physical activity, smoking status, alcohol use, family history of heart disease (mother & father), family history of high blood pressure (mother & father)

[c]model 3: model 2 + gender X education, gender X household income

Table 4.4 (con't)

	Model 4 [d]		Model 5 [e]		Final model [f]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Gender						
Women	0.61 (0.43-0.86)	0.004	0.72 (0.40-1.29)	0.268	0.81 (0.52-1.26)	0.350
Men	1.00		1.00		1.00	
Education						
Less than high school	1.23(1.03-1.47)	0.025	1.23 (1.03-1.48)	0.022	1.24 (1.03-1.48)	0.021
High school	1.11 (0.96-1.30)	0.169	1.12 (0.96-1.30)	0.148	1.12 (0.96-1.30)	0.149
More than high school	1.00		1.00		1.00	
Household income						
<$40,000	0.49 (0.29-0.81)	0.006	0.45 (0.27-0.76)	0.003	0.46 (0.20-0.77)	0.003
$40,000-79,999	0.65 (0.49 -0.86)	0.003	0.63 (0.48-0.84)	0.001	0.63 (0.48-0.84)	0.002
>=$80,000	1.00		1.00		1.00	
Area-level social deprivation						
High	1.39 (1.14-1.69)	0.001	2.18 (1.32-3.58)	0.001	2.21 (1.35-3.63)	0.002
Medium	1.12 (0.91-1.37)	0.292	1.40 (1.03-1.90)	0.034	1.41 (1.03-1.91)	0.030
Low	1.00		1.00		1.00	
Area-level material deprivation						
High	0.92 (0.77-1.08)	0.307	0.79 (0.49-1.30)	0.357	0.92 (0.77-1.09)	0.311
Medium	0.86 (0.70-1.05)	0.144	0.80 (0.59-1.09)	0.156	0.86 (0.70-1.05)	0.146
Low	1.00		1.00		1.00	
Interaction						
Education*gender						
Income*gender	1.30 (1.10-1.53)	0.002	1.33 (1.13-1.57)	0.001	1.33 (1.13-1.56)	0.002
Material*gender			1.05 (0.90-1.23)	0.542		
Social*gender			0.86 (0.74-1.00)	0.054	0.86 (0.73-1.00)	0.045

[d]model 4: model 3 + material deprivation, social deprivation

[e]model 5: model 4 + gender X material deprivation, gender X social deprivation

[f]final model: model 1 + statistically significant interaction terms

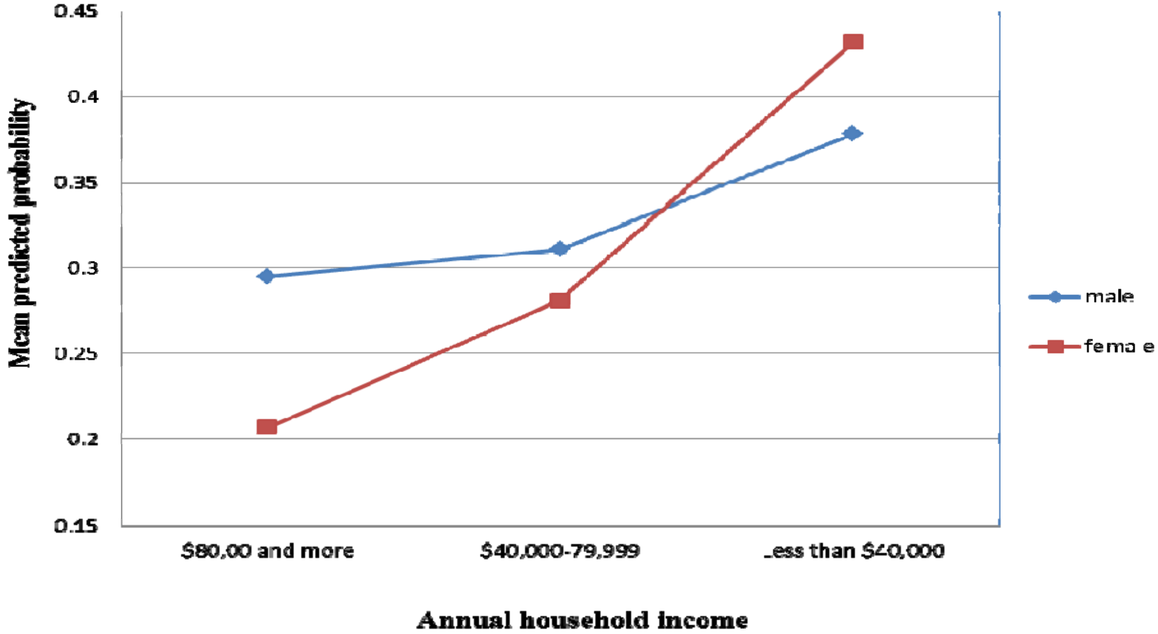

Figure 4.5: Adjusted probability* of reporting hypertension by gender and income

*Adjusted estimates obtained from Table 4.4 (final model)

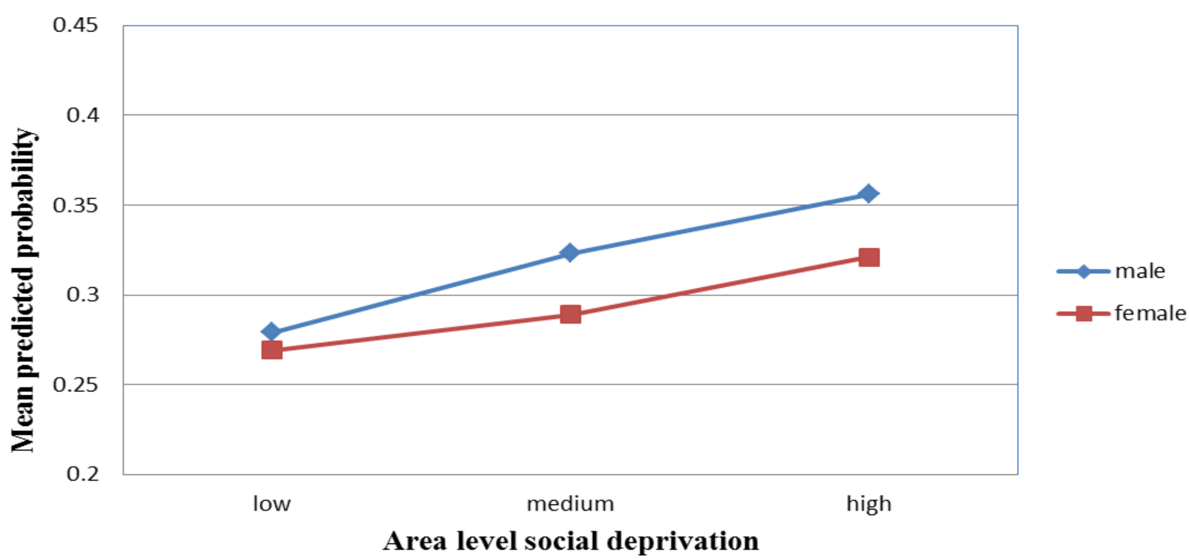

Figure 4.6: Adjusted probability* of reporting hypertension by gender and social deprivation

*Adjusted estimates obtained from Table 4.4 (final model)

4.2.2 Research question 3

Does individual/household SEP interact with area-level SEP to influence hypertension? Is gender an effect modifier in the relationship between individual/household SEP, area-level SEP and hypertension?

Table 4.5 shows the summary table of results for analyses (stratified by gender) examining the possibility of cross-level interactions between area-level social deprivation and individual/household SEP in relation to high blood pressure.[4] For men, in model 1, a greater odds of hypertension was associated with lower education and living in high socially deprived communities. With the introduction of cross-level interaction terms in model 2, education and social deprivation were no longer associated with hypertension. In addition, neither interaction terms were significant. For women, none of the variables, including interactions, were statistically significant.

Table 4.6 shows the summary table of results for analyses (stratified by gender) examining cross-level interactions between area-level material deprivation and individual/household SEP in relation to high blood pressure.[4] For men, no statistically significant associations emerged, though low education was of borderline significance (p=0.05) in model 2. Similarly, for women, there were no statistically significant main effects. However, in model 2, the cross-level interaction between education and material deprivation was borderline significant (p=0.051). The results of the likelihood ratio test showed that there was no interaction.

[4] See Appendix B for detailed table of results.

Table 4.5: Gender-stratified multilevel logistic regression models of hypertension by individual/household socioeconomic position and area-level social deprivation

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Education attainment								
Less than high school	1.31 (0.98-1.73)	0.064	1.71 (0.84-3.49)	0.140	1.21 (0.88-1.67)	0.243	0.84 (0.38-1.86)	0.660
High school	1.19 (0.92-1.53)	0.192	1.36 (0.89-2.06)	0.153	1.06 (0.84-1.33)	0.637	0.88 (0.58-1.33)	0.569
More than high school	1.00		1.00		1.00		1.00	
Household income								
<$40,000	0.91 (0.68-1.21)	0.508	0.68 (0.33-1.39)	0.285	1.27 (0.93-1.73)	0.131	1.31 (0.64-2.67)	0.457
$40,000-79,999	1.00 (0.79-1.27)	0.995	0.87 (0.59-1.29)	0.487	0.89 (0.69-1.16)	0.401	0.91 (0.61-1.35)	0.642
>=$80,000	1.00		1.00		1.00		1.00	
Area-level social deprivation								
High	1.42 (1.02-1.98)	0.036	1.40 (0.62-3.16)	0.413	1.30 (0.96-1.75)	0.087	1.01 (0.46-2.21)	0.977
Medium	1.02 (0.76-1.38)	0.873	1.03 (0.64-1.64)	0.908	1.03 (0.78-1.37)	0.826	0.92 (0.59-1.42)	0.694
Low	1.00		1.00		1.00		1.00	
Interaction								
Social*education			0.94 (0.80-1.09)	0.401			1.09 (0.92-1.29)	0.329
Social*income			1.08 (0.92-1.27)	0.372			0.99 (0.85-1.16)	0.916

[a]adjusted for age, crowding, home location, BMI, physical activity, smoking status, alcohol use, family history of heart disease (mother & father), family history of high blood pressure (mother and father)

[b]model 1 + social deprivation X education, social deprivation X income

Table 4.6: Gender-stratified multilevel logistic regression models of hypertension by individual/household socioeconomic position and area-level material deprivation

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95%) CI	**p**	**OR (95%) CI**	**p**	**OR (95%) CI**	**p**	**OR (95%) CI**	**p**
Education attainment								
Less than high school	1.27 (0.96-1.69)	0.091	2.11 (0.99-4.52)	0.053	1.21 (0.88-1.67)	0.246	0.56 (0.25-1.27)	0.167
High school	1.16 (0.90-1.50)	0.240	1.51 (0.97-2.37)	0.070	1.05 (0.84-1.33)	0.654	0.71 (0.45-1.12)	0.142
More than high school	1.00		1.00		1.00		1.00	
Household income								
<$40,000	0.92 (0.68-1.23)	0.554	0.70 (0.34-1.44)	0.331	1.29 (0.95-1.76)	0.993	2.02 (0.93-4.36)	0.130
$40,000-79,999	1.01 (0.80-1.29)	0.908	0.89 (0.59-1.34)	0.572	0.91 (0.70-1.18)	0.471	1.13 (0.73-1.75)	0.437
>=$80,000	1.00		1.00		1.00		1.00	
Area-level material deprivation								
High	0.81 (0.62-1.20)	0.177	1.05 (0.45-2.44)	0.918	0.97 (0.75-1.26)	0.839	0.79 (0.35-1.77)	0.561
Medium	0.87 (0.63-1.20)	0.388	0.99 (0.58-1.68)	0.970	0.96 (0.72-1.29)	0.810	0.86 (0.52-1.42)	0.557
Low	1.00		1.00		1.00		1.00	
Interaction								
Material*education			0.88 (0.75-1.05)	0.151			1.21 (1.00-1.47)	0.051
Material*income			1.07 (0.91-1.26)	0.439			0.90 (0.76-1.06)	0.211

[a]adjusted for age, crowding, home location, BMI, physical activity, smoking status, alcohol use, family history of heart disease (mother & father), family history of high blood pressure (mother and father).

[b]model 1 + material deprivation X education, material deprivation X income

CHAPTER 5: DISCUSSION

The purpose of this study was to examine the relationship between household- and area-level socioeconomic circumstances, gender, and hypertension in a rural Canadian population. Four main findings emerged: 1) lower educational attainment was associated with a greater odds of high blood pressure; 2) the relationship between lower household income and high blood pressure was more pronounced among women than men; 3) the relationship between higher area-level social deprivation and high blood pressure was more pronounced among men than women; and 4) area-level material deprivation was not associated with high blood pressure. These results are discussed below.

5.1 Individual/household-level SEP and high blood pressure

Consistent with previous research, low education attainment was associated with an increased likelihood of hypertension, even after adjustment for individual- and area-level covariates. Research suggests that the association between education and hypertension may be due, in part, to a differential distribution of behavioral characteristics across educational groups, such as alcohol use, cigarette smoking, physical activity and obesity[25] A recent study of young adults in the United States found lower body mass, smaller waist circumference and lower resting heart rate to be important mediators in the relationship between educational level and systolic blood pressure.[85] Further, when these effects were accounted for in the analysis, education was no longer significantly associated with blood pressure. Similarly, in a study of 30-79 year olds living in France, [25] 28% of the observed association between low education level and higher blood pressure could be explained by differences in BMI and waist circumference. The authors speculate that compared to their more highly educated counterparts, people with more limited education may be less knowledgeable of the health risks associated with obesity and therefore, less motivated to control their weight. Educational attainment may also influence the skill-set individuals have access to that would enable them to apply their knowledge in a practical way as to prevent hypertension.[120] In this thesis, however, the introduction of lifestyle characteristics into the multivariable model (Table 4.4) resulted in only a slight attenuation of the odds ratio, suggesting that other factors, not considered here, may also be important in explaining this association.

Previous research suggests that SEP in general, and educational attainment in particular, may be more strongly related to cardiovascular disease, metabolic syndrome, and hypertension in women than men.[96][102] For example, Thurston and colleagues reported an inverse association between household income and risk of incident heart disease that was similar for both women and men. However, the relationship between low education and hypertension was much stronger for women. Further analyses showed that low education for women (but not men) was associated with other risks related to heart disease, such as higher body mass index, unemployment, depressive symptoms, and single parenthood, perhaps reflecting "the synergistic effects of class and gender, two stratifying characteristics that may confer greater disadvantage than each alone".

In contrast to Thurston et al., the results of this thesis suggested a similar effect of low education on hypertension for men and women. Also contradictory to the Thurston study was the finding in this thesis of a stronger association between low income and hypertension among women than men. The predicted probability graph (Figure 4.1) shows that at high income levels, the probability of hypertension was greater for men than women – a pattern that reversed in the lowest household income grouping. What might explain this association? As suggested in one study, spending behaviors may be patterned by gender; that is "at any level of income, women may use their resources differently than men. Women may choose to invest more in their health by purchasing healthier (potentially more expensive) foods or fitness equipment. In contrast, men may be more likely to purchase other items less directly related to their health".

The different health outcomes examined in this thesis compared to the Thurston study (prevalent hypertension versus incident heart disease) might partly explain the discrepant findings, as might differences in the population of interest (rural Canadians versus a general population of Americans). It is also important to keep in mind that gender differences in associations between SEP and health may also depend on other socio-demographic characteristics not examined in this study such as age, marital status, employment status, and quite possibly, urban/rural status. The manner in which risk factors for hypertension may be differentially patterned by both gender and specific SEP indicator requires further study. There is growing awareness in the epidemiological literature that common indicators of SEP, though conceptually overlapping, likely tap into different causal mechanisms underlying associations between SEP and health. It is important to emphasize, however, that despite some discrepant findings, lower educational attainment and income were associated with a greater odds of hypertension for both women and men in this study. Although low-income rural women may be particularly vulnerable to their household financial circumstances, additional research is required to see if this finding can be replicated in future research.

5.2 Area-level SEP and high blood pressure

Area-level material deprivation in this study was unrelated to hypertension. This finding is in sharp contrast to the growing number of studies reporting associations between material deprivation and a greater likelihood of high blood pressure in urban settings. On the other hand, higher area-level social deprivation in this study was associated with a greater probability of hypertension, particularly among men. Research in urban settings has similarly reported significant associations between social aspects of neighborhoods and prevalent hypertension. For example, the results of a number of studies in the United States and Europe have shown elevated levels of blood pressure among residents living in neighborhoods characterized by higher crime rates, lower social cohesion, less interpersonal trust, and lower social status in comparison to their counterparts living in more socially desirable communities.[(25)(91)(93)(121)] Exposure to chronic social stressors may lead residents to view their communities as threatening, resulting in a physiologic response and elevation of blood pressure. More limited social resources in the community may also reduce residents' ability to cope with other life stresses. Alternatively, socially deprived neighborhoods may discourage engaging in healthy behaviors, such as regular physical activity. Two Canadian studies have examined hypertension in relation to area-level social deprivation, with mixed results. A study in Quebec using administrative data bases found *higher* levels of social deprivation to be associated with a *lower* risk of incident hypertension. Matheson and colleagues, using self-reported diagnosed hypertension as the outcome of interest, reported an increase in prevalent hypertension as neighborhood deprivation increased – but only among women. Several other studies have also shown a stronger impact of neighborhood social context on cardiovascular disease and hypertension for women than men. No studies could be located that reported, as this thesis did, a more pronounced effect of neighborhood social deprivation on men than women.

Why might the association between social deprivation and hypertension in this study be stronger for men? It is possible that rural men have a different relationship to their local social environment compared to rural women (and possibly compared to urban men). However, it is important to remember that the measure of social deprivation used in this study, derived from PCA, was comprised of the following three census indicators: the proportion of people living alone, the proportion separated/divorced/widowed, and the proportion employed. In most studies of area-level deprivation, including Pampalon's version, area-level employment is considered an indicator of material deprivation. Unfortunately, the aggregate nature of the measure used in this study prevents examining the unique contribution of any individual indicator.

Discrepancies in some of the findings between this study and the broader literature may be due to several reasons. On the one hand, it is possible that the relationship between SEP and hypertension may be different in rural versus urban settings. Rural and urban contexts differ in many ways, including access to material and social resources, which in turn, might impact observed associations between SEP and health. Some research[(34)(122)] but not all,[(35)(123)] does suggest that associations between SEP and health in rural settings may depart from expected patterns. For example in a recent study using data from the CCHS, household income was inversely associated with self-reported chronic health conditions among older women living in urban Canada, but unassociated with the health status of those in rural locals, which the authors suggest may be due to the more reasonable cost of living in rural than urban Canada, "possibly making income (and other measures capturing economically based resources) a less important explanatory variable".[(34)] In a longitudinal study of 49 to 59 year old American men, a strong inverse association was reported between SEP and mortality among urban and suburban dwelling men, but no association among rural men.[(122)] In attempting to explain such findings, the authors speculate, "Could it be, for example, that rural communities, by virtue of greater social cohesion, provide both a social bedrock leading to good health and a sharing of this bedrock across the range of social classes?". Using several measures of SEP, Pickett et al. also failed to find any evidence of an inverse association between SEP and unintentional injury in a cohort of predominantly male farmers in Saskatchewan Canada.[(124)]

On the other hand, the inverse relationships reported in this study between individual/household-level measures of SEP and hypertension were generally similar to those reported in the general literature. This suggests the possibility that area-level measures of SEP in particular may be less valid indicators of residents' access to material and social resources in rural compared to urban environments. Indicators of material deprivation, based on census data, are intended to measure access to tangible resources, such as good quality housing, healthy food, and recreational facilities. Conversely, measures of social deprivation attempt to assess the quality of social relationships within a community, such as social cohesion, social support, sense of community and mutual assistance and trust. It is possible that in rural settings, area-level measures based on census data may be poor proxies for the material and social constructs they are intended to represent.

5.3 Strengths and limitations

The large sample size of this study provided adequate statistical power to investigate hypotheses over a wide geographic area in Saskatchewan.[125] The SRHS design was based on Statistics Canada's census subdivisions, allowing for easier linkage between individual/household level data and area-level data. In addition, multilevel logistic regression modeling was successfully applied to take into account the hierarchical nature of the data.

Limitations were also present. Analyses were based on cross-sectional data, making it challenging to establish the temporal ordering of several of the study variables. The response rate of 42% may have introduced selection bias into our study findings. Some previous research suggests that non-respondents are more likely to be in poor health than respondents and belong to lower SEP groups, possibly resulting in an underestimation of associations between hypertension and socioeconomic circumstances in this study.[126][127] The restriction in our sampling frame to property tax paying households may have further contributed to an underestimation of SEP associations.

There are also limits to the generalizability of our findings. Compared to the overall Saskatchewan population residing outside of cities and First Nations reserves, our sample had a similar gender distribution, but a larger proportion of older people.[128] In addition, the rural areas examined in this study were restricted to no MIZ, weak MIZ or moderate MIZ. Therefore, it is necessary to be cautious in generalizing our results to the broader Saskatchewan population.

Limitations in measurement were also present. Being a self-reported survey, all participants' responses were prone to measurement error. The dependent variable was self-reported, diagnosed hypertension, which likely resulted in an underestimation of prevalence. Direct blood pressure measurement, especially systolic blood pressure, may provide a more accurate estimate of hypertension prevalence because it is not contingent upon diagnosis or awareness.(129) Several important risk factors for hypertension, such as dietary sodium intake, stress, abdominal obesity, and hip circumference, were not measured in the survey.(130)

In addition, study measures assessed adult SEP at one point in time. Socioeconomic conditions in childhood may also contribute to inequalities in adult health, including hypertension.(35) In older populations, several measures of SEP not included in this study, such as wealth and assets, may be more valid indicators of SEP. Area-level deprivation indices used in this study were based on the work of Pampalon and colleagues who recommend the dissemination area (DA) as the spatial unit to acquire data.(83)(119) DA's usually have populations of between 400 and 700 residents. Since almost all of the census indicators were based on 20% of the population, Statistics Canada prevents release of the data due to privacy restrictions. In the SRHS, CSDs have considerably fewer residents (less than 200). Several area-level indicators were suppressed to meet confidentially requirements, including the proportion of single parent households and median household income. This led to the use of only five SEP indicators instead of six. In addition, Pampalon's SEP indicators were designed for use in urban Canada.

A three-level multilevel model was adopted in this study: individuals (level 1) clustered in households (level 2), clustered in areas (level 3). For this kind of model, multilevel modeling methodologies are still under development, including goodness of fit statistics.(18)

5.4 Conclusion

Study results revealed complex relationships between SEP, gender, and high blood pressure in this rural Saskatchewan population. At the individual/household-level, lower SEP was associated with an increased likelihood of prevalent hypertension. The relationship between low income and hypertension was more pronounced among women than men. Higher social deprivation was associated with greater odds of high blood pressure, particularly for men. Area-level material deprivation was not associated with hypertension. Future research applying a longitudinal design is needed to advance understanding of the relationship between SEP and hypertension in rural Canada, including the identification of vulnerable subgroups. Also needed is research examining the factors which explain (ie., mediate) associations between SEP and hypertension in rural settings, particularly at the area-level.

REFERENCES

1. World Heart Federation. Hypertension. Available at http://www.world-heart-federation.org/cardiovascular-health/cardiovascular-disease-risk-factors/hypertension/ Accessed December 16 2014.
2. Wilkins K, Campbell NRC, Joffres MR, et al. Blood pressure in Canadian adults. Health Reports. 2010; 20(1):1-10.
3. Joffres MR, Ghadirian P, Fodor JG, et al. Awareness, treatment, and control of hypertension in Canada. Am. J Hypertens. 1997;10:1097-102.
4. Petrella RJ, Campbell NR. Awareness and misconception of hypertension in Canada: results of a national survey. Can J Cardiol. 2005 May 15;21(7):589-93.
5. Hypertension Canada. Canadian Hypertension Education Program 2014 Recommendations. Available at: https://www.hypertension.ca/en/professional Accessed December 16 2014.
6. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJL. Selected major risk factors and global and regional burden of disease. Lancet. 2002;360 (9343):1347-60.
7. Mackay J, Mensah GA. The atlas of heart disease and stroke. Geneva: World Health Organization, Centers for Disease Control and Prevention, 2004.
8. Lim SS, Vos T, Flaxman AD, Danaei G, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012; 380:2224-60.
9. Kearney PM, Whelton M, Reynolds K, et al. Global burden of hypertension: analysis of worldwide data. Lancet. 2005;365:217-23.
10. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update. J Am Coll Cardiol. 2004;43:1731-7.

11. Jatoi NA, Jerrard-Dunne P, Feely J, Mahmud A. Impact of smoking and smoking cessation on arterial stiffness and aortic wave reflection in hypertension. Hypertension. 2007;49:981-5.

12. Hu G, Barengo NC, Tuomilehto J, et al. Relationship of physical activity and body mass index to the risk of hypertension: a prospective study in Finland. Hypertension. 2004; 43:25-30.

13. Pereira MA, Folsom AR, McGovern PG, Carpenter M, Arnett DK, Liao D, Szklo M, Hutchinson RG. Physical activity and incident hypertension in black and white adults: the Atherosclerosis Risk in Communities Study. Prev Med. 1999;28:304-32.

14. Kawabe H, Shibata H, Hirose H, Tsujioka M, Saito I, Saruta T. Determinants for the development of hypertension in adolescents: a 6-year follow-up. J Hypertens. 2000;18:1557-61.

15. Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M. Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. Int J Epidemiol.1997;26:739-47.

16. Liebman M, Pelican S, Moore SA, et al. Dietary intake, eating behavior, and physical activity-related determinants of high body mass index in rural communities in Wyoming, Montana, and Idaho. Int J Obes Relat Metab Disord. 2003;27(6):684-92.

17. Joffres M R, Campbel N RC l, Manns B, Tu K. Estimate of the benefits of a population-based reduction in dietary sodium additives on hypertension and its related health care costs in Canada. Can. J Cardiol. 2007;23(6):437-43.

18. Colhoun HM, Hemingway H, Poulter NR. Socio-economic status and blood pressure: an overview analysis. J Hum Hypertens. 1998;12:91-110.

19. Galobardes B, Lynch J, Smith GD. Measuring socioeconomic position in health research. Br Med Bull. 2007. 81-82;21-37.

20. Mackenbach JP SI, Roskam AR, et al. Socioeconomic inequalities in health in 22 European countries. N Engl J Med. 2008;358:2468-81.

21. Dalstra J, Kunst A, Borrell C, et al. Socioeconomic differences in the prevalence of common chronic diseases: an overview of eight European countries. Int J Epidemiol. 2005;34:316-26.

22. Conen D, Glynn RJ, Ridker PM, Buring JE, Albert MA. Socioeconomic status, blood pressure progression, and incident hypertension in a prospective cohort of female health professionals. Eur Heart J 2009;30:1378-84.

23. Robitaille C, Dai S, Waters C, Loukine L, Bancej C, Quach S, et al. Diagnosed hypertension in Canada: incidence, prevalence and associated mortality. CMAJ. 2012;184(1):E49-E56.

24. Chaix B, Ducimetiere P, Lang T, Haas B, Montaye M, Ruidavets JB, Arveiler D, Amouyel P, Ferrieres J, Bingham A, Chauvin P. Residential environment and blood pressure in the PRIME Study: is the association mediated by body mass index and waist circumference? J Hypertens. 2008;26:1078-84.

25. Chaix B, Bean K, Leal C, et al. Individual/neighborhood social factors and blood pressure in the RECORD Cohort Study – which risk factors explain the associations? Hypertension. 2010;55:769-75.

26. Aube-Maurice J, Rochette L, Blais C. Divergent associations between incident hypertension and deprivation based on different sources of case identification. Chronic Dis Can. 2012;32:121-30.

27. Merlo J, Ostergren PO, Hagberg O, Lindstrom M, Lindgren A, Melander A, et al. Diastolic blood pressure and area of residence: multilevel versus ecological analysis of social inequity. J Epidemiol Community Health. 2001 Nov;55(11):791-8.

28. Van Minh H, Byass P, Chuc NTK, Wall S. Gender differences in prevalence and socioeconomic determinants of hypertension: findings from the WHO STEPs survey in a rural community of Vietnam. J Hum Hypertens. 2006;58:109-15.

29. Loucks E, Rehkopf D, Thurston R, Kawachi I. Socioeconomic disparities in metabolic syndrome differ by gender: evidence from NHANES III. Ann Epidemiol. 2007;17:19-26.

30. MacIntyre S, Hunt K. Socio-economic position, gender and health: how do they interact? J Health Psychol. 1997;2:315-34.

31. Matheson F, White H, Moineddin R, Dunn J, & Glazier R. Neighbourhood chronic stress and gender inequalities in hypertension among Canadian adults: a multilevel analysis. J Epidemiol Community Health. 2010; 64:705-13.

32. Canadian Institute for Health Information. How Healthy are Rural Canadians? An Assessment of Their Health Status and Health Determinants. Ottawa: CIHI; 2006. Available at: https://secure.cihi.ca/free_products/rural_canadians_2006_report_e.pdf. Accessed March 15, 2014.

33. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research – one size does not fit all. JAMA. 2005;294:2879-88.

34. Wanless D, Mitchell B, Wister A. Social determinants of health for older women in Canada: does rural-urban residency; matter? Canadian J Aging. 2010;29:233-47.

35. Pampalon R, Hamel D, Gamache P. Health inequalities in urban and rural Canada: comparing inequalities in survival according to an individual and area-based deprivation index. Health Place. 2010;16(2):416-20.

36. Salvadori M, Sontrop JM, Garg AX, et al. Elevated blood pressure in relation to overweight and obesity among children in a rural Canadian community. Pediatrics. 2008;122:e821-7.

37. Barton SN, Coombs DW, Millar HL, et al. Comparison of hypertension prevalence and control in 5,237 rural and urban Alabama residents. South Med J. 1987; 80(10):1220-2.

38. Pahwa P, Karunanayake CP, Hagel L, Janzen B, Pickett W, Rennie D, et al. The Saskatchewan Rural Health Study: an application of a population health framework to understand respiratory health outcomes. BMC Research Notes. 2012;5:400.

39. Pahwa P, Karunanayake C, Willson PJ, Hagel L, Rennie DC, Lawson JA, et al. Prevalence of chronic bronchitis in farm and nonfarm rural residents in Saskatchewan. JOEM. 2012;54(12):1481-90.

40. Janzen B, Karunanayake C, Pahwa P, et al. Exploring diversity in socioeconomic inequalities in health among rural dwelling Canadians. J Rural Health. (in press).

41. World Health Organization. Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. Geneva: World Health Organization Press, 2009.

42. Maetzel A, Li LC, Pencharz J, et al. The economic burden associated with osteoarthritis, rheumatoid arthritis, and hypertension: a comparative study. Ann Rheum Dis. 2004;63:395-401.

43. Lawes CM, Vander Hoorn S, Rodgers A. Global burden of blood pressure-related disease, 2001. Lancet. 2008;71(9623):1513-8.

44. Gaziano TA, Bitton A, Anand S, et al. The global cost of nonoptimal blood pressure. J Hypertens. 2009;27:1472-7.

45. Atwood KM, Robitaille CJ, Reimer K, Dai S, Johansen HL, Smith MJ. Comparison of diagnosed, self-reported, and physically-measured hypertension in Canada. Can J Cardiol. 2013;29(5):606-12.

46. Public Health Agency of Canada. Report from the Canadian Chronic Surveillance System: Hypertension in Canada, 2010. Available at: http://www.phac-aspc.gc.ca/cd-mc/cvd-mcv/ccdss-snsmc-2010/2-2-eng.php. Accessed December 16, 2014.

47. Statistics Canada. The Canadian Community Health Survey (CCHS) Cycle 1.1. Available at: www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/health70b-eng.htm. Accessed December 16, 2014.

48. Statistics Canada. Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 1, January 2010. Available at: www.statcan.gc.ca. Accessed Dec 17 2014.

49. Wilkins K GM, Cambell N. The difference in hypertension control between older men and women. Statistics Canada. Health Reports. 2012;23(4):2-10.

50. Statistics Canada. Blood pressure of Canadian adults: 2009 to 2011. Available at: http://www.statcan.gc.ca/pub/82-625-x/2012001/article/11714-eng.htm. Accessed December 17, 2014.

51. Veenstra G. Racialized identity and health in Canada: results from a nationally representative survey. Soc Sci Med. 2009;69(4):538-42.

52. Chiu M, Austin, P. C., Manuel, D. G., Tu, J. V. Comparison of cardiovascular risk profiles among ethnic groups using population health surveys between 1996 and 2007. CMAJ. 2010;182(8):E301-E310.

53. Bruce SG RN, Zacharias JM, Young TK. Obesity and obesity-related comorbidities in a Canadian First Nation population. Prev Chronic Dis. 2011;31(1):27-32.

54. Mitura V, Bollman R. The health of rural Canadians. A rural-urban comparison of health indicators. Rural and Small Town Canada Analysis Bull. 2003; 4(6):1-23.

55. Field AE, Coakley EH, Must A, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. Arch Intern Med. 2001;161:1581-6.

56. Warburton DE, Charlesworth S, Ivey A, Nettlefold L, Bredin SS. A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. Int J Behav Nutr Phy. 2010;7:39.

57. Katzmarzyk PT JI. The economic costs associated with physical inactivity and obesity in Canada: an update. Can J Appl Physiol. 2004;29(1):90-115.

58. He FJ, MacGregor GA. A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. J Hum Hypertens. 2009; 23(6):363-84.

59. Hypertension Canada. 2011 Canadian Hypertension Education Program recommendations. An annual update. Canadian Family Physician. 2011;57(12): 1393-1397.

60. World Health Organization. Global Health Risks: Mortality and Burden Of Disease Attributable To Selected Major Risks. Geneva: World Health Organization Press, 2009. Available at: http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf. Accessed December 17, 2014.

61. Koppes LL, Twisk JW, Van MechelenW, et al. Cross-sectional and longitudinal relationships between alcohol consumption and lipids, blood pressure and body weight indices. J Stud Alcohol. 2005;66(6):713–21.

62. Fuchs FD, Chambless LE, Whelton PK, et al. Alcohol consumption and the incidence of hypertension: the Atherosclerosis Risk in Communities Study. Hypertension. 2001;37(5):1242–50.

63. Halanych JH, Safford MM, Kertesz SG, Pletcher MJ, Kim YI, Person SD, et al. Alcohol consumption in young adults and incident hypertension: 20-year follow-up from the Coronary Artery Risk Development in Young Adults Study. Am J Epidemiol. 2010;171(5):532-9.

64. Bowman TS, Gaziano JM, Buring JE, Sesso HD. A prospective study of cigarette smoking and risk of incident hypertension in women. J Am Coll Cardiol. 2007; 50(21):2085-92.

65. Banda JA, Clouston K, Sui X, Hooker SP, Lee DC, Blair SN. Protective health factors and incident hypertension in men. Am J Hypertens. 2010;23(6):599-605.

66. Minami J, Ishimitsu T, Matsuoka H. Effects of smoking cessation on blood pressure and heart rate variability in habitual smokers. Hypertension. 1999; 33:586–90.

67. Onat A, Ugur M, Hergenc G, Can G, Ordu S, Dursunoglu D. Lifestyle and metabolic determinants of incident hypertension, with special reference to cigarette smoking: a longitudinal population-based study. Am J Hypertens. 2009;22(2):156-62.

68. Lee D, Ha M, Kim J, Jacobs DR. Effects of smoking cessation on changes in blood pressure and incidence of hypertension. Hypertension. 2001;37:194-8.

69. Green MS, Jucha E, Lz Y. Blood pressure in smokers and non-smokers: epidemiologic findings. Am Heart J. 1986;111: 932-40.

70. Carroll D, Ring C, Hunt K, et al. Blood pressure reactions to stress and the prediction of future blood pressure: effects of sex, age, and socioeconomic position. Psychosom Med. 2003;65:1058-64.

71. Sparrenberger F, Cichelero FT, Ascoli AM, Fonseca FP, Weiss G, Berwanger O, et al. Does psychosocial stress cause hypertension? A systematic review of observational studies. J Hum Hypertens. 2009;23(1):12-9.

72. Markovitz JH, Matthews KA, Whooley M, et al.: Increases in job strain are associated with incident hypertension in the CARDIA Study. Ann Behav Med 2004; 28:4-9.

73. Guimont C, Brisson C, Dagenais GR, et al.: Effects of job strain on blood pressure: a prospective study of male and female white-collar workers. Am J Public Health 2006, 96: 1436-9.

74. Cuffee Y, Ogedegbe C, Williams NJ, Ogedegbe G, Schoenthaler A. Psychosocial risk factors for hypertension: an update of the literature. Curr Hypertens Rep. 2014; 16(10):483.

75. Spruill TM. Chronic psychosocial stress and hypertension. Curr Hypertens Rep. 2010;12(1):10-6.

76. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J Epidemiol Community Health. 2006;60(1):7-12.

77. Commission on Social Determinants of Health. Closing the Gap in a Generation: Health Equity Through Action on the Social Determinants of Health. Final report of the Commission on Social Determinants of Health. Geneva (CH): World Health Organization; 2008. Available from: http://www.who.int/social_determinants/thecommission/finalreport/en/. Accessed March 15, 2014.

78. Kaplan GA. What is the role of the social environment in understanding inequalities in health? Ann N Y Acad Sci. 1999;896:116-9.

79. Pampalon R, Raymond G. A deprivation index for health and welfare planning in Quebec. Chronic Dis Can. 2000;21(3):104-13.

80. Townsend P. Deprivation. J Soc Pol. 1987;16:125-46.

81. Canadian Public Health Association. Contemporary uses of area-based socio-economic measures. Can J Public Health. 2012;103(suppl 2):S1-S32.

82. Pampalon R, Hamel D, Gamache P. Recent changes in the geography of social disparities in premature mortality in Québec. Soc Sci Med. 2008;67(8):1269-81.

83. Pampalon R, Hamel D, Gamache P, Raymond G. A deprivation index for health planning in Canada. Chronic Dis Can. 2009;29(4):178-91.

84. Lee DS, Chiu M, Manuel DG, Tu K, Wang X, Austin PC, et al. Trends in risk factors for cardiovascular disease in Canada: temporal, socio-demographic and geographic factors. CMAJ. 2009;181(3-4):E55-66.

85. Brummett BH, Babyak MA, Siegler IC, et al. Systolic blood pressure, socioeconomic status, and biobehavioral risk factors in a nationally representative US young adult sample. Hypertension. 2011;58:161-6.

86. Vargas CM, Ingram DD, Gillum RF. Incidence of hypertension and educational attainment: the NHANES I epidemiologic follow-up study. Am J Epidemiol. 2000; 152:272-8.

87. Ford ES, Cooper RS. Risk factors for hypertension in a national cohort study. Hypertension. 1991;18:598-606.

88. Matthews KA, Kiefe CI, Lewis CE, Liu K, Sidney S, Yunis C. Socioeconomic trajectories and incident hypertension in a biracial cohort of young adults. Hypertension. 2002;39:772-6.

89. Menec VH, Shooshtari S, Nowicki S, Fournier S. Does the relationship between neighborhood socioeconomic status and health outcomes persist into very old age? A population-based study. J Aging Health. 2010;22(1):27-47.

90. Breckenkamp J, Mielck A, Razum O. Health inequalities in Germany: do regional-level variables explain differentials in cardiovascular risk? BMC Public Health. 2007;7:132.

91. Van Hulst A, Thomas F, Barnett TA, Kestens Y, Gauvin L, Pannier B, et al. A typology of neighborhoods and blood pressure in the RECORD Cohort Study. J Hypertens. 2012;30(7):1336-46.

92. Hamano T, Fujisawa Y, Yamasaki M, Ito K, Nabika T, Shiwaku K. Contributions of social context to blood pressure: findings from a multilevel analysis of social capital and systolic blood pressure. Am J Hypertens. 2011;24(6):643-6.

93. Mujahid MS, Diez Roux AV, Morenoff JD, Raghunathan TE, Cooper RS, Ni H, et al. Neighborhood characteristics and hypertension. Epidemiol. 2008;19(4):590-8.

94. Krieger N. Genders, sexes, and health: what are the connections – and why does it matter? Int J Epidemiol. 2003;32(4):652-7.

95. Jenkins KR, Ofstedal MB. The association between socioeconomic status and cardiovascular risk factors among middle-aged and older men and women. Women Health. 2014;54:15-34.

96. Thurston RC, Kubzansky LD, Kawachi I, et al. Is the association between socioeconomic position and coronary heart disease stronger in women than in men? Am J Epidemiol. 2005;162:57-65.

97. Sundquist K, Malmstrom M, Johansson SE. Neighbourhood deprivation and incidence of coronary heart disease: a multilevel study of 2.6 million women and men in Sweden. J Epidemiol Community Health. 2004;58:71-7.

98. Winkleby M, Sundquist K, Cubbin C. Inequalities in CHD incidence and case fatality by neighbourhood deprivation. Am J Prev Med. 2007;32:97-106.

99. Kavanagh AM, Bentley R, Turrell G, Broom DH, Subramanian SV. Does gender modify associations between self rated health and the social and economic characteristics of local environments? J Epidemiol Community Health. 2006;60(6):490-5.

100. Alves L, Azevedo A, Silva S, Barros H. Socioeconomic inequalities in the prevalence of nine established cardiovascular risk factors in a southern European population. PloS ONE. 2012;7(5):e37158.

101. Stringhini S, Spencer B, Marques-Vidal P, Waeber G, Vollenweider P, Paccaud F, et al. Age and gender differences in the social patterning of cardiovascular risk factors in Switzerland: the CoLaus study. PloS ONE. 2012;7(11):e49443.

102. de Gaudemaris R, Lang T, Chatellier G, Larabi L, Lauwers-Cances V, Maitre A, et al. Socioeconomic inequalities in hypertension prevalence and care: the IHPAF Study. Hypertension. 2002;39(6):1119-25.

103. Clougherty JE, Eisen EA, Slade MD, Kawachi I, Cullen MR. Gender and sex differences in job status and hypertension. Occup Environ Med. 2011;68(1):16-23.

104. Levenstein S SM, and Kaplan GA. Psychosocial predictors of hypertension in men and women. Arch Intern Med. 2001;161(10):1341-6.

105. Diez-Roux AV LB, Northridge ME. A multilevel analysis of income inequality and cardiovascular disease risk factors. Soc Sci Med. 2000;50(5):673-87.

106. Plessis V, Beshiri R, Bollman RD, Clemenson H: Definitions of “Rural”. Agriculture and Rural Working Paper Series, Working Paper No. 61. Catalogue no. 21-601-MIE- No. 061. Ottawa, Canada: Agricultural Division, Statistics Canada; 2004.

107. Dillman DA: Mail and Telephone Surveys: The Total Design Method. New York: Wiley; 1978.

108. Statistics Canada. 2006 Census/Profile of Census Subdivisions. Available at: http://datacentre2.chass.utoronto.ca.cyber.usask.ca/cgi-bin/census/2006/displayCensusCSD.cgi?lang=&c=abo&ct=.html.

Accessed December 17 2014.

109. Field A P. Discovering Statistics Using SPSS. London, England: SAGE; 2009.

110. Häadle, W, Simar L. Applied Multivariate Statistical Analysis. Second Edition. New York: Springer; 2007.

111. Kaiser H F. The application of electronic computers to factor analysis. Educ Psychol Meas.1960:20;141-51.

112. Jolliffe IT. Discarding variables in a principal component analysis, I: artificial data. Appl Statist. 1972:21;160-73.

113. Pampalon R HD, Gamache P, Raymong G. etc. An area-based material and social deprivation index for public health in Québec and Canada. Can J Public Health. 2012;103(2):s17-s22.

114. McNiven C, Puderer H, Janes D. Census Metropolitan Area and Census Agglomeration Influenced Zones (MIZ): a Description of the Methodology. Ottawa (ON): Geography Division Statistics Canada; 2000.

115. Thomas G. Levels and Patterns of Alcohol Use in Canada. Alcohol Price Policy Series, Report 1 of 3. Ottawa, ON: Canadian Centre on Substance Abuse; 2012. Available at: http://www.ccsa.ca/Resource%20Library/CCSA-Patterns-Alcohol-Use-Policy-Canada-2012-en.pdf. Accessed December 17, 2014.

116. Rabe-Hesketh S, Skrondal A, Pickles A. Maximum likelihood estimation of limited and discrete dependent variable models with nested random effects. J Econometrics. 2005;128(2):301-23.

117. Rabe-Hesketh S, Skrondal A. Multilevel and Longitudinal Modeling Using Stata. College Station: Stata Press; 2008.

118. Huelsenbeck JP, Crandall KA. Phylogeny estimation and hypothesis testing using maximum likelihood. Annu Rev Ecol Syst. 1997;28:437-66.

119. ESRI 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute.

120. Geyer S, Norozi K, Zoege M, et al. Psychological symptoms in patients after surery for congenital cardiac disease. Cardiol Young. 2006;16:540-8.

121. Agyemang C, Van Hooijdonk C, Wendel-Vos W, et al. The association of neighbourhood psychosocial stressors and self-rated health in Amsterdam, The Netherlands. J of Epidemiol Community Health. 2007; 61(12):1042-9.

122. Hayward M, Pienta A, McLaughlin D. Inequality in men's mortality: the socioeconomic status gradient and geographic context. J Health Soc Behav. 1997; 38:313-30.

123. Lavergne MR, Kephart G. Examining variations in health within rural Canada. R Remote Health. 2012;12:1848-61.

124. Pickett W, Day A, Hagel L, et al. Socioeconomic status and injury in a cohort of Saskatchewan farmers. J Rural Health. 2011;27:245-54.

125. Hsieh FY: Sample size formula for intervention studies with the cluster as unit of randomization. Stat Med. 1988;7(11):1195–1201.

126. Mackenbach JP, Looman CW, Van der Meer JB. Differences in the misreporting of chronic conditions, by levels of education: the effect on inequalities in prevalence area. Am J Public Health. 1996;86:706-11.

127. Ekholm O, Gundgaard J, Rasmussen N, Holme Hansen E. The effect of health, socioeconomic position, and mode of data collection on non-response in health interview surveys. Scand J Public Health. 2010;38:699-706.

128. Bryan S LM, Campbell N, et al. Resting blood pressure and heart rate measurement in the Canadian Health Measures Survey, cycle 1. Health Reports. 2010;21:71-8.

129. Connor Gorber S, Tremblay M, Campbell N, et al. The accuracy of self-reported hypertension: a systematic review and meta-analysis. Curr Hypertens Rev. 2008;4:36-62.

130. Yusuf S, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364(9438):937-52.

APPENDIX A: Survey Questionnaire

SASKATCHEWAN RURAL HEALTH STUDY

UNIVERSITY OF SASKATCHEWAN

TO MEMBERS OF THE HOUSEHOLD AND THEIR FAMILIES:

The University of Saskatchewan is conducting this project to learn more about the health of rural dwellers in Saskatchewan. Families from across Saskatchewan are participating.

This questionnaire is our first contact with your family. Please have an adult family member complete this part of the questionnaire. Please try to answer all of the questions, but remember you don't have to answer any questions if you choose not to. When you have finished, place the questionnaire in the enclosed stamped envelope and mail it back to us at the University.

Instructions

1. Please have an adult family member (age 18 or over) complete Section A and Section B of this questionnaire.

   In Section B of this form, we have asked questions about each adult member (age 18 or over) of your family. We have included enough space in this booklet for 2 adults.

   If you have more than 2 adult family members living in your home, PLEASE COMPLETE "Section B" IN THE GREEN BOOKLET for each additional adult.

2. Please read each question carefully.

3. Answer each question by placing a check mark in the box provided. For some questions you will need to write in the space provided. Thank you for taking part in this important study.

4. **Please be sure to complete the last page.**

The University of Saskatchewan

Sponsored by the Canadian Institutes of Health Research
(Canada's main funder of medical research)

SECTION A YOUR HOME

PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT YOUR PRIMARY FAMILY HOME - THAT IS THE HOME WHERE YOU LIVE MOST OF THE TIME.

Today's Date: _____/_____/_____
(Day / Month / Year)

DEMOGRAPHICS

A-1 Where is your home located?
- ☐ Farm
- ☐ In town
- ☐ Acreage, please specify number of acres _______

A-2 How many people live in your home?
_____ Number

A-3 Please list all persons who usually live here including yourself.

Age	Sex	Family Member
	M ☐ F ☐	Yes ☐ No ☐
	M ☐ F ☐	Yes ☐ No ☐
	M ☐ F ☐	Yes ☐ No ☐
	M ☐ F ☐	Yes ☐ No ☐
	M ☐ F ☐	Yes ☐ No ☐
	M ☐ F ☐	Yes ☐ No ☐

(*IF MORE SPACES ARE REQUIRED CONTINUE ON THE BACK OF THE QUESTIONNAIRE.*)

A-4 How many bedrooms do you have in your home?
_____ Number

A-5 Do you own your home?
- ☐ Yes
- ☐ No
- ☐ Don't know

LIVING ENVIRONMENT

A-6 What year was your residence/apartment built (approximately)?
Year_____________ Don't know ☐

A-7 What are the types of fuel sources used to heat your home? **Please check all that apply.**

	Primary	Secondary
☐ Natural Gas	☐	☐
☐ Propane	☐	☐
☐ Electricity	☐	☐
☐ Fuel oil	☐	☐
☐ Coal	☐	☐
☐ Geo-thermal	☐	☐
☐ Solar energy	☐	☐
☐ Wood	☐	☐
➡ If yes, do you use: ☐ Fireplace ☐ Free standing wood stove ☐ Fireplace insert ☐ Outdoor wood stove		
☐ Other	☐	☐
Please specify ______________________		
☐ Don't Know		

A-8 Does your heating system have a filter?
- ☐ Yes
- ☐ No
- ☐ Don't Know

A-9 Does your home have air conditioning?
- ☐ Yes → **If yes, please check one:**
  ☐ Central ☐ Room ☐ Both
- ☐ No
- ☐ Don't Know

A-10 Is a humidifier or vaporizer used in your home?
- ☐ Yes
- ☐ No
- ☐ Don't Know

A-11 Do you use a dehumidifier in your home?
- ☐ Yes
- ☐ No
- ☐ Don't Know

A-12 On average, how often per month:
do you vacuum carpet? ____ times per month
do you mop smooth floors? ____ times per month
do you dry dust clean? _____ times per month
do you wet dust clean? _____ times per month

A-13 During the past 12 months, has there been water or dampness in your home from broken pipes, leaks, heavy rain, or floods?
- ☐ Yes
- ☐ No
- ☐ Don't Know

Your Home

Your Home

A-14 Does your home (including basement) frequently have a mildew odor or musty smell?

- ☐ Yes
- ☐ No
- ☐ Don't Know

A-15 In the past 12 months have you had any of the following pets living in your home? **Please check Yes or No for each type of pet.**

☐ Check here if you do not have any pets in the house.

	Yes	No	Don't Know
Cat	☐	☐	☐
Dog	☐	☐	☐
Bird	☐	☐	☐
Any other pet	☐	☐	☐

If Yes, please specify _______________

A-16 Within the past 12 months, were pesticides (including herbicides, insecticides, fungicides, rodenticides, fumigants) applied inside your residence (e.g., raid, spider bait, ant bait, rat bait)?

- ☐ Yes → **If Yes, what pesticide(s)? Please specify**_______________________
- ☐ No
- ☐ Don't Know

A-17 Do any of the people who live in your house use any of the following tobacco products in the home? **Please answer Yes or No for each product.**

	Yes	No	Don't Know
Cigarettes	☐	☐	☐
Cigars	☐	☐	☐
Pipes	☐	☐	☐

A-18 **If yes to cigarettes,** how many persons smoke cigarettes in your home?

_____ number of persons

A-19 **If yes to cigarettes,** how many cigarettes do they smoke per day in total?

_____ number of cigarettes

A-20 What is your best estimate of the total income, before taxes and deductions, of all household members from all sources in the past 12 months?

- ☐ Less than $14,999
- ☐ $15,000 to $19,999
- ☐ $20,000 to $29,999
- ☐ $30,000 to $39,999
- ☐ $40,000 to $49,999
- ☐ $50,000 to $59,999
- ☐ $60,000 to $79,999
- ☐ $80,000 or more

A-21 At the end of the month, how much money do you have left over? **(Please check only one)**

- ☐ Some money
- ☐ Just enough money
- ☐ Not enough money

ACCESS TO HEALTH CARE

A-22 Do you and your family members in your household have access to a regular family doctor or nurse practitioner?

- ☐ Yes
- ☐ No
- ☐ Don't Know

A-23 In the past 12 months did you ever experience any difficulties getting the routine or on-going care you or a family member in your household needed?

- ☐ Yes
- ☐ No
- ☐ Don't Know

A-24 In the past 12 months, have you required a visit to a medical specialist for a diagnosis or consultation for yourself or a family member in your household?

- ☐ Yes
- ☐ No → **If No, go to question A-28.**
- ☐ Don't Know

A-25 In the past 12 months did you ever experience any difficulty getting the specialist care you needed for a diagnosis or consultation for yourself or a family member in your household?

- ☐ Yes
- ☐ No
- ☐ Don't Know

Adult 1

SECTION B INDIVIDUAL QUESTIONS

WE WOULD LIKE TO KNOW ABOUT EACH ADULT FAMILY MEMBER (18 YEARS OR OVER) LIVING IN YOUR HOUSEHOLD. IN THIS BOOKLET, WE HAVE INCLUDED SPACE FOR 2 ADULTS.

IF YOU HAVE MORE THAN 2 ADULT FAMILY MEMBERS LIVING IN YOUR HOME, PLEASE COMPLETE "Section B" IN THE GREEN BOOKLET FOR EACH ADDITIONAL ADULT.

ADULT 1

NOW, PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT ADULT # 1.

B-1 Age as of January 1st, 2010: ___________

B-2 Date of birth: MM______ DD____ YY_______

B-3 Sex: Male ☐ Female ☐

B-4 Highest level of education:
- ☐ Less than high school
- ☐ Completed high school
- ☐ Completed university
- ☐ Completed post-secondary education other than above

B-5 What is your ethnic background?
- ☐ Caucasian
- ☐ First Nation
- ☐ Metis
- ☐ Other → **Please specify:** ____________

B-6 What is your height? _____cm. OR ______ft and in.

B-7 What is your weight? _______Kg. OR ______lbs

B-8 What is your marital status? **(Please check only one)**
- ☐ Married
- ☐ Common law/living together
- ☐ Widowed
- ☐ Divorced/separated
- ☐ Single, never married

RESPIRATORY HEALTH

COUGH

B-9 Do you usually have a cough?
- ☐ Yes
- ☐ No → **If no, go to question B-12.**

B-10 Do you usually cough like this on most days for 3 consecutive months or more during the year?
- ☐ Yes
- ☐ No

B-11 For how many years have you had this cough?
_____ years

PHLEGM

B-12 Do you usually bring up phlegm from your chest?
- ☐ Yes
- ☐ No → **If no, go to question B-15.**

B-13 Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?
- ☐ Yes
- ☐ No

B-14 For how many years have you had trouble with phlegm?
_____ years

WHEEZE

B-15 Does your chest ever sound wheezy or whistling:

	Yes	No
1. When you have a cold?	☐	☐
2. Apart from colds?	☐	☐
3. Most days or nights?	☐	☐

If YES to 1, 2, OR 3, for how many years has this been present? _____________number of years

B-16 Have you ever had an attack of wheezing that has made you feel short of breath?
- ☐ Yes
- ☐ No

If YES, have you ever required medicine or treatment for the(se) attack(s)?
- ☐ Yes
- ☐ No

BREATHLESSNESS

B-17 Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?
- ☐ Yes
- ☐ No

B-18 Do you have to walk slower than people of your age because of breathlessness?
- ☐ Yes
- ☐ No

B-19 Do you ever have to stop for breath when walking at your own pace on the level?
- ☐ Yes
- ☐ No

B-20 Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level?
- ☐ Yes
- ☐ No

B-21 Are you too breathless to leave the house or breathless on dressing or undressing?
- ☐ Yes
- ☐ No

ASTHMA

B-22 Have you ever had asthma?
- ☐ Yes
- ☐ No → **If no, go to question B-26.**

B-23 **If Yes to B-22:**

Do you still have it? ☐ Yes ☐ No
Was it confirmed by a doctor? ☐ Yes ☐ No

At what age did it start? ____ age in years

If you no longer have it, at what age did it stop?
____ age in years

B-24 **If yes to B-22**, how many times have you required services for asthma from the following places during the past 12 months?

Hospital inpatient: _________ times
Emergency room outpatient: _________ times
Doctor's office: _________ times

B-25 **If yes to B-22,** which of the following statements best describes your asthma medication use in the past 12 months:
- ☐ Never in the past 12 months
- ☐ At least once in the past 12 months
- ☐ At least once per month
- ☐ At least once per week
- ☐ Every day

ALLERGIES

B-26 Have you ever had an allergic reaction to any of the following: **(Please check all that apply).**

1. House dust	☐ Yes	☐ No
2. Cats	☐ Yes	☐ No
3. Dogs	☐ Yes	☐ No
4. Grasses	☐ Yes	☐ No
5. Pollens	☐ Yes	☐ No
6. Molds	☐ Yes	☐ No
7. Others,	☐ Yes	☐ No

Please specify:____________________

PHYSICAL ACTIVITY

B-27 Do you exercise?
- ☐ Yes → **If yes, how many times a week?**
  _____times a week
- ☐ No → **If no, go to question B-29.**

B-28 How long do you usually exercise?
- ☐ Less than 15 minutes
- ☐ 15 to 30 minutes
- ☐ 31 to 60 minutes
- ☐ More than 60 minutes
- ☐ Don't Know

B-29 In a **typical week** in the past **3 months**, how much time did you usually spend on a computer, including playing computer games and using the Internet or World Wide Web? **(Please do not include time spent at work or at school)**
- ☐ None
- ☐ Less than 1 hour
- ☐ From 1 to 2 hours
- ☐ From 3 to 5 hours
- ☐ From 6 to 10 hours
- ☐ From 11 to 14 hours
- ☐ From 15 to 20 hours
- ☐ More than 20 hours

B-30 In a **typical week** in the past **3 months**, how much time did you usually spend watching television or videos?
- ☐ None
- ☐ Less than 1 hour
- ☐ From 1 to 2 hours
- ☐ From 3 to 5 hours
- ☐ From 6 to 10 hours
- ☐ From 11 to 14 hours
- ☐ From 15 to 20 hours
- ☐ More than 20 hours

EARLY LIFE EXPOSURES

B-31 Have you ever lived on a farm?
- ☐ Yes
- ☐ No
- ☐ Don't know

B-32 Did you live on a farm during your first year of life?
- ☐ Yes → **If yes, what type of farm? (Check all that apply)**
  - ☐ Grain
  - ☐ Livestock
- ☐ No
- ☐ Don't know

B-33 Did your mother smoke while she was pregnant with you?
- ☐ Yes
- ☐ No
- ☐ Don't know

Adult 1

Adult 1

B-34 What was your birth weight?
_________ pounds or _________ grams
☐ Don't know

B-35 Were you breastfed as a child?
☐ Yes → **If yes, was it for 6 months or longer?** ☐ Yes ☐ No
☐ No
☐ Don't know

CIGARETTE SMOKING

B-36 Have you ever smoked cigarettes? **(If you have smoked less than 20 packs of cigarettes in your lifetime, answer no.)**
☐ Yes
☐ No → **If no, go to question B-43**

B-37 Do you now smoke cigarettes?
☐ Yes
☐ No

B-38 How old were you when you first started regular cigarette smoking? ____ years old

B-39 How many cigarettes do you smoke per day now?_____ cigarettes per day

B-40 On the average of the entire time you smoked, how many cigarettes did you smoke per day? _____ cigarettes per day

B-41 If you have stopped smoking cigarettes completely, how old were you when you stopped? _____ age stopped

B-42 If there have been periods when you abstained from smoking, indicate total years of abstinence from smoking. _____ years

B-43 Have you ever smoked a pipe regularly? **(Yes means more than 12 oz of tobacco in a lifetime)**
☐ Yes
☐ No

B-44 Have you ever smoked cigars regularly? **(Yes means more than 1 cigar a week for a year)**
☐ Yes
☐ No

B-45 Do you smoke a pipe or cigars regularly at present?
☐ Yes
☐ No

ALCOHOL CONSUMPTION

B-46 During the past 12 months, how often did you drink alcoholic beverages?
☐ Never
☐ Less than once a month
☐ Once a month
☐ 2 to 3 times a month
☐ Once a week
☐ 2 to 3 times a week
☐ 4 to 6 times a week
☐ Every day

B-47 How often in the past 12 months have you had 5 or more drinks on one occasion?
☐ Never
☐ Less than once a month
☐ Once a month
☐ 2 to 3 times a month
☐ Once a week
☐ More than once a week

MEDICAL HISTORY

B-48 In general would you say your health is:
☐ Excellent
☐ Very Good
☐ Good
☐ Fair
☐ Poor

B-49 During the past 12 months, were you seen by a doctor or other primary care giver for:

	Yes	No	Don't know
Stomach acidity or reflux?	☐	☐	☐
An ear infection?	☐	☐	☐
An injury?	☐	☐	☐

B-50 Has a doctor or primary care giver ever said you have:

	Yes	No	Don't Know
Diabetes	☐	☐	☐
Heart Disease	☐	☐	☐
Heart Attack	☐	☐	☐
Hardening of the arteries	☐	☐	☐
High Blood Pressure	☐	☐	☐
Cystic Fibrosis	☐	☐	☐
Tuberculosis	☐	☐	☐
Stroke	☐	☐	☐
Cancer	☐	☐	☐

If yes to cancer, please specify type(s):
____
____

CHEST ILLNESSES

B-51 Has a doctor ever said you had any of the following chest illnesses:

	Chest Illness	During the Past 12 Months		Ever In Your Life	
a.	Attack of bronchitis	☐ Yes	☐ No	☐ Yes	☐ No
b.	Pneumonia	☐ Yes	☐ No	☐ Yes	☐ No
c.	Hay Fever	☐ Yes	☐ No	☐ Yes	☐ No
d.	Sinus Trouble	☐ Yes	☐ No	☐ Yes	☐ No
e.	Chronic Bronchitis	☐ Yes	☐ No	☐ Yes	☐ No
f.	Emphysema	☐ Yes	☐ No	☐ Yes	☐ No
g.	COPD (Chronic Obstructive Pulmonary Disease)	☐ Yes	☐ No	☐ Yes	☐ No
h.	Sleep Apnea	☐ Yes	☐ No	☐ Yes	☐ No
i.	Other Chest Illness (Example chest operation) please specify:	☐ Yes ________	☐ No	☐ Yes ________	☐ No

B-52 **If yes to Chronic Obstructive Pulmonary Disease (COPD) in question B-51g,** how many times have you required services for COPD from the following places during the **past 12 months**?

Hospital inpatient: ________ times

Emergency room outpatient: ________ times

Doctor's office: ________ times

REST AND SLEEP

B-53 Do you snore?

☐ Yes
☐ No → **If no, go to question B-55.**
☐ Don't know

B-54 If you snore, is your snoring:

☐ Slightly louder than breathing?
☐ As loud as talking?
☐ Louder than talking?
☐ Very loud - can be heard in adjacent rooms?

B-55 How likely are you to doze off or fall asleep in the situations described below, in contrast to just feeling tired? This refers to your usual way of life in recent times. Even if you haven't done some of these things recently, try to work out how they would have affected you. **Please check one response choice for each situation.**

SITUATION	RESPONSE CHOICES: Would never doze	Slight chance of dozing	Moderate chance of dozing	High chance of dozing
Sitting and reading	☐	☐	☐	☐
Watching TV	☐	☐	☐	☐
Sitting inactive in a public place (e.g., a theatre or a meeting)	☐	☐	☐	☐
As a passenger in a car for an hour without a break	☐	☐	☐	☐
Lying down to rest in the afternoon when circumstances permit	☐	☐	☐	☐
Sitting and talking to someone	☐	☐	☐	☐
Sitting quietly after lunch without alcohol	☐	☐	☐	☐
In a car, while stopped for a few minutes in the traffic	☐	☐	☐	☐

Adult 1

FAMILY HISTORY

B-56 Have the following members of your biological family ever had:

	FATHER			MOTHER			BROTHER/SISTER		
	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know
Diabetes	☐	☐	☐	☐	☐	☐	☐	☐	☐
Heart Disease	☐	☐	☐	☐	☐	☐	☐	☐	☐
Heart Attack	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hardening of the arteries	☐	☐	☐	☐	☐	☐	☐	☐	☐
High Blood Pressure	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cystic Fibrosis	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tuberculosis	☐	☐	☐	☐	☐	☐	☐	☐	☐
Stroke	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lung Trouble (Asthma, Emphysema, Chronic Bronchitis)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cancer If yes to cancer, please specify type(s):	☐	☐	☐	☐	☐	☐	☐	☐	☐

OCCUPATIONAL HISTORY

B-57 Please list all full-time jobs at which you have worked for at least one year, starting with your present or most recent job. Please state the job title and business as specifically as possible. For example, 'mixed farming' instead of 'farming'.

Job Title	Business, Industry or Service	Total number of Years at job
e.g. Nurse	Health Care	10
e.g. Farmer	Mixed Farming	30

B-58 Have you ever been exposed to any of the following in the work place?

	No	Yes	If Yes, how often?	How many years?
Grain Dust	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Mine dust (e.g. potash, uranium) Specify ______	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Asbestos dust	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Wood dust	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Other dust Specify ______	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Livestock	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Smoke from stubble burning	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Diesel fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Welding fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Solvent fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Oil / Gas well fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Herbicides (to kill plants)	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Fungicides (to treat grain)	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Insecticides (to kill insects)	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Molds	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Radiation	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Other, Specify ______	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	

Adult 1

B-59 How often do you (did you) wear a dust mask when exposed to grain dust?

☐ Always ☐ Most of the time ☐ Sometimes ☐ Never

B-60 We wish to find out more about respiratory health of rural people. Would you be willing to be contacted about having breathing and/or allergy tests at a nearby location?

☐ Yes
☐ No
☐ I would like more information

IF THERE IS ONLY ONE ADULT IN YOUR FAMILY, PLEASE SKIP TO THE LAST PAGE.

IF THERE IS ANOTHER ADULT IN YOUR FAMILY, PLEASE CONTINUE ON THE NEXT PAGE.

REMEMBER TO COMPLETE THE CONTACT INFORMATION ON THE LAST PAGE!
(THIS INFORMATION WILL BE REMOVED FROM YOUR QUESTIONNAIRE TO ENSURE CONFIDENTIALITY.)

SECTION B INDIVIDUAL QUESTIONS

ADULT 2

NOW, PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT ADULT # 2.

B-1 Age as of January 1st, 2010: ___________

B-2 Date of birth: MM______ DD____ YY_______

B-3 Sex: Male ☐ Female ☐

B-4 Highest level of education:
- ☐ Less than high school
- ☐ Completed high school
- ☐ Completed university
- ☐ Completed post-secondary education other than above

B-5 What is your ethnic background?
- ☐ Caucasian
- ☐ First Nation
- ☐ Metis
- ☐ Other → **Please specify:** ____________

B-6 What is your height? _____cm. **OR** ______ft and in.

B-7 What is your weight? _______Kg. **OR** ______lbs

B-8 What is your marital status? **(Please check only one)**
- ☐ Married
- ☐ Common law/living together
- ☐ Widowed
- ☐ Divorced/separated
- ☐ Single, never married

RESPIRATORY HEALTH

COUGH

B-9 Do you usually have a cough?
- ☐ Yes
- ☐ No → **If no, go to question B-12.**

B-10 Do you usually cough like this on most days for 3 consecutive months or more during the year?
- ☐ Yes
- ☐ No

B-11 For how many years have you had this cough?
_____ years

PHLEGM

B-12 Do you usually bring up phlegm from your chest?
- ☐ Yes
- ☐ No → **If no, go to question B-15.**

B-13 Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?
- ☐ Yes
- ☐ No

B-14 For how many years have you had trouble with phlegm?
_____ years

WHEEZE

B-15 Does your chest ever sound wheezy or whistling:

	Yes	**No**
1. When you have a cold?	☐	☐
2. Apart from colds?	☐	☐
3. Most days or nights?	☐	☐

If YES to 1, 2, OR 3, for how many years has this been present? _____________number of years

B-16 Have you ever had an attack of wheezing that has made you feel short of breath?
- ☐ Yes
- ☐ No

If YES, have you ever required medicine or treatment for the(se) attack(s)?
- ☐ Yes
- ☐ No

BREATHLESSNESS

B-17 Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?
- ☐ Yes
- ☐ No

B-18 Do you have to walk slower than people of your age because of breathlessness?
- ☐ Yes
- ☐ No

B-19 Do you ever have to stop for breath when walking at your own pace on the level?
- ☐ Yes
- ☐ No

Adult 2

B-20 Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level?
- ☐ Yes
- ☐ No

B-21 Are you too breathless to leave the house or breathless on dressing or undressing?
- ☐ Yes
- ☐ No

ASTHMA

B-22 Have you ever had asthma?
- ☐ Yes
- ☐ No → **If no, go to question B-26.**

B-23 **If Yes to B-22:**

Do you still have it? ☐ Yes ☐ No
Was it confirmed by a doctor? ☐ Yes ☐ No

At what age did it start? ____ age in years

If you no longer have it, at what age did it stop? ____ age in years

B-24 **If yes to B-22**, how many times have you required services for asthma from the following places during the past 12 months?

Hospital inpatient: _________ times
Emergency room outpatient: _________ times
Doctor's office: _________ times

B-25 **If yes to B-22,** which of the following statements best describes your asthma medication use in the past 12 months:
- ☐ Never in the past 12 months
- ☐ At least once in the past 12 months
- ☐ At least once per month
- ☐ At least once per week
- ☐ Every day

ALLERGIES

B-26 Have you ever had an allergic reaction to any of the following: **(Please check all that apply).**

1. House dust	☐ Yes	☐ No
2. Cats	☐ Yes	☐ No
3. Dogs	☐ Yes	☐ No
4. Grasses	☐ Yes	☐ No
5. Pollens	☐ Yes	☐ No
6. Molds	☐ Yes	☐ No
7. Others,	☐ Yes	☐ No

Please specify:____________________

PHYSICAL ACTIVITY

B-27 Do you exercise?
- ☐ Yes → **If yes, how many times a week?** _____times a week
- ☐ No → **If no, go to question B-29.**

B-28 How long do you usually exercise?
- ☐ Less than 15 minutes
- ☐ 15 to 30 minutes
- ☐ 31 to 60 minutes
- ☐ More than 60 minutes
- ☐ Don't Know

B-29 In a **typical week** in the past **3 months**, how much time did you usually spend on a computer, including playing computer games and using the Internet or World Wide Web? **(Please do not include time spent at work or at school)**
- ☐ None
- ☐ Less than 1 hour
- ☐ From 1 to 2 hours
- ☐ From 3 to 5 hours
- ☐ From 6 to 10 hours
- ☐ From 11 to 14 hours
- ☐ From 15 to 20 hours
- ☐ More than 20 hours

B-30 In a **typical week** in the past **3 months**, how much time did you usually spend watching television or videos?
- ☐ None
- ☐ Less than 1 hour
- ☐ From 1 to 2 hours
- ☐ From 3 to 5 hours
- ☐ From 6 to 10 hours
- ☐ From 11 to 14 hours
- ☐ From 15 to 20 hours
- ☐ More than 20 hours

EARLY LIFE EXPOSURES

B-31 Have you ever lived on a farm?
- ☐ Yes
- ☐ No
- ☐ Don't know

B-32 Did you live on a farm during your first year of life?
- ☐ Yes → **If yes, what type of farm? (Check all that apply)**
  - ☐ Grain
  - ☐ Livestock
- ☐ No
- ☐ Don't know

B-33 Did your mother smoke while she was pregnant with you?
- ☐ Yes
- ☐ No
- ☐ Don't know

Adult 2

B-34 What was your birth weight?
__________ pounds or __________ grams
☐ Don't know

B-35 Were you breastfed as a child?
☐ Yes → **If yes, was it for 6 months or longer?** ☐ Yes ☐ No
☐ No
☐ Don't know

CIGARETTE SMOKING

B-36 Have you ever smoked cigarettes? **(If you have smoked less than 20 packs of cigarettes in your lifetime, answer no.)**
☐ Yes
☐ No → **If no, go to question B-43**

B-37 Do you now smoke cigarettes?
☐ Yes
☐ No

B-38 How old were you when you first started regular cigarette smoking? _____ years old

B-39 How many cigarettes do you smoke per day now?______ cigarettes per day

B-40 On the average of the entire time you smoked, how many cigarettes did you smoke per day?
______ cigarettes per day

B-41 If you have stopped smoking cigarettes completely, how old were you when you stopped?
______ age stopped

B-42 If there have been periods when you abstained from smoking, indicate total years of abstinence from smoking. ______ years

B-43 Have you ever smoked a pipe regularly? **(Yes means more than 12 oz of tobacco in a lifetime)**
☐ Yes
☐ No

B-44 Have you ever smoked cigars regularly? **(Yes means more than 1 cigar a week for a year)**
☐ Yes
☐ No

B-45 Do you smoke a pipe or cigars regularly at present?
☐ Yes
☐ No

ALCOHOL CONSUMPTION

B-46 During the past 12 months, how often did you drink alcoholic beverages?
☐ Never
☐ Less than once a month
☐ Once a month
☐ 2 to 3 times a month
☐ Once a week
☐ 2 to 3 times a week
☐ 4 to 6 times a week
☐ Every day

B-47 How often in the past 12 months have you had 5 or more drinks on one occasion?
☐ Never
☐ Less than once a month
☐ Once a month
☐ 2 to 3 times a month
☐ Once a week
☐ More than once a week

MEDICAL HISTORY

B-48 In general would you say your health is:
☐ Excellent
☐ Very Good
☐ Good
☐ Fair
☐ Poor

B-49 During the past 12 months, were you seen by a doctor or other primary care giver for:

	Yes	No	Don't know
Stomach acidity or reflux?	☐	☐	☐
An ear infection?	☐	☐	☐
An injury?	☐	☐	☐

B-50 Has a doctor or primary care giver ever said you have:

	Yes	No	Don't Know
Diabetes	☐	☐	☐
Heart Disease	☐	☐	☐
Heart Attack	☐	☐	☐
Hardening of the arteries	☐	☐	☐
High Blood Pressure	☐	☐	☐
Cystic Fibrosis	☐	☐	☐
Tuberculosis	☐	☐	☐
Stroke	☐	☐	☐
Cancer	☐	☐	☐

If yes to cancer, please specify type(s):
____
____

Adult 2

CHEST ILLNESSES

B-51 Has a doctor ever said you had any of the following chest illnesses:

	Chest Illness	During the Past 12 Months		Ever In Your Life	
a.	Attack of bronchitis	☐ Yes	☐ No	☐ Yes	☐ No
b.	Pneumonia	☐ Yes	☐ No	☐ Yes	☐ No
c.	Hay Fever	☐ Yes	☐ No	☐ Yes	☐ No
d.	Sinus Trouble	☐ Yes	☐ No	☐ Yes	☐ No
e.	Chronic Bronchitis	☐ Yes	☐ No	☐ Yes	☐ No
f.	Emphysema	☐ Yes	☐ No	☐ Yes	☐ No
g.	COPD (Chronic Obstructive Pulmonary Disease)	☐ Yes	☐ No	☐ Yes	☐ No
h.	Sleep Apnea	☐ Yes	☐ No	☐ Yes	☐ No
i.	Other Chest Illness (Example chest operation) please specify:	☐ Yes ________	☐ No	☐ Yes ________	☐ No

B-52 **If yes to Chronic Obstructive Pulmonary Disease (COPD) in question B-51g,** how many times have you required services for COPD from the following places during the **past 12 months**?

Hospital inpatient: ________ times

Emergency room outpatient: ________ times

Doctor's office: ________ times

REST AND SLEEP

B-53 Do you snore?

☐ Yes

☐ No → **If no, go to question B-55.**

☐ Don't know

B-54 If you snore, is your snoring:

☐ Slightly louder than breathing?

☐ As loud as talking?

☐ Louder than talking?

☐ Very loud - can be heard in adjacent rooms?

B-55 How likely are you to doze off or fall asleep in the situations described below, in contrast to just feeling tired? This refers to your usual way of life in recent times. Even if you haven't done some of these things recently, try to work out how they would have affected you. **Please check one response choice for each situation.**

SITUATION	RESPONSE CHOICES: Would never doze	Slight chance of dozing	Moderate chance of dozing	High chance of dozing
Sitting and reading	☐	☐	☐	☐
Watching TV	☐	☐	☐	☐
Sitting inactive in a public place (e.g., a theatre or a meeting)	☐	☐	☐	☐
As a passenger in a car for an hour without a break	☐	☐	☐	☐
Lying down to rest in the afternoon when circumstances permit	☐	☐	☐	☐
Sitting and talking to someone	☐	☐	☐	☐
Sitting quietly after lunch without alcohol	☐	☐	☐	☐
In a car, while stopped for a few minutes in the traffic	☐	☐	☐	☐

Adult 2

Adult 2

FAMILY HISTORY

B-56 Have the following members of your biological family ever had:

	FATHER			MOTHER			BROTHER/SISTER		
	Yes	No	Don't Know	Yes	No	Don't Know	Yes	No	Don't Know
Diabetes	☐	☐	☐	☐	☐	☐	☐	☐	☐
Heart Disease	☐	☐	☐	☐	☐	☐	☐	☐	☐
Heart Attack	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hardening of the arteries	☐	☐	☐	☐	☐	☐	☐	☐	☐
High Blood Pressure	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cystic Fibrosis	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tuberculosis	☐	☐	☐	☐	☐	☐	☐	☐	☐
Stroke	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lung Trouble (Asthma, Emphysema, Chronic Bronchitis)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cancer If yes to cancer, please specify type(s):	☐	☐	☐	☐	☐	☐	☐	☐	☐

OCCUPATIONAL HISTORY

B-57 Please list all full-time jobs at which you have worked for at least one year, starting with your present or most recent job. Please state the job title and business as specifically as possible. For example, 'mixed farming' instead of 'farming'.

Job Title	Business, Industry or Service	Total number of Years at job
e.g. Nurse	Health Care	10
e.g. Farmer	Mixed Farming	30

B-58 Have you ever been exposed to any of the following in the work place?

	No	Yes	If Yes, how often?	How many years?
Grain Dust	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Mine dust (e.g. potash, uranium) Specify ______	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Asbestos dust	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Wood dust	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Other dust Specify ______	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Livestock	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Smoke from stubble burning	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Diesel fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Welding fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Solvent fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Oil / Gas well fumes	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Herbicides (to kill plants)	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Fungicides (to treat grain)	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Insecticides (to kill insects)	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Molds	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Radiation	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	
Other, Specify ______	☐	☐	Daily ☐ Weekly ☐ Monthly ☐ Occasionally ☐	

Adult 2

B-59 How often do you (did you) wear a dust mask when exposed to grain dust?

☐ Always ☐ Most of the time ☐ Sometimes ☐ Never

B-60 We wish to find out more about respiratory health of rural people. Would you be willing to be contacted about having breathing and/or allergy tests at a nearby location?

☐ Yes
☐ No
☐ I would like more information

IF THERE ARE MORE THAN TWO ADULT FAMILY MEMBERS LIVING IN YOUR HOUSEHOLD, PLEASE CONTINUE IN THE GREEN BOOKLET.

REMEMBER TO COMPLETE THE CONTACT INFORMATION ON THE LAST PAGE!
(THIS INFORMATION WILL BE REMOVED FROM YOUR QUESTIONNAIRE TO ENSURE CONFIDENTIALITY)

CONTACT INFORMATION (PLEASE PRINT)

NAME: ______________________ Age: ______ ☐ Male ☐ Female

(Name of person completing the survey)

____

Address (number and street and Box Number)

______________________ , ______________________

Town Postal code

If you live on a farm give the land location of your residence.

____

Land location (quarter, section, township, meridian)

Telephone Numbers **(check most preferred):**

Work ______________________ ☐

Home ______________________ ☐

Cell ______________________ ☐

THIS IS THE END OF THE SURVEY.

THANK YOU VERY MUCH FOR YOUR HELP!

APPENDIX B: Detailed Results Tables

Table A-3-1: Bivariate associations between independent variables and hypertension

	Without hypertension	With hypertension	p-value	Missing data
Demographics				
Gender				5 (0.1%)
Female	2736(50.7%)	1390(50.9%)	0.818	
Male	2657(49.3%)	1343(49.1%)		
Age				5 (0.1%)
60 years and over	1627(30.2%)	1748(64.0%)	0.000	
40 to 59 years	2595(48.1%)	890(32.6%)		
Younger than 40 years	1170(21.7%)	95(3.5%)		
Marital status				35 (0.4%)
Widow/divorced/separated	423(7.9%)	425(15.6%)	0.000	
Single	445(8.3%)	114(4.2%)		
Married/common-in-law	4508(83.9%)	2187(80.2%)		
Socioeconomic position				
Education				102 (1.2%)
Less than high school	1131(21.2%)	930(34.5%)	0.000	
High school	1904(35.6%)	875(32.5%)		
More than high school	2306(43.2%)	889(33.0%)		
Household income				
<$40,000	1109(23.9%)	896(39.1%)	0.000	
$40,000 -$79,999	1682(36.2%)	748(32.6%)		
>= $80,000	1857(40.0%)	650(28.3%)		
Material deprivation				4 (0%)
Low	1697(31.5%)	964(35.2%)	0.125	
Medium	1747(32.4%)	838(30.6%)		
High	1946(36.1%)	934 (34.1%)		
Social deprivation				4 (0%)
Low	1889(35.0%)	793(29.0%)	0.001	
Medium	1481(27.5%)	762(27.9%)		
High	2020(37.5%)	1181(43.2%)		
Place				
Crowding				
One and more person per bedroom	1939(36.4%)	628(23.3%)	0.000	102 (1.2%)
Less than one person per bedroom	3395(63.6%)	2069(76.7%)		
Home location				53 (0.6%)
Non-farm	2993(55.8%)	1690(62.2%)	0.000	
Farm	2370(44.2%)	1027(37.8%)		
Quadrant				4 (0%)
NW	1677(31.1%)	805(29.4%)	0.242	
NE	1533(28.4%)	827(30.2%)		
SE	1159(21.5%)	605(22.1%)		
SW	1021(18.9%)	499(18.2%)		

	Without hypertension	With hypertension	p-value	Missing data
Metropolitan influence zone (MIZ)				4 (0%)
Moderate MIZ	908(16.8%)	443(16.2%)	0.707	
Weak MIZ	2982(55.3%)	1517(55.4%)		
No MIZ	1500(27.8%)	776(28.4%)		
Lifestyle				
BMI				419 (5.1%)
Obese	1195(23.2%)	1062(41.3%)	0.000	
Overweight	2141(41.5%)	1018(39.6%)		
Normal	1820(35.3%)	490(19.1%)		
Physical activity				352 (4.3%)
More than 30 min	1424(27.4%)	443(17.1%)	0.000	
30 min or Less	1597(30.7%)	966(37.2%)		
None	2183(41.9%)	1189(45.8%)		
Smoking status				44 (0.5%)
Current smoking	681(12.7%)	268(9.9%)	0.000	
Ex-smoking	1740(32.3%)	1142(42.0%)		
Never smoking	2960(55.0%)	1309(48.1%)		
Alcohol use				36 (0.4%)
More than four times a week	537(10.0%)	317(11.6%)	0.000	
Four times and less per week	2913(54.1%)	1188(43.5%)		
Never or less than once a month	1933(35.9%)	1225(44.9%)		
Family disease history				
CVD history (father)				0 (0%)
Yes	2033(37.7%)	1373(50.2%)	0.000	
No	3361(62.3%)	1363(49.8%)		
CVD history (mother)				0 (0%)
Yes	1345(24.9%)	1073(39.2%)	0.000	
No	4049(75.1%)	1663(60.8%)		
HBP history (father)				751 (9.1%)
Yes	1270(25.3%)	888(36.9%)	0.000	
No	3750(74.7%)	1516(63.1%)		
HBP history (mother)				687 (8.3%)
Yes	1691(33.6%)	1183(48.3%)	0.000	
No	3348(66.4%)	1265(51.7%)		

Table A-3-2: Full multilevel logistic regression models

	Model 1[a]		Model 2[b]		Model 3[c]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Demographic						
Gender						
Women	1.02 (0.91-1.15)	0.691	1.01 (0.88-1.16)	0.862	0.56 (0.37-0.85)	0.862
Men	1.00		1.00		1.00	
Age						
60 years and older	12.10 (9.39-15.59)	0.000	8.62 (6.47-11.49)	0.000	8.58 (6.35-11.59)	0.000
40-59 years	4.09 (3.22-5.19)	0.000	2.53 (1.94-3.31)	0.000	2.54 (1.94-3.33)	0.000
Younger than 40 years	1.00		1.00		1.00	
Marital status						
Separated/divorced/widowed			1.08 (0.86-1.35)	0.522	1.03 (0.82-1.29)	0.804
Single			0.79 (0.58-1.08)	0.147	0.80 (0.59-1.10)	0.165
Married or common-in-law			1.00		1.00	
Socioeconomic Position						
Education attainment						
Less than high school	1.26 (1.08-1.46)	0.003	1.22 (1.02 - 1.46)	0.031	1.05 (0.62-1.78)	0.856
High school	1.15 (1.01-1.31)	0.042	1.12 (0.96 - 1.30)	0.142	1.02 (0.74-1.39)	0.918
More than high school	1.00		1.00		1.00	
Household income						
<$40,000	1.23 (1.06-1.43)	0.008	1.09 (0.90-1.31)	0.371	0.51 (0.30-0.87)	0.013
$40,000-79,999	0.99 (0.86-1.14)	0.876	0.97 (0.83-1.13)	0.674	0.67 (0.50-0.89)	0.006
>=$80,000	1.00		1.00		1.00	
Area-level social deprivation						
High						
Medium						
Low						
Area-level material deprivation						
High						
Medium						
Low						
Place						
Crowding						
One or more person per bedroom			0.60 (0.48-0.75)	0.000	0.71 (0.61-0.83)	0.000
Less than person per bedroom			1.00		1.00	
Home location						
Non-farm			1.13 (1.01-1.25)	0.027	1.12 (1.01-1.25)	0.032
Farm			1.00		1.00	

	Model 1[a]		Model 2[b]		Model 3[c]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Quadrant						
NW			0.92 (0.76-1.11)	0.394	0.92 (0.76-1.11)	0.384
NE			0.87 (0.72-1.06)	0.166	0.87 (0.72-1.05)	0.157
SE			1.03 (0.84-1.25)	0.771	1.03 (0.84-1.26)	0.766
SW			1.00		1.00	
Lifestyle						
Body mass index						
Obesity			3.67 (3.07-4.40)	0.000	3.62 (2.99-4.39)	0.000
Overweight			1.69 (1.42-2.00)	0.000	1.67 (1.41-2.00)	0.000
Normal			1.00		1.00	
Physical activity						
More than 30 mins			0.73 (0.62-0.87)	0.000	0.74 (0.62-0.88)	0.001
30 mins or less			1.00 (0.86-1.16)	0.999	1.00(0.87-1.17)	0.912
No exercise			1.00		1.00	
Smoking status						
Current smoking			1.04 (0.84-1.29)	0.721	1.05 (0.84-1.30)	0.670
Ex-smoking			1.05 (0.91-1.21)	0.533	1.06 (0.92-1.23)	0.402
Never smoking			1.00		1.00	
Alcohol use						
More than four times per week			1.07 (0.86-1.33)	0.538	1.06 (0.86-1.32)	0.569
One or more per month, less than four per week			0.91 (0.79-1.05)	0.184	0.91 (0.79-1.05)	0.204
Never or less than once a month			1.00		1.00	
Family disease history						
Family history of CVD (Father)						
Yes			1.16 (1.01-1.33)	0.030	1.16 (1.01-1.32)	0.032
No			1.00		1.00	
Family history of CVD (Mother)						
Yes			1.25 (1.09-1.44)	0.001	1.26 (1.09-1.44)	0.001
No			1.00		1.00	
Family history of hypertension (Father)						
Yes			1.90 (1.64-2.20)	0.000	1.90 (1.64-2.21)	0.000
No			1.00		1.00	
Family history of hypertension (Mother)						
Yes			1.76 (1.54-2.02)	0.000	1.76 (1.54-2.03)	0.000
No			1.00		1.00	
education*gender					1.06 (0.89-1.26)	0.542
household income*gender					1.29 (1.09-1.52)	0.003
material deprivation*gender						
social deprivation*gender						

[a]model 1: adjusted for age

[b]model 2: model 1 + crowding, home location, BMI, physical activity, smoking status,

[c]model 3: model 2 + gender X education, gender X household income

Table A-3-2: con't

	Model 4[d]		Model 5[e]		Final model[f]	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	P
Demographic						
Gender						
Women	0.61 (0.43-0.86)	0.004	0.72 (0.40-1.29)	0.268	0.81 (0.52-1.26)	0.350
Men	1.00		1.00		1.00	
Age						
60 years and older	8.77 (6.57-11.71)	0.000	8.79 (6.58-11.73)	0.000	8.77 (6.57-11.71)	0.000
40-59 years	2.60 (1.99-3.40)	0.000	2.60 (1.99-3.40)	0.000	2.60 (1.99-3.40)	0.000
Younger than 40 years	1.00		1.00		1.00	
Marital status						
Separated/divorced/widowed	1.01 (0.80-1.27)	0.927	1.02 (0.81-1.28)	0.873	1.02 (0.81-1.28)	0.874
Single	0.79 (0.58-1.08)	0.139	0.80 (0.58-1.09)	0.158	0.80 (0.58-1.09)	0.159
Married/common-in-law	1.00		1.00		1.00	
Socioeconomic position						
Education attainment						
Less than high school	1.23 (1.03-1.47)	0.025	1.23 (1.03-1.48)	0.022	1.24 (1.03-1.48)	0.021
High school	1.11 (0.96-1.30)	0.169	1.12 (0.96-1.30)	0.148	1.12 (0.96-1.30)	0.149
More than high school	1.00		1.00		1.00	
Household income						
<$40,000	0.49 (0.29-0.81)	0.006	0.45 (0.27-0.76)	0.003	0.46 (0.27-0.77)	0.371
$40,000-79,999	0.65 (0.49-0.86)	0.003	0.63 (0.48-0.84)	0.001	0.63 (0.48-0.84)	0.002
>=$80,000	1.00		1.00		1.00	
Area-level social deprivation						
High	1.39 (1.14-1.69)	0.001	2.18 (1.32-3.58)	0.001	2.21 (1.35-3.63)	0.002
Medium	1.12 (0.91-1.37)	0.292	1.40 (1.03-1.90)	0.034	1.41 (1.03-1.91)	0.030
Low	1.00		1.00		1.00	
Area-level material deprivation						
High	0.92 (0.77-1.08)	0.307	0.79 (0.49-1.30)	0.357	0.92 (0.77-1.09)	0.311
Medium	0.86 (0.70-1.05)	0.144	0.80 (0.59-1.09)	0.156	0.86 (0.70-1.05)	0.146
Low	1.00		1.00		1.00	
Place						
Crowding						
One or more person per bedroom	0.60 (0.48-0.75)	0.000	0.59 (0.47-0.75)	0.000	0.59 (0.47-0.75)	0.000
Less than person per bedroom	1.00		1.00		1.00	
Home location						
Non-farm	1.02 (0.90-1.15)	0.784	1.02 (0.90-1.15)	0.771	1.02 (0.90-1.15)	0.776
Farm	1.00		1.00		1.00	
Quadrant						
NW	0.96 (0.78-1.17)	0.673	0.96 (0.78-1.18)	0.673	0.96 (0.78-1.18)	0.674
NE	0.85 (0.68-1.08)	0.181	0.85 (0.67-1.08)	0.185	0.85 (0.67-1.08)	0.185
SE	1.05 (0.83-1.31)	0.699	1.05 (0.83-1.32)	0.689	1.05 (0.83-1.32)	0.693
SW	1.00		1.00		1.00	

	Model 4[d]		Model 5[e]		Final model[f]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**P**
Lifestyle						
Body mass index						
Obesity	3.64 (3.04-4.37)	0.000	3.66 (3.06-4.39)	0.000	3.66 (3.66-4.39)	0.000
Overweight	1.69 (1.43-2.01)	0.000	1.70 (1.43-2.02)	0.000	1.70 (1.43-2.02)	0.000
Normal	1.00		1.00		1.00	
Physical activity						
More than 30 mins	0.74 (0.62-0.88)	0.001	0.74 (0.62-0.88)	0.001	0.74 (0.62-0.88)	0.001
30 mins or less	1.01 (0.87-1.17)	0.884	1.01 (0.87-1.17)	0.915	1.01 (0.87-1.17)	0.919
No exercise	1.00		1.00		1.00	
Smoking status						
Current smoking	1.04 (0.83-1.29)	0.742	1.03 (0.83-1.28)	0.742	1.03 (0.83-1.28)	0.773
Ex-smoking	1.05 (0.91-1.21)	0.533	1.04 (0.90-1.20)	0.533	1.04 (0.90-1.20)	0.563
Never smoking	1.00		1.00		1.00	
Alcohol use						
More than four times per week	1.05 (0.85-1.31)	0.632	1.05 (0.85-1.31)	0.654	1.05 (0.85-1.31)	0.650
One or more per month but less than four per week	0.91 (0.79-1.05)	0.193	0.91 (0.78-1.05)	0.188	0.91 (0.78-1.05)	0.188
Never or less than once a month	1.00		1.00		1.00	
Family disease history						
Cardiovascular disease (Father)						
Yes	1.16 (1.01-1.32)	0.035	1.16 (1.01-1.33)	0.032	1.16 (1.01-1.32)	0.032
No	1.00		1.00		1.00	
Cardiovascular disease (Mother)						
Yes	1.26 (1.10-1.45)	0.001	1.26 (1.10-1.45)	0.001	1.26 (1.10-1.45)	0.001
No	1.00		1.00		1.00	
High blood pressure (Father)						
Yes	1.89 (1.63-2.19)	0.000	1.89 (1.63-2.19)	0.000	1.89 (1.63-2.19)	0.000
No	1.00		1.00		1.00	
High blood pressure (Mother)						
Yes	1.77 (1.54-2.02)	0.000	1.76 (1.54-2.02)	0.000	1.76 (1.54-2.02)	0.000
No	1.00		1.00		1.00	
education*gender					1.06 (0.89-1.26)	0.542
household income*gender	1.30 (1.10-1.53)	0.002	1.33 (1.13-1.57)	0.001	1.33 (1.13-1.57)	0.002
material deprivation*gender			1.05 (0.90-1.23)	0.542		
social deprivation*gender			0.86 (0.74-1.00)	0.054	0.86 (0.73-1.00)	0.045

[d]model 4: model 3 + material deprivation, social deprivation

[e]model 5: model 4 + gender X material deprivation, gender X social deprivation

[f]final model: model 1 + statistically significant interaction terms

Table A-3-3: Social deprivation adjusted with other covariates by gender

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Demographic								
Age								
60 years and older	8.68 (3.93-19.19)	0.000	8.48 (3.91-18.39)	0.000	15.10 (6.14-37.16)	0.000	14.67 (6.07-35.50)	0.000
40 to 59 years	2.68 (1.66-4.31)	0.000	2.66 (1.66-4.25)	0.000	3.13 (1.88-5.22)	0.000	3.09 (1.86– 5.11)	0.000
younger than 40 years	1.00		1.00		1.00		1.00	
Marital status								
Separated /divorced/widowed	0.98 (0.64-1.48)	0.909	0.97 (0.64-1.46)	0.886	1.06 (0.77-1.47)	0.705	1.07 (0.77-1.47)	0.699
Single	0.97 (0.63-1.49)	0.895	0.97 (0.64-1.48)	0.892	0.60 (0.31-1.13)	0.115	0.60 (0.32-1.14)	0.122
Married/common-in-law	1.00		1.00		1.00		1.00	
Socioeconomic position								
Education attainment								
Less than high school	1.31 (0.98-1.73)	0.064	1.71 (0.84-3.49)	0.140	1.21 (0.88-1.67)	0.243	0.84 (0.38-1.86)	0.660
Completed high school	1.19 (0.92-1.53)	0.192	1.36 (0.89-2.06)	0.153	1.06 (0.84-1.33)	0.637	0.88 (0.58-1.33)	0.569
More than high school	1.00		1.00		1.00		1.00	
Household income								
<$40,000	0.91 (0.68-1.21)	0.508	0.68 (0.33-1.39)	0.285	1.27 (0.93-1.73)	0.131	1.31 (0.64-2.67)	0.457
$40,000-79,999	1.00 (0.79-1.27)	0.995	0.87 (0.59-1.29)	0.487	0.89 (0.69-1.16)	0.401	0.91 (0.61-1.35)	0.642
>=$80,000	1.00		1.00		1.00		1.00	
Area-level social deprivation								
High	1.42 (1.02-1.98)	0.036	1.40 (0.62–3.16)	0.413	1.30 (0.96-1.75)	0.087	1.01 (0.46-2.21)	0.977
Medium	1.02 (0.76-1.38)	0.873	1.03 (0.64-1.64)	0.908	1.03 (0.78-1.37)	0.826	0.92 (0.59-1.42)	0.694
Low	1.00		1.00		1.00		1.00	
Place								
Crowding								
Less than one person	0.66 (0.50-0.86)	0.002	0.66 (0.51-0.87)	0.003	0.67 (0.51-0.89)	0.005	0.68 (0.51-0.89)	0.005
One and more person	1.00		1.00		1.00		1.00	
Home location								
Non-farm	1.14 (0.94-1.37)	0.191	1.14 (0.94-1.37)	0.184	0.92 (0.74-1.14)	0.432	0.92 (0.74-1.13)	0.431
Farm	1.00		1.00		1.00		1.00	

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Lifestyle								
Body mass index								
Obesity	4.23 (2.38-7.53)	0.000	4.17 (2.37-7.32)	0.000	4.30 (2.49-7.42)	0.000	4.27 (2.49-7.30)	0.000
Overweight	1.73 (1.22-2.46)	0.002	1.72 (1.21- 2.43)	0.002	1.91 (1.37-2.67)	0.000	1.91 (1.38-2.66)	0.000
Normal	1.00		1.00		1.00		1.00	
Physical activity								
More than 30min	0.78 (0.59-1.04)	0.089	0.78 (0.59-1.04)	0.088	0.66 (0.49-0.90)	0.008	0.66 (0.49- 0.89)	0.007
30 min or less	1.07 (0.84-1.37)	0.569	1.07 (0.85-1.36)	0.556	0.94 (0.74-1.20)	0.635	0.94 (0.74-1.19)	0.598
None	1.00		1.00		1.00		1.00	
Smoking status								
Current smoker	1.12 (0.79-1.58)	0.525	1.11 (0.79-1.57)	0.531	1.00 (0.71-1.42)	0.984	1.00 (0.71-1.41)	0.997
Ex-smoker	1.27 (1.00-1.62)	0.051	1.27 (1.00-1.62)	0.050	0.91 (0.72-1.15)	0.419	0.91 (0.72-1.14)	0.404
Never smoking	1.00		1.00		1.00		1.00	
Alcohol use								
More than four times per week	1.33 (0.95-1.85)	0.094	1.33 (0.96-1.85)	0.087	0.79 (0.52-1.19)	0.261	0.79 (0.53-1.19)	0.264
Four times or less per week	1.06 (0.83-1.35)	0.638	1.06 (0.83-1.35)	0.627	0.78 (0.61-0.99)	0.038	0.78 (0.62-0.99)	0.041
Never or less than once a month	1.00		1.00		1.00		1.00	
Family disease history								
Cardiovascular disease (father)								
Yes	1.15 (0.92-1.44)	0.214	1.15 (0.92-1.44)	0.208	1.21 (0.97-1.51)	0.093	1.21 (0.97-1.50)	0.093
No	1.00		1.00		1.00		1.00	
Cardiovascular disease (mother)								
Yes	1.23 (0.97-1.55)	0.089	1.22 (0.96-1.44)	0.098	1.35 (1.06-1.72)	0.016	1.35 (1.06-1.71)	0.015
No	1.00		1.00		1.00		1.00	
High blood pressure (father)								
Yes	2.82 (1.87-4.25)	0.000	2.79 (1.87-4.17)	0.000	1.43 (1.10-1.85)	0.000	1.43 (1.11-1.85)	0.006
No	1.00		1.00		1.00		1.00	
High blood pressure (mother)								
Yes	1.77 (1.32-2.38)	0.000	1.77 (1.33-2.36)	0.000	2.07 (1.53-2.80)	0.000	2.06 (1.53-2.77)	0.000
No	1.00		1.00		1.00		1.00	

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Interaction								
Social*education			0.94 (0.80-1.09)	0.401			1.09 (0.92-1.29)	0.329
Social*income			1.08 (0.92-1.27)	0.372			0.99 (0.85-1.16)	0.916

[a]model 1: adjusted for age, crowding, home location, BMI, physical activity, smoking status, alcohol use, family history of heart disease (mother & father), family history of high blood pressure (mother and father)

[b]model 2: model 1 + social deprivation X education, social deprivation X income

Table A-3-4: Material deprivation adjusted with other covariates by gender

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Demographic								
Age								
60 years and older	8.62 (3.90-19.03)	0.000	8.87 (3.96-19.88)	0.000	14.84 (6.04-36.46)	0.000	15.75 (6.19-40.06)	0.000
40 to 59 years	2.65 (1.65-4.27)	0.000	2.68 (1.66-4.36)	0.000	3.08 (1.85-5.13)	0.000	3.14 (1.87-5.29)	0.000
Younger than 40 years	1.00		1.00		1.00		1.00	
Marital status								
Separated /divorced/widowed	0.99 (0.63-1.48)	0.958	0.98 (0.64- 1.50)	0.932	1.09 (0.79-1.51)	0.602	1.10 (0.79-1.53)	0.116
Single	0.96 (0.65-1.50)	0.868	0.98 (0.63-1.51)	0.916	0.62 (0.33-1.17)	0.140	0.61 (0.32-1.17)	0.691
Married/common-in-law	1.00		1.00		1.00		1.00	
Socioeconomic position								
Education attainment								
Less than high school	1.27 (0.96-1.69)	0.091	2.11 (0.99- 4.52)	0.053	1.21 (0.88- 1.67)	0.246	0.56 (0.25-1.27)	0.167
Completed high school	1.16 (0.90-1.50)	0.240	1.51 (0.97- 2.37)	0.070	1.05 (0.84-1.33)	0.654	0.71 (0.45-1.12)	0.142
More than high school	1.00		1.00		1.00		1.00	
Household income								
<$40,000	0.92 (0.68- 1.23)	0.554	0.70 (0.34- 1.44)	0.331	1.29 (0.95-1.76)	0.993	2.02 (0.93- 4.36)	0.130
$40,000-79,999	1.01 (0.80- 1.29)	0.908	0.89 (0.59- 1.34)	0.572	0.91 (0.70-1.18)	0.471	1.13 (0.73-1.75)	0.437
>=$80,000	1.00		1.00		1.00		1.00	
Area-level material deprivation								
High	0.81 (0.62-1.20)	0.177	1.05 (0.45- 2.44)	0.918	0.97 (0.75-1.26)	0.839	0.79 (0.35-1.77)	0.561
Medium	0.87 (0.63-1.20)	0.388	0.99 (0.58-1.68)	0.970	0.96 (0.72-1.29)	0.810	0.86 (0.52-1.42)	0.557
Low	1.00		1.00		1.00		1.00	
Place								
Crowding								
Less than one person	0.66 (0.51-0.87)	0.003	0.66 (0.50-0.87)	0.003	0.68 (0.51-0.89)	0.006	0.67 (0.50-0.89)	0.005
One and more person	1.00		1.00		1.00		1.00	
Home location								
Non-farm	1.23 (1.01-1.50)	0.039	1.24 (1.01- 1.51)	0.038	1.01 (0.84- 1.22)	0.912	1.01 (0.83-1.22)	0.953
Farm	1.00		1.00		1.00		1.00	

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Lifestyle								
Body mass index								
Obesity	4.19 (2.36- 7.44)	0.000	4.28 (2.39- 7.67)	0.000	4.33 (2.49-7.51)	0.000	4.49 (2.53-7.97)	0.000
Overweight	1.71 (1.21- 2.44)	0.003	1.73 (1.21-2.48)	0.003	1.92 (1.37-2.67)	0.000	1.94 (1.38- 2.73)	0.000
Normal	1.00		1.00		1.00		1.00	
Physical activity								
More than 30min	0.78 (0.59-1.04)	0.096	0.78 (0.58-1.04)	0.095	0.67 (0.49-0.90)	0.008	0.66 (0.49-0.89)	0.008
30 min or less	1.08 (0.85- 1.37)	0.546	1.08 (0.84- 1.37)	0.556	0.94 (0.74-1.20)	0.663	0.95 (0.74-1.21)	0.653
None	1.00		1.00		1.00		1.00	
Smoking status								
Current smoker	1.14 (0.80-1.60)	0.471	1.14 (0.80- 1.61)	0.475	1.01 (0.71-1.44)	0.946	1.02 (0.71-1.45)	0.927
Ex-smoker	1.30 (1.01-1.66)	0.038	1.30 (1.01- 1.66)	0.040	0.92 (0.73-1.16)	0.455	0.92 (0.73-1.17)	0.504
Never smoking	1.00		1.00		1.00		1.00	
Alcohol drinking								
More than four times per week	1.33 (0.96-1.86)	0.089	1.33 (0.95-1.87)	0.094	0.80 (0.53-1.20)	0.280	0.80 (0.53-1.22)	0.297
Four times or less per week	1.06 (0.83- 1.36)	0.617	1.07 (0.83- 1.37)	0.611	0.78 (0.62-0.99)	0.042	0.78 (0.61-1.00)	0.049
Never or Less than once a month	1.00		1.00		1.00		1.00	
Family disease history								
Cardiovascular disease (father)								
Yes	1.15 (0.92-1.44)	0.211	1.15 (0.9 -1.45)	0.211	1.21 (0.97-1.52)	0.0.0 88	1.22 (0.97-1.53)	0.088
No	1.00		1.00		1.00		1.00	
Cardiovascular disease (mother)								
Yes	1.22 (0.97 - 1.54)	0.096	1.22 (0.97-1.54)	0.088	1.34(1.05- 1.71)	0.017	1.35 (1.06-1.74)	0.017
No	1.00		1.00		1.00		1.00	
High blood pressure (father)								
Yes	2.84 (1.88-4.29)	0.000	2.88 (1.89-4.37)	0.000	1.43 (1.10-1.85)	0.007	1.44 (1.11- 1.88)	0.007
No	1.00		1.00		1.00		1.00	
High blood (pressure mother)								
Yes	1.78 (1.33- 2.39)	0.000	1.80 (1.33- 2.43)	0.000	2.05 (1.52- 2.78)	0.000	2.07 (1.51-2.82)	0.000
No	1.00		1.00		1.00		1.00	

	Men				Women			
	Model 1[a]		Model 2[b]		Model 1[a]		Model 2[b]	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Interaction								
Material*education			0.88 (0.75-1.05)	0.151			1.21 (1.00-1.47)	0.051
Material*income			1.07 (0.91-1.26)	0.439			0.90 (0.76-1.06)	0.211

[a]model 1: adjusted for age, crowding, home location, BMI, physical activity, smoking status, alcohol use, family history of heart disease (mother & father), family history of high blood pressure (mother and father)

[b]model 2: model 1 + material deprivation X education, material deprivation X income

Table A-4-1: Random effect variances, VPC and ICC for the two-level variance components model (model 3)

Level	Random effect variances	VPC	ICC
Household	0.003	0.0009	0.0009
Individual	3.29	1.00	--

Table A-4-2: Random effect variances, VPC and ICC for the three-level variance components model (model 5)

Level	Random effect variances	VPC	ICC
Area	0.005	0.002	0.002
Household	4.0×10^{-9}	1×10^{-9}	1×10^{-9}
Individual	3.29	1.0	--