Gender differences in socioeconomic inequalities in health: trends in Canada, 1994-2003

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ABSTRACT

Gender and socioeconomic inequalities in health are ubiquitous in developed countries; however, the modifying effect of gender on the relationship between socioeconomic position (SEP) and health over time is less clear. The potentially different health effects of changes in SEP on changes in health for working-age women and men are examined over a 10-year period. Three main questions are addressed: 1) are there gender differences in health over time, 2) do changes in SEP lead to health inequalities and 3) do changes in SEP impact health differently for women and men? Generalized estimating equations (GEE) were used to analyze the Canadian National Population Health Survey for four measures of health, number of chronic conditions, self-rated health, functional health, and psychological distress, and three measures of SEP, income, education and employment status. Men and women in this nationally-representative sample of Canadians do not differentially embody changes in SEP, though both gender and SEP independently impact health.

RÉSUMÉ

Quoique les inégalités sociales et de santé soient amplement documentées, l'effet du genre sur le gradient social de santé est moins bien connu. Cette recherche examine les effets modificateurs du genre sur la relation entre la position socioéconomique et la santé parmi la population générale canadienne en âge de travailler, et ce, sur une période de 10 ans. Nous tenterons de déterminer : 1) s'il existe des différences de santé selon le genre à travers le temps; 2) si les changements de statut socioéconomique sont associés à des changements de santé; 3) si les changements de statut socioéconomique ont des impacts sur la santé qui diffèrent selon le genre. Des modèles de moyenne populationnelle (GEE) sont utilisés pour analyser l'Enquête nationale sur la santé des populations. Les résultats ne supportent pas l'hypothèse de gradients significativement différents selon le genre, et ce malgré que le statut socioéconomique et le genre soient indépendamment associés avec la santé.

CHAPTER 1
INTRODUCTION

Inequalities in health between women and men are a consequence of biological differences relating to sex and social differences produced by gender roles, opportunities and beliefs [1]. It is widely accepted that women have greater life expectancy than men, but suffer more morbidity [2]; however, this generalization has been criticized as 'oversimplified' as emerging evidence suggests a more variable pattern of gender differences in health [3-5]. Socioeconomic inequalities in health are equally well-described in most developed countries, with those lower on the social ladder displaying worse health [6]. Similar to gender, however, the extent and direction of socioeconomic inequalities are not invariable. Some dimensions of health do not show simple or consistent patterning by social position, other have flatter gradients and some show complex interaction patterns by age and sex [6, 7]. Compared to men, however, women *generally* experience poorer socioeconomic circumstances [8] and poorer health status [2].

The study of the intersection of these two fields, namely gender differences in socioeconomic inequalities in health, is relatively rare [9, 10]. It has been generally accepted that women exhibit shallower socioeconomic gradients than men [11-13]; however, this perspective has been called to question by many studies that show more variable patterns [5, 8, 10, 14-22]. Few studies have examined the evolution of gender and socioeconomic differences in health over time and have been able to account for changes in the multiple correlates of

health, gender, and socioeconomic position (SEP). The goal of this study is to estimate the potentially different health effects of changes in SEP for working-age women and men over a 10-year period. Using a longitudinal dataset that includes a number of potential time-dependent confounders (social structure, behavioural and psychosocial characteristics) and a longitudinal analysis that accounts for measured and unmeasured time-invariant within-individual characteristics, we examine the moderating effect of gender on the relationship between changes in SEP and health over time among middle-aged adults. Three main questions are addressed:

1) **Are there gender differences in health over time?**
2) **Do changes in socioeconomic position lead to health inequalities?**
3) **Do changes in socioeconomic position impact health differently for women and men?**

CHAPTER 2
LITERATURE REVIEW

This chapter provides a synthesis of pertinent literature for the three objectives of this study. Accordingly, the literature review is composed of three parts: gender and health, socioeconomic position and health, and gender differences in socioeconomic inequalities in health. The goal of the review is to provide a rationale for doing further research in this field by highlighting substantive and methodological issues that were identified in the literature. In the first section, the case for examining both the biological and social aspects of gender is made. Then the gender morbidity/mortality paradox and potential explanations for this paradox are presented. Finally, known gender biases that have pervaded past research are discussed. The second part of the review describes the epidemiological evidence for socioeconomic inequalities in health, the explanations and mechanisms for those inequalities, and the rationale for assessing the interaction between gender and SEP, namely, the observation that low SEP individuals tend to have worse health and women tend to have lower SEP. Finally, the third part details the controversial findings of previous research on the interaction between gender and SEP, paying particular attention to methodological issues.

1. Gender and Health

1.1 Sex and Gender

Sex differences result from differences in the chromosomal structure of men and women that are determined at conception and influence the biological characteristics of individuals. Proponents of a purely biomedical model of health hold that male and female disparities in health can be primarily attributed to these biological differences [1, 23, 24]; however, medical sociologists have criticized this perspective because it ignores the manner in which gender as a social construct affects health [5]. In this perspective, it is never sufficient to simply control for sex in statistical analyses as it may mask gender roles and impair the understanding of the nature and influence of gender differences [22].

Gender can be defined as how society and culture interpret biological differences and is used to describe social patterns associated with being male or female. As a social construction based on societal norms, values and sanctions, gender determines the behaviour, roles and life opportunities of women and men, which in turn affect health [1, 23, 24]. Gender roles associated with masculinity or femininity, in addition to biological sex differences, may lead to different exposures and different response patterns that have positive and deleterious effects on health. For example, being male is often associated with risk-taking behaviour, aggression and stoicism, which are associated with increased injuries and mortality. Female gender roles generally demand that women have a multitude of responsibilities, including domestic labour and care-giving, often in addition to paid employment in the labour force. Such multiplicity of roles can

lead to conflicts between work, home and family, and thus may make women more vulnerable to role-related exposures that negatively impact health [25]. Given the importance of both social and biological factors for producing and maintaining health, researchers have called for an interdisciplinary approach that combines the biomedical and sociological models. Such collaboration is necessary to fully understand the determinants of health and illness, as each model describes different aspects of the differences in men's and women's lives [1, 23, 24]. Thus, it is the aim of this research to take into account aspects of both sex and gender that influence health.

1.2 The Gender Mortality/Morbidity Paradox

The prevalence and incidence rates of specific physical and mental conditions vary by gender; however, men generally report better physical health than women, but die younger [26]. Men and women have similar rates of mental illness overall, although women experience more depressive disorders and men experience more substance abuse and antisocial behaviour disorders [3, 23]. This generalization, however, has been criticized as 'oversimplified' as emerging evidence suggests a more variable pattern of gender differences in health. Male-female health disparities seem to depend substantially on the health outcome measure and the age of the population under study [3-5].

It has been widely suggested that gender inequalities in health maybe be partly attributed to social stratification. The hierarchical distribution of society, based on factors such as socioeconomic status, prestige, and power, allots differential

opportunities to men and women that subsequently affect their health and quality of life [2, 24, 27]. Specifically, socially-based gender inequities are thought to be a product of the demands of multiple-gender roles, environmental exposures, the threat and consequences of gender violence, workplace hazards, economic disparities, the costs of poverty, social marginalization and racism, aging, health conditions and interactions with health services and health behaviours [25].

1.2.1 Physical Health

Canadian average life expectancy at birth in 2003 was a record high 82.4 years for women and 77.4 years for men. Between 1979 and 2003, overall mortality rates have declined for both men and women and the gap in life expectancy has narrowed from 7.4 to 5.0 years. Over this 24 year period, men gained one year in life expectancy every four calendar years, while women gained one year in life expectancy every 6.7 calendar years [28].

Overall mortality is higher among men, compared to women. The all-cause age-standardized mortality rate for Canadian men was 733.4 deaths/100,000 persons in 2003, while the rate among women was 475.4 deaths/100,000 persons. However, the leading causes of death were the same for both men and women: malignant neoplasms (cancer) and diseases of the circulatory system [28]. In spite of this similarity, causes of death also show considerable gender variation. Men are much more likely to die at earlier ages from chronic diseases such as cardiovascular disease, lung cancer, communicable diseases, and injuries than are women [23].

The patterns of male and female morbidity are also highly variable [3, 5]. A notable example is self-rated health, which has been shown to be a consistent predictor of mortality and is largely explained by patterns of mental and physical health [29]. A 59-year longitudinal study on gender differences in the natural history or "life course trajectory" of self-rated health found that men rated their health better than women throughout most stages of adulthood, but they declined at a faster rate than women. Self-rated health was found to be stable until about age 50 and then it decelerated for both men and women (men at a faster rate) until gender differences disappeared in late adulthood [30]. This longitudinal analysis confirms the patterns observed by several previous studies, that gender differences in self-rated health are strong only among younger adults and are non-existent or very small among older adults [4, 5, 26, 27, 31].

Men and women have also demonstrated considerable variation in the number and type of chronic conditions they develop. For example, in Canada, 11% of women compared to 4% of men suffer from chronic conditions [32]. However, men suffer from more life-threatening illnesses (e.g. heart disease) that develop as they age and shorten their lifespan, while women have more non-fatal chronic conditions, such as arthritis [26]. Similar to self-rated health, the male advantage is thought to be present in early life and then shrink as men age and life-threatening illnesses begin to emerge. This pattern, however, was only observed among married and divorced/separated individuals and not among single or widowed people in a recent American study [5]. When considering functional limitations and disability, women fairly consistently show excess morbidity that

increases with age, relative to men. This is thought to be a consequence of the greater number of non-fatal debilitating chronic conditions suffered by women [5, 26].

1.2.2 Mental Health

For decades it was believed that women suffered higher rates of mental illness than men; however, this finding was contradicted when a wider range of mental disorders was examined. As mentioned previously, overall rates of psychological illness are similar, but women are thought to suffer more from depressive disorders, such as anxiety, distress and depression, while men suffer more substance abuse disorders and antisocial behaviours [3, 23]. However, this generalization may again be an oversimplification of the pattern of gender differences in mental health. In a study conducted on gender disparities in social support and psychological distress, the authors found that the occurrence of distress was broadly similar for men and women [33], contrary to other studies which showed women's excess psychological distress, relative to men [10, 34, 35]. However, in a more recent study, Sacker and Wiggins [36] found that women had higher rates of distress throughout the 1980s and 90s, but women's levels declined during this period, whereas men's did not and consequently the gender gap has reduced in magnitude. Periodic re-examination of gender differences in health is thus warranted [4]. Furthermore, failure to examine a wider range of mental health indicators, including conditions that are also

prevalent among men, will lead to biased estimates of gender differences in mental illness [23].

1.3 Biological Explanations for Gender Differences in Health

The paradox of higher mortality and lower morbidity among men, compared to women has often been explained by gender differences in the patterns of disease. As stated above, men experience more life-threatening chronic conditions, while women suffer more chronic debilitating disorders, irritating less serious diseases, and acute conditions [26]. Other biological explanations for the greater longevity of women call attention to the health advantages of different hormones and physiological mechanisms associated with pregnancy and childbirth. It was hypothesized that these advantages lower the risk of coronary heart disease among pre-menopausal women [24]; however, evidence from recent clinical trials involving hormone replacement therapy does not support that assumption [37]. During the reproductive years, the theory of natural selection also presents evidence for women's greater longevity. The idea is that women have evolved health advantages in order to bear more children, as natural selection favours individuals that reproduce more and therefore are more genetically represented in future generations. However, past the reproductive age evidence for natural selection is much weaker at explaining gender differences in longevity [24].

It has also been hypothesized that gender differences in mental health may contribute to gender differences in physical health. Depressive symptoms

magnify pain and disability, thus they may be associated with immune function and disease severity [38]. However, the relationship between depression and physical health is likely bidirectional, such that physical health also affects rates of depression [5, 24]. Thus, more research using longitudinal data is needed to determine the true causal linkages between mental and physical health [5]. The above biological mechanisms are inadequate at fully explaining the gender morbidity/mortality paradox [24]. Thus, we turn to sociological theories to provide further explanations for the presence of gender differences in health.

1.4 Sociological Explanations for Gender Differences in Health

The sociological perspective regards health as a function of social and economic resources and the related variations in exposure to risky and protective factors. Specifically, two sociological theories are most commonly used to explain health inequalities: the differential exposure theory and the differential vulnerability theory [3, 23]. These theories examine the differences in the distribution (exposure theory) and susceptibility (vulnerability theory) of men and women to the social determinants of health, namely social structure, health-related behaviours, and psychosocial factors [2]. However, emerging evidence suggests that behavioural factors may not be as important at predicting health [39] as structural and psychosocial factors [2, 22, 25]. Although discussed here with reference to gender differences in health, these theories have also been applied to explain socioeconomic inequalities in health, as well as gender differences in

socioeconomic inequalities in health. Extensions of the theories will thus be presented in sections 2 and 3 of this review.

1.4.1 The Differential Exposure Theory

The differential exposure theory asserts that because of the gender and social roles associated with being female or male, women and men do not have equal access to the material and social conditions of life that are protective for health, nor are they equally exposed to the same health risks [2, 23, 24, 27, 31]. Implicit in this theory is that equal allocation of material and social conditions should eliminate gender differences in health [3]. Much research has focused on the differential relationships men and women have to the formal labour market and on gender differences in health-related behaviours.

It has been demonstrated that women are less likely to be employed and are more likely to have lower incomes, to do domestic labour and to be single parents than men [22, 24, 27]. Employment, compared to household labour, is associated with higher levels of perceived control and consequently lower levels of psychological distress [23]. Women also face a greater burden of hardship, constrained choice, and stress in the labour market and in their social and family roles, which contribute to their higher prevalence of chronic non-fatal illness and disability compared to men [2, 3, 5, 23]. Men's lower levels of distress and chronic conditions (non-fatal) have often been attributed to their relatively advantaged position in the labour force and in the family [23].

Health-related behaviours are also patterned by gender. Men are more likely to smoke, consume alcohol, have poor nutrition, and to be overweight, while women are more likely to be physically inactive [22, 27]. Health-seeking behaviour is also gender-dependent, with women more likely to seek health services relative to men [40, 41]. Furthermore, other resources, such as education, also vary by gender and may provide knowledge, opportunity, and income with which to avoid risky health behaviours and acquire health resources [24]. In Canada, the number of women attending university has grown from 1991 to 2001. Among young people aged 25-34 in 2001, women were in the majority at both the bachelor's level and the master's level: 56% of persons holding a bachelor's degree were women, as were 52% of those holding a master's. Men still outnumbered women, however, at the doctoral level [42].

1.4.2 The Differential Vulnerability Hypothesis

The differential vulnerability theory contends that the effects of structural, behavioural and psychosocial conditions that foster health differ according to gender [2, 3, 23]. It is hypothesized that women have more morbidity than men because of their disadvantaged opportunities and options (e.g. men have higher incomes and greater chances of marrying a homemaker) and their higher responsiveness to stress [3, 23]. Two recent Canadian studies demonstrated gender-based susceptibility to various social determinants. They showed that women's health is more responsive to the effects of high income, working full-time and caring for a family, and having social support than men's health. In

terms of lifestyle factors, smoking and alcohol consumption are more important determinants of men's health, while physical inactivity and obesity are more important for women [2, 22]. However, Canadian women and men are not differentially vulnerable to the effects of financial stress [3].

McDonough and Walters [3] suggest that the weight of the evidence favours the differential vulnerability hypothesis, rather than the differential exposure hypothesis for explaining gender differences in health. Denton and colleagues [2] also conclude that the different exposures of men and women fail to fully account for gender differences in self-rated health, functional health, chronic illness and distress. These authors primarily attributed health disparities between men and women to their differential susceptibility to the social determinants of health. Gender differences in health, however, are often quite small in magnitude [5, 10]. Thus, as one study claimed, it may be worthwhile to examine the similarities in men's and women's stresses and experiences, rather than focusing solely on their differences [3].

1.5 Gender Bias in Research

Ruiz and Verbrugge [43] articulated two main types of gender bias in health research. First, is the assumption that men and women are interchangeable. This assumption (made frequently in early health research) led to the notion that studies based on one gender (usually men) are generalizable to both men and women [11]. In instances where a disease is more prevalent in a given gender (e.g. heart disease among men), this gender bias has been particularly pervasive.

Past researchers have often contended that knowledge on diagnosis, prognosis, and risk factor assessment need only be determined by studying men, as in the case of heart disease. In studies which have examined both genders, those that merely adjusted for sex in multivariate analyses made the further assumption that men and women have the same relationship between a given risk factor and disease [43]. Therefore, more complex patterns, such as potential effect modification by sex, should also be examined.

An extension to this is the argument that women's excess morbidity may be attributed to a gender bias in outcome measures. Researchers in gender and health have more often examined illnesses that are more prevalent among women [3, 23] and gender differences in health have been shown to be outcome and age-specific [5, 10, 34, 35]. Calls for research on gender differences in health that incorporate multiple outcome measures [including illnesses that are prevalent among men and women] are ample [2, 3, 5, 10, 24].

The second type of gender bias is the assumption that men and women are fundamentally different. When making this conjecture, researchers often do not question the basis of gender differences in health, and thus may fail to make systematic comparisons of men and women [11]. It has also been widely suggested that gender differences in health may actually be the consequence of women more readily reporting illness and seeking medical attention than men [44]. Macintyre, Ford and Hunt [40] challenged this assumption and demonstrated that on the contrary, there were no gender differences in the reporting of chronic conditions on a standardized questionnaire and women were

no more likely to report 'trivial' or mental health conditions than men. Furthermore, self-reports of functional limitations were also shown to be accurate for both women and men [45].

Gender bias has also been problematic in the study of social inequalities in health. Many large studies on social inequalities have included only men, have combined men and women without controlling for sex, or have adjusted for sex without examining potential gender interactions [11]. The intersection of gender, socioeconomic position and health will be discussed in part 3, but first, a review of socioeconomic inequalities in health is presented in the following section.

2. Socioeconomic Position and Health

2.1 Epidemiological Evidence

Extremely well documented in developed countries is the disproportionate burden of mortality and morbidity among people at the lower end of the socioeconomic ladder. Many measures of socioeconomic position (SEP) have illustrated this relationship, including income [2, 6, 19, 46-48], education [2, 46, 49-52], social class [2, 46, 51, 53-55], occupational status [2, 51], and housing tenure [46]. However, poor health is not simply concentrated among the most disadvantaged. Rather, health status declines with each decline in SEP, thus emphasizing the import of focusing on the broader structure of socioeconomic condition, instead of material deprivation alone [56]. In addition to health, the prevalence of risk factors for chronic life-style diseases, such as smoking, obesity, high blood pressure, and physical inactivity, are also patterned by SEP [57].

Socioeconomic gradients are similar to gendered health patterns in that they display variability across health outcome measures. A longitudinal American study demonstrated a strong, consistent inverse association between income and mortality, though the gradient was non-linear [58]. In contrast, a linear gradient was observed between income and self-rated health (which is linked to mortality) in Britain and Finland [48]. However, some dimensions of health do not show simple or consistent patterning by social position, other have flatter gradients and some show complex interaction patterns by age and sex [6, 7]. A Scottish cohort study found that height displayed class gradients for both sexes at age 15, 35, and 55 years, whereas mental health and the presence of chronic illness only displayed gradients in later life and not in adolescence. In addition, they found that measures of body shape displayed sex, but not age differences and blood pressure did not show any clear pattern [7]. In Canada, occupational status was associated with declines in self-rated health for men, but not for women [54].

Although pervasive among industrialized countries, socioeconomic inequalities also display cross-national variation. In a study of 22 European countries, inequalities were found to be relatively small in Austria, Norway, Sweden and the United Kingdom, but were large for Hungary, Poland and Portugal [49]. Similarly, another study also found the level of social inequalities (based on occupational class) in self-rated health to be comparable in Sweden and Britain [53]. An examination of 16 wealthy countries, however, demonstrated

inconsistencies in the association between income inequality and specific causes of death, despite showing a strong association with adult and child mortality [59].

2.2 Explanations for Socioeconomic Inequalities in Health

Two primary mechanisms are used to explain socioeconomic inequalities in health: causation and selection (reverse-causation) [50, 60]. The causal mechanism attributes socioeconomic inequalities in health to the *differential exposure* of low SEP individuals, relative to those with a better socioeconomic condition. It is proposed that individuals with fewer socioeconomic resources are exposed to more hardship and stress and have limited access to health protective resources [27, 61]. Individuals in the lower socioeconomic strata tend to have fewer material assets, engage in more high-risk behaviours such as smoking and excessive alcohol consumption, feel like they have less control over their lives, and consult more general practitioners and fewer specialist doctors. In turn, these suboptimal conditions are thought to have a direct and detrimental effect on health [18, 50].

In contrast, the selection mechanism examines the impact of childhood and adult health on SEP. For example, people who are sick during childhood may have lower educational and occupational achievements, and those who are ill during adulthood may be excluded from certain type of jobs or from the labour market entirely [62]. The presence of reverse-causation is, however, contested. The Black Report (on socioeconomic inequalities in the United Kingdom) rejected the selection mechanism as an explanation for socioeconomic inequalities

in health [63], as did the Dutch GLOBE cohort study [50] and an American longitudinal study [64]. However, an analysis of the American Health and Retirement study indicated that among people in their 50s, new health events were found to have an impact on work, income and wealth [60]. Unravelling the pathways between SEP and health is not a trivial endeavour and the possibility of reverse causation, particularly in cross-sectional research, should be considered.

2.2.1. Life Course Causal Models

Life course epidemiology provides a framework for examining the causal effects of SEP on health. It postulates three processes by which exposure to social and environmental conditions can impact health: latent effects, pathway effects, and cumulative effects. The latency or critical period model is essentially when exposures at sensitive or critical periods in development (usually early life) have a lifelong impact on health, irrespective of future conditions and experiences. Pathway effects are described as experiences that set individuals onto a particular life trajectory that in turn affects health throughout the life course. Also known as chains of risk models, pathway effects raise disease risk because one negative exposure tends to lead to additional negative exposures. Finally, cumulative effects are the accumulation of advantageous or disadvantageous exposures over time (e.g. environmental, behavioural, psychosocial, etc.), that again, have a long-term influence on health [65-67]. Life course epidemiologists, social epidemiologists and medical sociologists are particularly interested in examining

the clustering of such negative exposures, as they are often related to an individual's or family's SEP [66-68]

Socioeconomic conditions likely affect adult health (particularly for chronic diseases) through the complex interplay of latent, pathway and cumulative effects [67]. The 'fetal origins of adult disease' hypothesis is an example of a latent effect. Babies born to low SEP mothers are more likely to be low birth weight and low birth weight has consistently been shown to be associated with adult coronary heart disease and its related risk factors [69]. An example of a pathway effect would be parental SEP during childhood influencing a child's life chances through education, social networks and behavioural patterns that would later impact health and well-being [65]. A cumulative effect was demonstrated by Lynch, Kaplan and colleagues [64]: sustained economic hardship had a cumulative negative impact on physical, cognitive, and psychological functioning among American adults. The life course perspective is useful to the study of health inequalities, by both SEP and gender, because it attempts to integrate biological and social risk processes that independently, cumulatively and interactively influence health and disease throughout an individual's life [66]. However, separating latent, pathway, and cumulative effects is empirically quite complex and must rely on a priori knowledge of specific causal processes [70].

2.3. Gender Differences in Socioeconomic Condition

Women generally have fewer socioeconomic resources than men [8]. Ross [71] advocates that educational attainment is an important component of a

life course pathway effect; indeed, it is central to one's position in the social stratification system because it shapes the future likelihood of being employed, the kind of job a person can get, and thus the level of income one can earn. In addition to economic resources, education can impact psychosocial resources, including sense of personal control and social support, and lifestyle choices, including exercise, alcohol consumption, and smoking [71]. However, equal education does not translate into equal benefit for women and men. Well-educated women have less authority and autonomy and lower incomes than their similarly well-educated male counterparts. In the U.S. and many other countries, the average increase in earnings associated with an additional year of education or work experience is smaller for women than for men [8].

Stemming directly from education is the probability of being employed and the type of work one can obtain. Both women and men have paid and unpaid work roles that may influence health [22]. In most developed societies, employment benefits well-being, while unemployment is associated with ill health. Among men and women, the employed report the best physical health, homemakers report lower health, and the unemployed report the worst health. Furthermore, part-time employment is not as beneficial as full-time employment [22, 71]. However, gender differences in the workforce are pervasive. Women are more likely to be economically dependent, to have restricted opportunities for paid employment, to be employed in more routine, poorly paid, and unfulfilling work and to have less authority, compared to men [8]. Exposure to negative workplace conditions such as sexual harassment, job insecurity and low levels of

control is also more common among women. Moreover, women who take maternity leave are often penalized financially over their lifetime as income levels and pension benefits are impacted by their absence [25].

As a final consideration to gender differences in SEP, attention must be paid to earned income, the product of both education and employment. As mentioned above, women's earnings are on the average less than men's. In Canada the 1997 average annual income for women was only 67% of that of men. Furthermore, 13.4% of Canadian women were persistently poor and 25% of women were poor for one year. Among the elderly population, 29% of women were poor for at least one year, compared to 12.9% of men [32].

Many life course factors may contribute to gender differences in income, such as social role-related expectations and activities, occupational choice, opportunities for employment and advancement, work-related skills and experience, and access to job benefits including health insurance, pensions, and other retirement income. Women are also more likely to be single parents and thus have a lower income per capita. In addition, levels of income may vary by gender for reasons other than one's current job or pay inequity. For example, welfare and income entitlements such as Social Security are tied to both one's own employment and income history and that of one's spouse [24]. Also noteworthy is that income may not have the same meaning to each member of a household, as it is typically not shared equally. Men's standards of living improve more with increased household income, relative to female members,

because men generally have more power over financial decision-making and thus more access to resources [15, 72].

It has been suggested that improvements in the socioeconomic standing of women would likely lead to at least modest improvements in their functional health and chronic conditions and a dramatic increase in their self-perceived health relative to men [5]. Given women's *generally* higher morbidity and poorer socioeconomic circumstances relative to men, examining the joint effects of gender and SEP on health is worthwhile. However, there is controversy in the literature surrounding the nature of these effects. Thus, the remainder of this review will focus on the complex relationship between SEP, gender and health, highlighting both the theoretical and methodological issues that have contributed to this controversy.

3. Gender Differences in Socioeconomic Inequalities

3.1 Do Women or Men Exhibit Steeper Socioeconomic Gradients?

Important to the understanding of the causal processes linking social position, gender and health is the examination of the modifying effect of gender on the SEP-health relationship. Among many researchers, it has been generally accepted that women exhibit weaker socioeconomic gradients than men [11-13], even though formal statistical tests of gender differences are rarely done [15]. In a cross-national comparison of Britain and Finland, low household income and low individual income were related to poor health for both British and Finnish men. Among women, however, only household income was related to health and

this association was very weak among British women and practically non-existent among Finnish women [48]. Even for measures of gender inequality (measured by women's political participation and their position relative to men for employment, earnings and autonomy), men's mortality has shown a stronger social gradient than women's [73]. However, this generalization is widely disputed. Some researchers have found that men and women display similar socioeconomic gradients [14-16], some have shown that women have stronger socioeconomic inequalities [8, 17-22], while yet others have concluded that gradient differences are inconsistent and depend on the health outcome measure and life stage [5, 10].

Caution must be exercised when making inferences about gender differences in socioeconomic inequalities. First, there is considerable cross-national variability in gendered patterns of socioeconomic inequalities in health, particularly for women [13, 14, 17, 19, 20, 48, 74, 75]. This inconsistency could be a reflection of poor measurement of SEP, given the different relationships women have with the labour force in different socio-cultural settings [10]. Thus, the cross-cultural generalizability of studies on gender differences in socioeconomic inequalities is questionable.

Second, gender differences in socioeconomic inequalities are sensitive to the measure of inequality. In a recent systematic review of gender differences in socioeconomic inequality in mortality, it was found that using absolute measures of inequality (e.g. rate difference) about 90% of the studies examined demonstrated greater inequality among men. However, studies that employed

relative indices of inequality (e.g. rate ratio) showed that socioeconomic inequalities in mortality were similar among women and men. The lack of relative socioeconomic differences suggests that men and women are not differentially exposed to the structural, behavioural, and psychosocial conditions that impact health [76]. There is a general call for research on gender differences in socioeconomic inequalities to use more systematic methodology, as there remains considerable controversy in this domain [9, 10, 76].

Third, and perhaps most importantly, much of the research in this field is cross-sectional. The use of cross-sectional data makes it very difficult to unravel the causal pathways between SEP and health [48] because the temporal ordering of an individual's socioeconomic status and health status is unknown [15, 77]. As previously discussed, there is a possibility of reverse causation in social inequality research, whereby health may impact SEP [50, 60]. However, the presence of reverse causation cannot be evaluated with cross-sectional data since the exposure and the outcome are assessed concomitantly; only longitudinal data can begin to provide interpretation to the differential life course patterns of inequalities [7]. Part of the debate about whether men and women exhibit differences in their socioeconomic gradients may be attributed to the relative dearth of longitudinal studies that examine social inequalities by gender [6, 8, 10, 14-16, 54, 58].

3.2 Explanations for Gender Differences in Socioeconomic Inequalities

Three hypotheses have been offered to explain why socioeconomic inequalities would vary by gender: differential exposure, differential

vulnerability, and methodological artefact [11]. As I have already given attention to the first two hypotheses, I will only briefly discuss them before focusing on to the issue of artefact.

3.2.1 The Differential Exposure and Differential Vulnerability Hypotheses

Differential exposure theory attributes gender differences [in socioeconomic inequality] to the diverse experiences men and women have. If we were to accept that men have steeper socioeconomic gradients than women, this could be the result of men's greater exposure to health risks, such as toxins, in their occupations [11], risky health-related behaviours, such as smoking and alcohol consumption, [22, 27], and their reluctance to report illnesses and use health care services [40, 41] relative to women. The differential vulnerability hypothesis contends that men have greater susceptibility to their physical and social environment. Men may embody the effects of SEP to a larger extent than women, as evidenced by their greater likelihood of dying at every stage in life [11].

3.2.2 Men's Steeper Socioeconomic Gradients: Fact or Artefact?

The methodological artefact hypothesis has received a large amount of attention in inequality research. Specifically, there has been a lot of concern that measurements of SEP are less precise for women, compared to men [9, 15]. In addition, choice of health indicator (given gender differences in diseases and

causes of death) [12] and health-reporting bias [7] have been discussed in the explanation of men's steeper gradients.

With regards to the measurement of SEP, occupational classification schemes, income (household and individual), and education have received much attention in the field of gender differences in socioeconomic inequalities [25]. Occupational class has been widely criticized because of the pervasiveness of gender segregation in the labour force [15]. Despite many cultural and legislative changes in the occidental world in recent years, men's and women's positions in the labour market remain very distinct. When women are employed, they occupy a very limited number of jobs and these jobs are characterized by relatively low wages and status. In addition, where women have obtained more high status "male" jobs, they generally remain in the least senior positions [9]. Thus, assessing SEP based on one's own occupational class or that of one's spouse (often the case for women) is not likely to be an accurate measure, given the differential relationships women and men have with the formal labour market [10, 15].

Income is less frequently criticized compared to occupational class. Household income, adjusted for employment status, has been deemed preferable to individual income because of the fewer women in the labour market compared to men [48]. Among employed men and women, however, individual income was shown to be more important for predicting the health of women, relative to men [19]. Interestingly, it has also been shown that women's earned incomes enhance the risks of their husbands dying, while men's income is an asset for their wives.

However, given gender differences in the distribution of household income (with males generally having more access to money than females) [15], SEP should be assessed by both individual and household income whenever possible.

Finally, education is argued by some to be the best measure of SEP as it precludes both occupation and income and it should have a similar meaning for both women and men [8]. While it has been hypothesized by some that education has less significance for women because they receive fewer returns in the form of occupational status increases and wage increases than men with similar educational qualifications, on the contrary, it was demonstrated that education has a greater significance for women because they have fewer socioeconomic resources to draw from [8]. Despite the absence of a gold standard measure, many indicators of SEP have demonstrated inverse gradients with mortality and morbidity. Therefore, assessing multiple dimensions of SEP for gender comparisons is the optimal method as each indicator will have its own strengths and biases [7, 10].

The second point of contention is the possibility of an artefactual relationship associated with the choice of health status indicator. The distribution structure of illnesses and causes of death varies between men and women [26]; hence, the choice of the health outcome measure will affect conclusions about the presence of gender differences in socioeconomic gradients [12, 18]. Notably, a more in depth examination of gender patterns in disease revealed that women likely exhibit a steeper gradient in coronary heart disease morbidity and mortality than men. In addition, women also display socioeconomic gradients in body mass

index, whereas men do not [9]. Thus, multiple indicators of health and causes of death are preferable in this domain of research, as results are likely to be outcome-specific [3, 5, 7, 10].

A third type of artefact that may be present in this field of research is reporting bias, as the data are largely provided by subjective self-reported surveys. Much attention has been given to potential differences in reporting of illnesses and help-seeking behaviour among men and women [40, 41] and among social groups [7]. Two studies addressing this issue of illness behaviour did not show differential reporting by gender [40, 45] or by SEP [78]; however, differences in reporting of illness and SEP, remains an important potential bias to consider.

3.3 'Third' Variables: Confounders and Mediators

In addition to measurement and reporting bias, the relationships between SEP, gender and health may also be prone to confounding. A confounding variable is one which is expected to be associated with both the outcome (health) and the exposure (SEP), yet is not an effect of the exposure (i.e. an intermediary variable in the causal pathway between SEP and health) [77]. Some studies on the SEP-health relationship only included age and gender as potential confounders [46, 49], while others adjusted for many more potentially confounding variables. In addition to age and gender, family history [2, 6, 19, 50, 53, 55, 79, 80], health behaviours [2, 19, 54, 55], work characteristics [6, 19, 54, 55, 79], measures of health and disease [47, 54], socio-demographics [2], psychosocial factors [2],

activity status [2, 55] and social support [19] have been known to be associated with SEP and health.

Researchers have also examined the role of factors which mediate the association between SEP and health. That is, factors which can be found in the causal pathway between SEP and health. Some important variables which have demonstrated a significant mediating effect include work environment factors (mediating wage income) [53], income and poverty (mediating social class) [50, 81], and health behaviour, material factors, psychosocial factors, and cultural factors (mediating education) [81].

A point to consider is that certain factors, for example health behaviours, have been suggested by some authors to be confounders of SEP, while others say that they are mediators of SEP. As mentioned above, Rothman [77] stipulates that factors found in the causal pathway between an exposure and an outcome should not be treated as confounders as they are part of the effect of the exposure. Hence, adjusting for potentially confounding factors which may in fact be mediators will result in estimates of the independent effect of the SEP variables on health. As such, these adjustments may lead to an underestimate of the true effect size.

4. Summary

The influence of gender on the relationship between socioeconomic position and health is related to the understanding of gender differences in health, socioeconomic inequalities in health, and gender differences (or similarities) in

SEP-health gradients. There is a relative paucity of research examining the intersection of these two fields of social inequality, particularly on the longitudinal level. Using a range of health indicators, the interactive effects of sex and gender with multiple dimensions of SEP should be analyzed over time so that the nature of women's and men's embodiment of SEP can be better understood. This knowledge is crucial for the development of interventions aimed at reducing social inequalities in health. In addition, it is necessary to be aware of potential biases relating to study design, measurement, and confounding while addressing this important population health question. Giving due attention to these issues, the following manuscript examines the longitudinal relationships between gender, changes in socioeconomic position and changes in health over time in order to help resolve the debate on women's and men's experience of socioeconomic mobility.

CHAPTER 3
PREFACE TO THE MANUSCRIPT

The manuscript, Gender differences in socioeconomic inequalities in health: Trends in the Canadian Population, 1994-2003, has been formatted for submission to the *Journal of Epidemiology and Community Health.* The objectives of the manuscript are the same as the overall goals of the thesis, that is, to determine 1) if there are gender differences in health over time, 2) if changes in socioeconomic position lead to health inequalities and 3) if changes in socioeconomic position impact health differently for women and men. These questions are examined using the Canadian National Population Health Survey and generalized estimating equations (GEE) for four measures of health, number of chronic conditions, self-rated health, functional health and psychological distress, and three measures of SEP, income, education and employment status. Although gender and changes in SEP significantly affect changes in health, there is no evidence of effect modification in this dataset. These results are discussed with respect to previous longitudinal research in the field and the potential implications of the study are suggested. Finally, the strengths and limitations are examined, paying particular attention to the methodological issues highlighted in the literature review, and overall conclusions are made. A final summary and an extended version of the discussion are presented following the manuscript.

CHAPTER 4
GENDER DIFFERENCES IN SOCIOECONOMIC INEQUALITIES IN HEALTH: TRENDS IN THE CANADIAN POPULATION, 1994-2003

Background: Gender and socioeconomic inequalities in health are ubiquitous in developed countries; however, the modifying effect of gender on the relationship between socioeconomic position (SEP) and health over time is less clear. **Objective:** To estimate the potentially different health effects of changes in SEP on changes in health for working-age women and men over a 10-year period. Three main questions are addressed: 1) are there gender differences in health over time, 2) do changes in SEP lead to health inequalities and 3) do changes in SEP impact health differently for women and men?

Methods: Generalized estimating equations (GEE) longitudinal models were used to analyze cycles 1-5 of the Canadian National Population Health Survey for four measures of health, number of chronic conditions, self-rated health, functional health, and mental distress, and three measures of SEP, income, education and employment status.

Results: Health inequalities by gender and by changes in SEP were present for all four outcomes in age-adjusted models; however, after controlling for time-dependent social structure, behaviour, and psychosocial factors the relationships persisted only for chronic conditions and psychological distress. There was no evidence that these effects differed, over time, by gender.

Conclusions: Men and women in this nationally-representative sample of Canadians do not differentially embody changes in SEP, though both gender and changes in SEP independently impact health.

Inequalities in health between women and men are a consequence of biological differences relating to sex and social differences produced by gender roles, opportunities and beliefs [1]. It is widely accepted that women have greater life expectancy than men, but suffer more morbidity [2]; however, emerging evidence suggests that the pattern of inequality is more variable and may depend on the choice of health indicator and the age groups examined [3-5, 10, 34, 35]. Socioeconomic inequalities in health are equally well-described in most developed countries, with those lower on the social ladder displaying worse health [6]. Similar to gender, however, the extent and direction of socioeconomic inequalities are not invariable. Some dimensions of health do not show simple or consistent patterning by socioeconomic position (SEP), others have flatter gradients and some show complex interaction patterns by age and sex [6, 7]. Compared to men, however, women *generally* experience poorer socioeconomic circumstances [8] and poorer health status [2].

The study of the intersection of these two dimensions of social inequality, namely gender differences in socioeconomic inequalities in health, is relatively rare [9, 10]. It has been generally contended that women exhibit shallower socioeconomic gradients than men [11-13]; however, this perspective has been called to question by many studies that show more variable patterns [5, 8, 10, 14-22, 58]. Assessing multiple outcomes over time, one study indicated that males indeed had steeper income gradients for high blood pressure, self-rated health, depression, heart trouble, trouble breathing, trouble feeding and sick days [6]. Another study that also examined several health measures found no longitudinal

gradient differences between women and men based on occupational class; however, steeper male gradients based on education were present for chronic illnesses and respiratory symptoms and steeper female gradients were present for self-rated health and psychological distress. Furthermore, no education gradient differences were observed for asthma, obesity and height [10]. Longitudinal studies that employed only one outcome measure showed stronger female gradients for heart disease [14, 16] and depression [8] based on income [14, 16] and education [8, 16], and similar income-mortality gradients for both genders [15, 58].

Few studies have examined the evolution of gender and socioeconomic differences in health over time and have been able to account for changes in the multiple correlates of health, gender, and SEP. The goal of this study is to estimate the potentially different health effects of changes in SEP for working-age women and men over a 10-year period. Using a longitudinal dataset that includes a number of potential time-dependent confounders (social structure, behavioural and psychosocial characteristics) and a longitudinal analysis that accounts for measured and unmeasured time-invariant within-individual characteristics, we examine the moderating effect of gender on the relationship between SEP and health over time among middle-aged adults. Three main questions are addressed: 1) are there gender differences in health over time, 2) do changes in socioeconomic position lead to health inequalities and 3) do changes in socioeconomic position impact health differently for women and men?

METHODS

Population

Data were obtained from the Canadian National Population Health Survey (NPHS), a nationally representative longitudinal household survey conducted by Statistics Canada [82]. Selected using multistage sampling, respondents were contacted every two years from 1994/95-2002/03 at the time of analysis. The overall response rates were: Cycle 1: 83.6%, Cycle 2: 92.8%, Cycle 3: 88.2%, Cycle 4: 84.8%, Cycle 5: 80.6%. The Cycle 1 response rate is based on the 20,095 persons initially selected to form the longitudinal panel, while the response rate for subsequent cycles is based on the 17,276 individuals who form the longitudinal panel. Cyclically adjusted sampling weights were used to account for non-response and attrition. Only panel members 35-54 years old (N = 3481) were included for analysis, as socioeconomic inequalities have been found to be strongest among middle-aged adults [7, 10]. Individuals that had completely missing data across all measures were excluded from the analysis (N = 89).

Health Outcomes

Health was assessed using four indicators. First, was the number of chronic conditions (NCC), derived as a count of the number of long-term diagnosed chronic health conditions that had lasted or were expected to last six months or more. These include, asthma, fibromyalgia, arthritis or rheumatism, back problems, high blood pressure, migraine or headache, food or other allergies, bronchitis or emphysema, sinusitis, diabetes, epilepsy, heart disease, cancer,

stomach or intestinal ulcers, effects of stroke, urinary incontinence, and acne requiring prescription medication. Second, self-rated health (SRH) was measured by a five item question that asked respondents to rate their own health as excellent (coded as 5), very good (4), good (3), fair (2) or poor (1). Third, functional health was measured using the Health Utilities Index-3 (HUI). The HUI score is based on a combination of eight sub-scales: vision, hearing, speech, mobility, dexterity, cognition, emotion, and pain/discomfort. Scores are defined on a scale anchored by dead=0.000 and perfect health=1.000 in increments of 0.001; however, negative scores, with a minimum of -0.360, are also possible [83]. Negative scores represent states of health where respondents are deemed clinically alive, but lack all functional capacity to participate in social life (e.g. being in a coma and on mechanical life support). Finally, psychological distress was measured by a subset of items from the Composite International Diagnostic Interview (CIDI). Respondents were asked, during the month prior to the interview how often did you feel: (1) so sad that nothing could cheer you up; (2) nervous; (3) restless/fidgety (4) hopeless; (5) worthless; and (6) everything was an effort. Possible responses ranged from 0 (none of the time) to 4 (all of the time); therefore, composite scores ranged from 0 to 24 (higher scores indicate more distress). All four measures of health were treated as continuous. Sensitivity analyses using different model specifications showed similar results.

SEP

Socioeconomic position (SEP) was assessed through three variables, income adequacy, highest level of education, and employment status. Treated as a dichotomous variable, income adequacy was calculated based on the dollar distance between the individual's household income in the past 12 months and the Canadian low-income cut-off (poverty line) for a given household size. Analyses based on quintiles of income adequacy yielded similar results, thus for ease of interpretation the binary variable was deemed preferable. Highest level of education was categorized as individuals who did not complete secondary school (reference), secondary school graduates (coded as 1) or post-secondary graduates (2). Again, using a greater number of categories did not affect the final results. Finally, employment status was treated as a dichotomous variable that compared individuals who were employed to those who were unemployed (out of work, retired, disabled) during the past 12 months. Given the age of this cohort, the vast majority of individuals were employed full-time and thus finer categorizations were not possible due to statistical imprecision. A further limitation was that it was not known if participants' employment status changed within the given year. The variance inflation factor (VIF) of these variables did not indicate a problem with multi-collinearity: all VIF scores were less than five.

Covariates

Following previous research [2], three broad categories of social determinants, social structure, health-related behaviours, and psychosocial factors,

were included as time-dependent control variables (see appendix A). Social structure was measured by age, marital/partner status, household size, and social support. Health-related behaviours were represented by physical activity, body mass index, and smoking. Respondents' psychosocial factors were assessed with the adjusted specific chronic stress index (number of stressors related to activity overload, financial difficulties and problems with relationships in day-to-day encounters) and sense of mastery index (measures the extent to which individuals believe that their life-chances are under their control); however, these indices were only measured during cycles 1, 4 and 5. Sensitivity analyses were performed to compare models with the full range of covariates, except chronic stress and mastery, using all five cycles of data to models using only three cycles of data. The results were similar, so analyses were restricted to cycles 1, 4 and 5 in order to incorporate the psychosocial dimension.

Statistical Analysis

To describe the data for each cycle, weighted gender-stratified means and 95% confidence intervals were computed for each health outcome and weighted means and proportions were produced for each independent variable. The longitudinal analytic strategy entailed a three step process using Generalized Estimating Equations (GEE) models, also known as population averaged models. With GEE, the effect of a given exposure is interpreted as the effect on the average person, or a person selected at random from the population. To adjust for the correlation of individuals' responses over time, GEE models utilize

information from the factors that are constant *within* an individual, in addition to factors that are similar *between* individuals, to estimate the regression parameters [84]. The *within* information may be thought of as time-invariant individual propensity (measured and unmeasured) to develop illness. As such, biological susceptibility to poor health (genetic make-up, sex hormones, fetal development, etc.) as well as early life course factors known to impact adult health (parental and childhood SEP, childhood development, etc.) were controlled for (see appendix B).

The first step in the analysis was to evaluate longitudinal gender differences in health using age-adjusted and fully adjusted (structure, behaviour, and psychosocial) GEE models. Second, similar models were used to examine longitudinal health inequalities produced by changes in SEP. Finally, gender differences in socioeconomic inequalities were examined by including a multiplicative interaction term for gender and each of the SEP variables in both age-adjusted and fully adjusted models. Gender-stratified models were planned if any of the interaction terms were statistically significant at α-level < 0.05.

To test the strength of the relationships, age-adjusted and fully adjusted interaction models were also computed using two other types of longitudinal regression, random effects and fixed effects. GEE and random effects both account for correlated data using within and between-individual information, whereas fixed effects use only within information and thus completely attributes the correlation of responses to the time-invariant characteristics of each person.

Conclusions based on these models were similar to GEE. Analyses were performed using Stata SE 9 statistical software [85].

RESULTS

Overview of the Data in Cross-Section

To get an overview of what is being modelled over time, Figure 1 contains the cross-sectional weighted means and 95% confidence intervals for the four health outcomes. It shows that the number of chronic conditions increases, self-rated health gets worse, the health utilities index increases and then decreases, and mental distress lessons as the cohort ages. Overall, men have better health than women for each outcome, though the confidence intervals overlap during some cycles. Table 1 displays the cross-sectional trends in SEP, structure, behaviour and psychosocial variables throughout the survey.

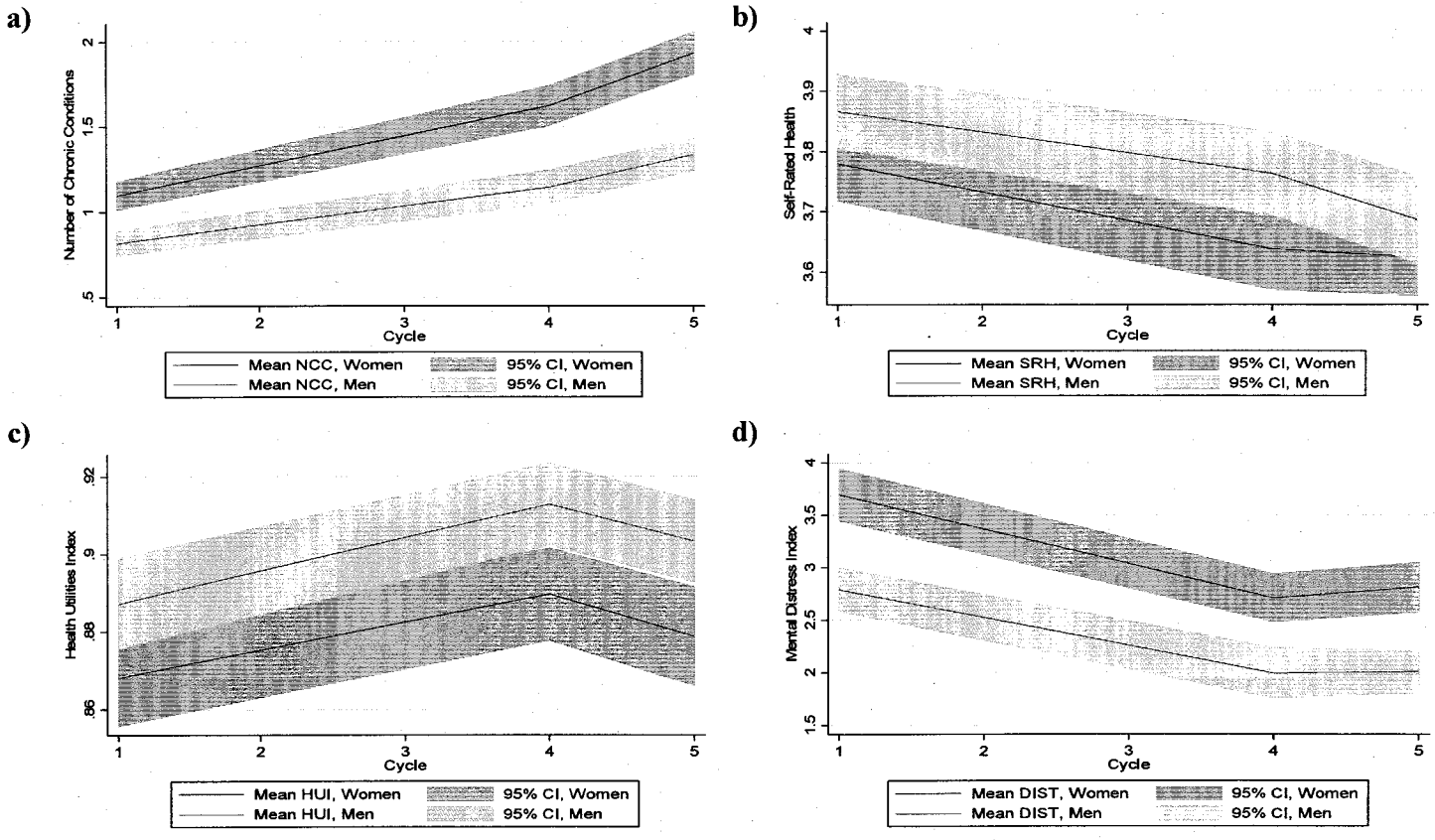

Figure 1. Cross-sectional trajectories of health by gender. a) Number of Chronic Conditions (NCC), b) Self-Rated Health (SRH), c) Health Utilities Index (HUI) and d) Psychological Distress (DIST).

Table 1. Survey trends in SEP, social structure, behaviour and psychosocial measures. Cross-sectional weighted means and percentages by cycle and gender.

	Women			Men		
Survey Cycle	**94/95**	**00/01**	**02/03**	**94/95**	**00/01**	**02/03**
Number of Observations	1741	1369	1288	1476	1189	1115
SEP Measures						
Income Adequacy (%)						
Middle/High (ref)	**87**	**92**	**93**	**88**	**95**	**96**
Low	**13**	**8**	**7**	**12**	**5**	**4**
Education (%)						
< Secondary School (ref)	**19**	**15**	**15**	**18**	**16**	**14**
Secondary School Graduate	**36**	**39**	**40**	**43**	**45**	**44**
Post-secondary Graduate	**45**	**46**	**45**	**39**	**39**	**42**
Employment (%)						
Unemployed (ref)	**23**	**19**	**20**	**6**	**9**	**10**
Employed	**77**	**81**	**80**	**94**	**91**	**90**
Social Structure Measures						
Age	**43.2**	**48.9**	**50.7**	**43.2**	**49.4**	**51.3**
Marital Status (%)						
Unmarried (ref)	**23**	**24**	**24**	**17**	**18**	**17**
Married	**77**	**76**	**76**	**83**	**82**	**83**
Household Size	**3.3**	**3.0**	**2.8**	**3.3**	**3.1**	**3.0**
Social Support	**3.8**	**2.1**	**2.1**	**3.7**	**2.2**	**2.2**
Behavioural Measures						
Smoking (pack-years)	**9.2**	**9.5**	**9.5**	**15.6**	**15.7**	**14.8**
Never Smoked (%)						
Current/former smoker (ref)	**52**	**50**	**51**	**63**	**66**	**63**
Never smoked	**48**	**50**	**49**	**37**	**34**	**37**
Physical Activity Index (%)						
Active (ref)	**13**	**14**	**19**	**15**	**16**	**24**
Moderate	**20**	**24**	**30**	**24**	**26**	**28**
Inactive	**67**	**62**	**51**	**61**	**58**	**48**
Body Mass Index (%)						
Underweight	**3**	**1**	**1**	**0**	**2**	**1**
Normal weight (ref)	**54**	**49**	**42**	**34**	**27**	**26**
Overweight	**28**	**30**	**36**	**50**	**51**	**52**
Obese	**15**	**20**	**21**	**16**	**20**	**21**
Psychosocial Measures						
Chronic Stress Index	**3.6**	**2.9**	**3.0**	**2.9**	**2.4**	**2.3**
Mastery	**19.4**	**19.5**	**19.2**	**20.1**	**19.9**	**19.6**

Longitudinal Gender and Socioeconomic Differences in Health

In age-adjusted models, significant gender differences in health are observed over time: men have significantly fewer chronic conditions, better SRH, higher HUI scores, and less mental distress than women (Table 2, model 1). Taking chronic conditions as an example, the average male in the population has 0.458 (95% CI 0.565-0.350) fewer chronic conditions over the 10-year period than the average female. In addition, people who experience an increase in SEP over time have better health, and similarly those who decrease have worse health (Table 2, model 2). Those who change from middle/high household income to low income have significantly worse SRH and HUI scores, as well as more psychological distress compared to those who maintain their income level. Individuals with less than a high school education that attain their high school diploma or a post-secondary degree report fewer chronic illnesses and better SRH and functional health than those who do not go back to school. Finally, those who become employed report fewer chronic illnesses, rate their health to be better, have fewer functional limitations and suffer less mental distress than those who remain out of work, disabled, or retired.

Concurrently modeling gender and SEP, while adjusting for social structure, health behaviours, and psychosocial characteristics, yielded similar results to the age-adjusted models for the number of chronic conditions and psychological distress, though not for SRH and HUI (Table 2, model 1+2). Gender differences and socioeconomic inequalities remain statistically significant for both chronic conditions and distress, although the regression coefficients are

slightly attenuated after adjustment. For SRH and HUI, significant gender differences in health disappear once fully adjusted. In addition, income and education no longer significantly predict health, although employment status remains an important predictor for both SRH and HUI.

Longitudinal Gender Differences in Socioeconomic Inequalities in Health

By and large, the interaction terms between gender and SEP are not statistically significant in age-adjusted and fully adjusted GEE models (table 3). The one exception is a significant interaction between high school graduates and gender for psychological distress in the age-adjusted model; however, this effect is not observed when the model is adjusted for the complete set of controls. As gender differences were not present in fully adjusted models for either SRH or HUI, the results for the interaction between gender and SEP (also non-significant) are not shown for these outcomes. In addition, interaction models using random effects and fixed effects regression were mainly similar and did not change the overall interpretation (results not shown).

Table 2. Changes in health according to longitudinal gender differences and changes in socioeconomic position (GEE). N = 3481.

		Model 1: Age-adjusted Gender Differences		Model 2: Age-adjusted SEP Inequalities		Model 1 + 2: Fully adjusted[2] Gender & SEP	
	Variable	β Coef	95% CI	β Coef	95% CI	β Coef	95% CI
NCC[1]	Male	-0.458	(-0.565, -0.350)	-	-	-0.399	(-0.507, -0.291)
	Low income	-	-	0.095	(-0.076, 0.265)	0.048	(-0.122, 0.218)
	High school graduate	-	-	0.265	(0.120, 0.411)	0.274	(0.132, 0.415)
	Post-secondary graduate	-	-	0.224	(0.078, 0.370)	0.285	(0.144, 0.426)
	Employed	-	-	-0.541	(-0.690, -0.391)	-0.477	(-0.625, -0.330)
SRH	Male	0.095	(0.025, 0.165)	-	-	0.036	(-0.029, 0.100)
	Low income	-	-	-0.138	(-0.254, -0.022)	-0.073	(-0.188, 0.042)
	High school graduate	-	-	0.139	(0.039, 0.240)	0.075	(-0.021, 0.172)
	Post-secondary graduate	-	-	0.270	(0.169, 0.370)	0.158	(0.060, 0.255)
	Employed	-	-	0.376	(0.284, 0.467)	0.351	(0.268, 0.434)
HUI	Male	0.022	(0.010, 0.035)	-	-	0.001	(-0.010, 0.011)
	Low income	-	-	-0.036	(-0.058, -0.014)	-0.013	(-0.035, 0.008)
	High school graduate	-	-	0.016	(-0.003, 0.036)	0.004	(-0.014, 0.022)
	Post-secondary graduate	-	-	0.027	(0.008, 0.046)	0.005	(-0.013, 0.023)
	Employed	-	-	0.101	(0.077, 0.125)	0.091	(0.069, 0.112)
DIST	Male	-0.803	(-1.044, -0.563)	-	-	-0.342	(-0.543, -0.142)
	Low income	-	-	1.015	(0.604, 1.427)	0.478	(0.155, 0.800)
	High school graduate	-	-	-0.122	(-0.442, 0.198)	0.076	(-0.176, 0.327)
	Post-secondary graduate	-	-	-0.210	(-0.556, 0.136)	0.226	(-0.042, 0.494)
	Employed	-	-	-1.041	(-1.445, -0.637)	-0.654	(-0.943, -0.365)

[1] NCC = number of chronic conditions, SRH = self-rated health, HUI = health utilities index (functional health), DIST = psychological distress

[2] Adjusted for structure (age, marital/partner status, household size, social support), behaviour (physical activity, BMI, smoking), and psychosocial (chronic stress, mastery)

Table 3. Changes in health according to interaction effects between gender and changes in socioeconomic position (GEE). N = 3481.

		Model 3: Age-adjusted Interaction		Model 3: Fully-adjusted[2] Interaction	
	Variable	**β Coef**	**95% CI**	**β Coef**	**95% CI**
NCC[1]	Male	-0.153	(-0.519, 0.214)	-0.172	(-0.522, 0.177)
	Low income	0.062	(-0.180, 0.304)	0.017	(-0.224, 0.258)
	Low income*male	0.051	(-0.285, 0.387)	0.053	(-0.285, 0.390)
	High school graduate	0.268	(0.044, 0.491)	0.291	(0.077, 0.505)
	High school graduate*male	-0.036	(-0.324, 0.252)	-0.046	(-0.320, 0.229)
	Post-secondary graduate	0.200	(-0.023, 0.422)	0.262	(0.050, 0.475)
	Post-secondary grad*male	0.049	(-0.239, 0.338)	0.031	(-0.242, 0.304)
	Employed	-0.397	(-0.578, -0.216)	-0.390	(-0.568, -0.212)
	Employed*male	-0.286	(-0.615, 0.043)	-0.256	(-0.572, 0.059)
DIST	Male	-0.691	(-1.537, 0.155)	-0.161	(-0.828, 0.506)
	Low income	1.236	(0.641, 1.831)	0.704	(0.262, 1.147)
	Low income*male	-0.493	(-1.297, 0.310)	-0.516	(-1.155, 0.122)
	High school graduate	-0.488	(-1.013, 0.038)	-0.119	(-0.506, 0.269)
	High school graduate*male	0.666	(0.027, 1.305)	0.368	(-0.133, 0.869)
	Post-secondary graduate	-0.539	(-1.095, 0.016)	0.046	(-0.362, 0.454)
	Post-secondary grad*male	0.660	(-0.036, 1.355)	0.351	(-0.174, 0.875)
	Employed	-0.724	(-1.251, -0.197)	-0.474	(-0.835, -0.113)
	Employed*male	-0.544	(-1.337, 0.249)	-0.504	(-1.095, 0.087)

[1] NCC = number of chronic conditions, DIST = psychological distress
[2] Adjusted for structure (age, marital/partner status, household size, social support), behaviour (physical activity, BMI, smoking), and psychosocial (chronic stress, mastery)

DISCUSSION

The health of men and women in this nationally-representative sample of Canadians is not differentially impacted by changes in SEP, though both gender and SEP independently affect health. For the health outcomes examined here, number of chronic conditions, self-rated health, functional health (health utilities index) and psychological distress, the magnitude of the effects of declining (or improving) SEP was similar for Canadian men and women. Significantly poorer health across all outcomes, however, is observed for women, those whose income level declines, those who do not finish at least high school and those who are not employed. The significance of these relationships after controlling for time-varying social structure, health-related behaviours and psychosocial factors persists only for chronic conditions and psychological distress

Previous Research

The widely accepted view that men have generally steeper socioeconomic gradients in health than women [11-13] was not supported by this investigation or several other longitudinal studies [8, 10, 14-16, 58]. Men's steeper gradients, when observed, have often been attributed to either methodological artefact or the differential exposure/vulnerability of men and women to the determinants of health [2, 3, 11, 23]. The lack of differential gradients in the NPHS may be partly explained by the control of both differential vulnerability and exposure in this analysis. The GEE models accounted for time-invariant illness propensity through the inclusion of within-individual information to adjust for correlated

data. In addition, multiple time-dependent variables of social structure, health-related behaviours, and psychosocial factors controlled for gender differences in exposure that may have arisen over the course of the survey. If the steeper socioeconomic gradients observed among men in previous studies were largely due to uncontrolled gender differences in vulnerability or exposure, it is understandable that we did not observe such gradient differences.

The possibility of methodological artefacts as explanations for these results must be considered. Differences in reporting between women and men and socioeconomic groups have often been thought to contribute to gradient differences (or similarities) [40, 45, 78]. As reporting bias is an inherent problem to survey research, Statistics Canada has used the best available measures to help minimize differential reporting in the NPHS [82]. Moreover, recent research has claimed that the threat of reporting bias is smaller than originally thought [40, 45, 78]. Gender differences in socioeconomic gradients may also be the result of choices in measures of SEP and/or health outcome [10, 12]. However, despite using three measures of SEP (which were not found to be multi-collinear) and four measures of health, men did not exhibit steeper gradients. Furthermore, finer categorizations of SEP displayed similar results.

Implications of the Study

These findings do not preclude the possibility of gender differences in socioeconomic inequalities in Canada. Given the boundaries of observational research and the measurement of health and SEP in the NPHS, it is possible that

gender differences in socioeconomic gradients have gone undetected. These results may also be the product of unmeasured cohort effects. Canadian women of this age group have attained similar education levels to men and are well-represented in the paid workforce [32]. As such, income, education and employment may in fact have a similar meaning to the health of middle-aged Canadian women and men. The results of this study emphasize the importance of re-examining patterns that are assumed to be factual and static through time and context.

Strengths and Limitations

The major strengths of this research lie in the design of the survey and the methods of analysis employed. With respect to design, the NPHS is longitudinal, has a large sample size, is nationally representative, and makes use of extensively validated instruments for data collection. The statistical modeling techniques included weighting of the data, robust standard error correction, and testing for model misspecification. In addition, comparisons of the chosen longitudinal model, GEE, to other available models (i.e. fixed effects and random effects) yielded similar results.

This study, however, is not without its limitations. These are observational data spanning only ten years of follow-up. However, the inclusion of multiple time-dependent controls, in addition to using longitudinal models which account for within-individual heterogeneity, was an effort to reduce the likelihood of confounding, which is a common problem in observational studies.

Another point of consideration is that time lag between SEP and the development or incidence of a given health outcome was not addressed.

As in any large-scale longitudinal survey, non-response and sample attrition may lead to selection bias if those who do not respond or who drop out of the survey are not representative of the target population. Multi-stage stratified probability sampling of participants and the use of cyclically adjusted sampling weights were an attempt to best reflect the 1994 Canadian population. Finally, information or misclassification bias could be problematic, as the data are self-reported; however, the NPHS has taken measures to help reduce misclassification [82] and the severity of this bias is contested in controlled research settings [40, 45, 78]. If present, it is difficult to know whether, confounding, selection bias, and/or misclassification would lead to an attenuation or an increase in the observed effect size [77].

Conclusions

Although gender and changes in SEP both independently impact the health of middle-aged men and women in the NPHS over time, there is no evidence to suggest that men embody changes in SEP to a greater extent than women. The absence in this study of this assumed "general pattern" of men's steeper socioeconomic gradients [11] and its inconsistency in other longitudinal studies, highlight the need for more longitudinal research in other settings using similar datasets and modeling techniques. In addition, given that biological sex categories are a proxy for gender, analyzing socioeconomic inequalities in health

by specific roles, attitudes or opportunities (which may be typified by sex, but are not restricted to either males or females) may elucidate what exactly about being a man or woman may result in differential socioeconomic gradients.

What is already known

- Gender and socioeconomic inequalities in health are ubiquitous in developed countries: women and those with lower socioeconomic position tend to have higher morbidity.
- Longitudinal analyses examining the potentially different health impacts of changes in socioeconomic position are necessary to help resolve the debate on whether men exhibit steeper socioeconomic gradients than women.

What this study adds

- Middle-aged Canadian men and women do not differentially embody changes in socioeconomic position, though both gender and socioeconomic position independently impact health.
- These results demonstrate the importance of re-examining over-generalized patterns in different contexts

Policy implications

- Policies aimed at reducing social inequalities in health in Canada should put equal effort into eliminating income, education, and employment disparities for women and men.

CHAPTER 5
SUMMARY AND DISCUSSION

1. Summary

There are three main findings from this study. First, there is no evidence to suggest that changes in socioeconomic position, as measured in the NPHS, have differential health effects based on gender. For the health outcomes examined here, number of chronic conditions, self-rated health, functional health (health utilities index) and psychological distress, the magnitude of the effects of changes in socioeconomic circumstances over 10 years was similar for Canadian men and women. Second, poorer health (as measured by all outcomes) is observed for individuals whose income level declines, who do not attain at least a high school diploma and who are not employed over the course of the survey; however, these relationships persist only for chronic conditions and psychological distress after adjustment for time-varying social structure, health-related behaviours and psychosocial factors. Third, as seen in other studies, Canadian men in the NPHS dataset display significantly fewer chronic conditions, better self-rated health, higher functional ability and less psychological distress over time compared to women. Again the relationship only holds for chronic conditions and distress after adjustment for the time-dependent covariates.

2. Previous Research

The widely accepted view that men have steeper socioeconomic gradients in health than women [11-13] was not supported by this investigation. A review

of eight longitudinal studies in developed countries also indicated the possibility of a more complex pattern. One American study followed individuals aged 40-59 for 29 years from 1965 to1994 and examined the shape of women's and men's socioeconomic gradients at four points in time for seven health outcomes [6]. They indicated that males had distinctly more non-linear income gradients, relative to women's gradients, for high blood pressure, self-rated health, depression, heart trouble, trouble breathing, trouble feeding and sick days, suggesting a high concentration of ill health among the cohort's poorest men. A study based on the 1958 British birth cohort also examined several health measures over time, using data from birth to age 33 [10]. Longitudinal differences in inequality based on occupational class were absent between women and men at ages 23 and 33, although education displayed greater inequalities for males at age 33 for chronic illnesses and respiratory symptoms. Females, however, showed greater education-based inequalities for self-rated health at age 23 and psychological distress at age 33. Furthermore, no education gradient differences were observed for asthma, obesity and height at any age.

The remaining longitudinal studies examined only one outcome measure over time. Two of such studies showed stronger female income [14, 16] and education [16] gradients using survival analysis for heart disease in 20+ year old Danes [14] and 25-74 year old Americans [16]. In addition, growth curve models demonstrated that changes in depression level depend more strongly on changes in education among adult (18+ years) women, than men in the U.S. [8]. Income gradients for American mortality over a 30-year period were similar for both

genders [15, 58]. However, a study of self-rated health [29] indicated that baseline occupational position led to future declines in men's self-rated health and not women's over a 48-month period among a nationally representative sample of the Canadian labour force [54].

Men's steeper socioeconomic gradients, when observed, have often been attributed to either methodological artefact or the differential exposure/vulnerability of men and women to the determinants of health [2, 3, 11, 23]. The lack of differential gradients in the current study of the NPHS may be partly explained by the fact that both differential vulnerability and exposure were largely accounted for in this analysis. To adjust for the correlation of individuals' responses over time, GEE models utilize information from the factors that are constant *within* an individual (in addition to factors that are similar *between* individuals) to estimate the regression parameters. The *within* information may be thought of as an individual's propensity (measured and unmeasured) to develop illness that does not change over time. As such, biological susceptibility to poor health (genetic make-up, sex hormones, fetal development, etc.) as well as early life course factors known to impact adult health (parental and childhood SEP, childhood development, etc.) can be thought of as controlled for in the analysis (though we cannot provide an estimate for their effect on health). In addition, a considerable number of time-dependent controls for social structure, health-related behaviours, and psychosocial factors were included. Hence, gender differences in exposure that may have arisen over the course of the survey were accounted for. If the steeper socioeconomic gradients observed among men in

previous studies were largely due to uncontrolled gender differences in vulnerability or exposure, it is understandable that we did not observe gradient differences between women and men in the NPHS.

A final point to consider is that the results of this study are the consequence of methodological artefacts. Frequently discussed in this domain are the issues of reporting and measurement. Differences in reporting have often been thought to affect social gradients in health. Notably, men [40, 45] and lower socioeconomic groups [78] may have a higher threshold for reporting illness than women and higher socioeconomic groups.. The gender differences in health observed in this study may actually be smaller if women more readily reported poor health than men and the socioeconomic gradients in health may be underestimated if those with lower SEP were less inclined to report poor health. Furthermore, the interaction between gender and SEP would also be impacted if such biases were present. For example, if men on average had lower SEP than women in the NPHS (which was not actually the case), their gradients may have been doubly affected by their reluctance to report poor health, thus preventing an observed gender difference in socioeconomic inequality. Reporting bias is an inherent problem to survey research, thus Statistics Canada has used the best available measures to help minimize differential reporting in the NPHS [82]. Moreover, recent research has claimed that the threat of reporting bias is smaller than originally thought [40, 45, 78].

Gender differences in socioeconomic gradients may also be the result of choices in measures of SEP, for which education and income are preferable,

and/or health outcome [10, 12], given that the distribution structure of illnesses varies between men and women [26]. However, despite using three measures of SEP and four measures of health, men did not exhibit steeper gradients. Moreover, finer categorizations of SEP were robust to the findings and displayed similar results.

3. Implications of the Study

The results of this study do not preclude the possibility of gender differences in socioeconomic inequalities in Canada. Given the boundaries of observational research and the measurement of health and SEP in the NPHS, it is possible that gender differences in socioeconomic gradients have gone undetected. However, given that the non-significant relationships found between gender and changes in SEP were robust to three different types of models using a large sample over a 10-year period, it is unlikely that Canadian men and women experience socioeconomic mobility differently. This is an important finding to direct and inform population health efforts that aim to reduce social inequalities in the Canadian population. Interventions designed to improve SEP, and subsequently health, need not be gender-specific in order to be effectual in the working-aged population of Canada.

One possible explanation for the lack of gradient differences is that this study reflects a context-specific situation, whereby SEP affects middle-aged Canadians similarly in 1994-2003 because of some unmeasured cohort effects. These individuals were born from 1939 to 1959: Canadian women of this age

group have attained similar education levels to men and are well-represented in the paid workforce [32]. In contrast, a study that observed steeper socioeconomic gradients for men noted that British women in the 1990s were often financially dependent on their male counterparts, 25-64% were housewives, and among those women who were employed, nearly half worked part-time [48]. Thus, it is possible that whereas SEP may not have as much of an impact on the health of British women, because of their relatively low participation in the workforce, SEP may in fact have a similar meaning to the health of middle-aged Canadian women and men given their more similar involvement in the paid labour market.

Our study however, was not designed to answer this specific question: first, because our employment variable contrasted employed individuals (full or part-time) with those who were either out of work, retired or disabled, and second because it dealt only with the Canadian context. Future Canadian studies on this topic should use finer-grained categorizations of labour force participation, as our dichotomy may have obscured gender differences in full-time versus part-time work, as well as retirement (after ten years of follow-up, the oldest members would have been 60-64 years old), because women are more likely to engage in part-time work [22] and take early retirement [86]. However, the true test of these effects is likely to only come from cross-national studies, which should examine whether differential (or similar) involvement in the paid labour market along those heterogeneous statuses may be at the root of these international inconsistencies in gender differences in socioeconomic inequalities in health. At

the very least, the results of our study emphasize the importance of re-examining over-generalized patterns in different historical and national contexts.

The lack of gradient differences between men and women in the NPHS may also be a consequence of the nature of the research questions examined. Previously observed cross-sectional gender differences in socioeconomic inequalities may reflect baseline differences between men and women that may or may not persist over time. In contrast, the relationship of interest in longitudinal studies is the health impact of change in SEP over time. Hence, it is possible that men and women indeed have different socioeconomic gradients at any given point in time (with men more often exhibiting stronger inequalities), although a change in SEP may not affect the health of men and women differentially. Cross-sectional and longitudinal research address very different questions and both types of analyses contribute to our understanding of the embodiment of SEP.

4. Strengths and Limitations

The major strengths of this research lie in the design of the survey and the methods of analysis employed. With respect to design, the NPHS is longitudinal, has a large sample size, is nationally representative, and makes use of extensively validated instruments for data collection. The statistical modeling techniques included weighting of the data to represent the 1994 Canadian population, robust standard error correction, and contrasting residual versus fitted plots to determine and test different model specifications (distribution, link function, correlation structure). In addition, the observation that the chosen longitudinal model, GEE,

yielded similar results to other available models (i.e. fixed effects and random effects) lends support to the strength of the relationships found.

This study, however, is not without its limitations and potential biases. These are observational data spanning only ten years of follow-up. However, the inclusion of multiple time-dependent controls, in addition to using longitudinal models that account for within-individual heterogeneity, was an effort to reduce the likelihood of confounding, which is a common problem in observational studies. Another point of consideration is the appropriate time lag between SEP and health. From a life course perspective, early life exposures act in concert with changing adult conditions to produce health and illness, particularly for chronic conditions that have long latency periods [67]. Given that GEE models account for time-invariant within-individual factors, they take into consideration some aspects of SEP throughout the life course that do not change (e.g. parental SEP during childhood, SEP during young adulthood) and may thus capture some latent effects of SEP on health. However, the appropriate time lag between adult SEP and the development or incidence of a given health outcome was not addressed.

A further limitation imposed by not lagging the data is the possibility of reverse causation, also known as health selection. As discussed in Chapter 2, there is concern that individuals with poor health, particularly during childhood, may be selected into low SEP groups, rather than SEP exerting effects on health [62]. When SEP and health are assessed concomitantly it is difficult to know whether low SEP preceded poor health, or whether the reverse is true. However, several major studies on socioeconomic inequalities in health have shown that

social inequalities in health are primarily due to the effects of SEP on health, and not to health selection [50, 63, 64]. Furthermore, as discussed in the previous paragraph, inherent in these longitudinal models is that they control for time-invariant factors, of which childhood health is an example. This analysis examines the health effects of changes of SEP, net of the early life factors that may have contributed to individuals' baseline SEP. Contemporary changes in health, however, may have had some influence on changes in SEP, but this hypothesis was not tested in this study.

As in any large-scale longitudinal survey, non-response and sample attrition may lead to selection bias if those who do not respond or who drop out of the survey are not representative of the target population. Multi-stage stratified probability sampling of participants and the use of cyclically adjusted sampling weights were an attempt to best reflect the 1994 Canadian population and remove the threat of selection bias. Finally, information or misclassification bias could be problematic, as the data are self-reported. It is possible that individuals may report their health status differently, because of their SEP or gender. As discussed above, there is evidence to contest that this is an issue in developed countries [40, 45, 78] and the NPHS has taken measures to help reduce misclassification of responses [82]. If present, it is difficult to know whether, confounding, selection bias, and/or misclassification would lead to an attenuation or an increase in the observed effect size [77].

5. Conclusions and Future Research

Although gender and changes in SEP both independently impact the health of middle-aged men and women in the NPHS over time, there is no evidence to suggest that men embody changes in SEP to a greater extent than women. As the assumed "general pattern" of men's steeper socioeconomic gradients is absent in this study and inconsistent in other longitudinal studies, the need for more longitudinal research in other settings using similar datasets and modeling techniques may be worthwhile. In addition, biological sex categories are a proxy for gender, and thus the lived experiences of men and women. Analyzing socioeconomic inequalities in health by those experiences, such as specific roles, attitudes or opportunities (which may be typified by sex, but are not restricted to either males or females) may elucidate what exactly about being a man or woman may result in differential or similar socioeconomic gradients. Policies aimed at reducing social inequalities in health in Canada should give equal attention to preventing income loss, promoting further education, and reducing unemployment for women and men.

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Appendix A: Measurement of Covariates

Social Structure		
Age	Continuous	Age on the day of interview in 1994
Marital/ partner status	Binary	0 = married, common-low, living with a partner, 1 = single (never-married), widowed, separated, divorced
Household size	Continuous	Number of individuals living in the household
Social Support	Ordinal 0-4	Cycles 1& 2, social support was measured by the perceived social support index which is composed of four items on whether respondents feel that they have someone they can confide in, someone they can count on, someone who can give them advice and someone who makes them feel loved. In cycles 3-5, social support was measured by four separate indices, corresponding to each of the four items that the perceived social support index measured. These indices were summed and quartiles were calculated to be able use the same 0-4 scoring method as the perceived social support index in cycles 1&2.
Health-related Behaviours		
Physical activity	Ordinal 1-3	Active (amount of exercise required for cardiovascular benefit), moderate (some health benefits, but no cardiovascular benefit), and inactive categories were derived from a continuous variable that calculated the energy expenditure (frequency, duration, MET value) for a range of leisure activities.
Body mass index	Ordinal 1-4	BMI is weight in kg/(height in m)2. Individuals were classified as 1 = underweight (BMI <18.5), 2 = normal (>18.5 and <25.0), 3 = overweight (>25.0 and <30.0), and 4 = obese (>30.0).
Smoking (Pack-years)	Continuous	Pack-years (number of packs smoked per year x the number of years smoked) were computed from multiple variables in the dataset, including data for current, former, occasional, and never smokers
Smoking (Never smoked)	Binary	As the pack-years variable was very skewed towards 0, an additional control was created to account for those that never smoked. 1= never smoked 0 = smoker in any capacity
Psychosocial Factors		
Chronic stress	Ordinal 0-16	This index measures the total number of stressors respondents were exposed to. The range of the final score (as well as the number of questions) varies as a function of the respondents' personal situation. For example, for partnered persons, questions about relationship with partner are included. For persons not partnered, the index contains a question on the difficulty of finding someone compatible. For persons who have children, questions about children become part of the index.
Mastery	Ordinal 0-35	This index measures the extent to which individuals believe that their life-chances are under their control. There are 7 items in the index and responses are on a 5-point scale

Appendix B - Statistical Models Supplement

Generalized Estimating Equations

Generalized estimating equations (GEE) models, also known as population-averaged (PA) models, are used with longitudinal panel data to control for the correlation of responses within groups over time. These models produce the average response for observations that share the same covariates as a function of the covariates. The interpretation is very similar to OLS estimates, for every one-unit increase in a covariate (e.g. changing from low income to high income) across the population, GEE tells the user how much the average response would change. The model does not distinguish between time periods; rather it averages the effect of a one unit increase between any two time points in the data and produces an estimate for the average change in the response variable. GEE fits the generalized linear form of y_{it} with covariates x_{it}, where i denotes group and t time:

$$g\{E(y_{it})\} = \beta x_{it} \text{ where } y \sim F \text{ with parameters } \theta_{it} \quad \textbf{(1)}$$

In equation 1, $g\{\ \}$ is called the link function. The link function is the transformation on the dependent variable that the user specifies. If no transformation is necessary to normalize the dependent variable, the 'identity' link is specified. Alternate link functions include the log function, power function, logit function and others. F is the distributional family, again specified by the user. If the data are normal, a Gaussian distribution is specified. The link function and distributional family must make sense, for example a logit link

function cannot be combined with a Gaussian distribution, rather must be used with a binomial distribution. The default GEE model, which is the primary model used for the analysis in the thesis, uses the identity link function and a Gaussian distribution, as seen in equation **(2)**. As discussed in the manuscript, sensitivity analyses using alternate specifications (i.e. link functions and distributions) yielded similar results.

$$E(y_{it}) = \beta x_{it} \quad \text{where } y \sim N \tag{2}$$

In addition to the link function and distributional family, the user must also specify the anticipated *within-group* correlation structure. GEE models are generally robust to misspecification, but the appropriate specification may produce more efficient estimates. For data that are correlated within a group over time, an autoregressive correlation structure is specified to set the within-group correlations as an exponential function of a lag period determined by the user. An exchangeable correlation structure is set when the user anticipates that the within-group observations are equally correlated. Finally, an unstructured correlation matrix may be specified to permit the free estimation of all possible correlations between within-group responses. In the thesis analyses the exchangeable correlation structure (default) was used, but again sensitivity analyses revealed no major differences when alternate correlation structures were specified.

The Relationship between GEE, Fixed Effects and Random Effects

As described in the manuscript, estimates produced by GEE, random effects, and fixed effects were found to be largely similar and did not change the

overall interpretation of the results. The similarities and differences of these models are described here. Estimates from GEE and random effects utilize information from *within-unit (group or individual)* similarities, in addition to *between-unit* differences, whereas fixed effects uses only the *within* information. Expanding the general linear model in **(2)** yields **(3)**:

$$E(y_{it}) = \alpha + \beta_1 x_{it} + \beta_2 x_i + \nu_i + \varepsilon_{it} \quad \textbf{(3)}$$

The intercept is denoted by α. $\beta_1 x_{it}$ corresponds to measured factors that vary across time and units, for instance, income. Factors that vary between units, but are constant through time within a group are denoted $\beta_2 x_i$, for which race and gender are examples. The other key feature to notice is that the residual has been decomposed into two parts. The unobserved factors that are constant through time (e.g. genetic profile) are represented by ν_i ; these residuals may differ between units, but are fixed within a given unit. The random idiosyncratic error, with its usual properties (mean 0, uncorrelated with itself, uncorrelated with x, uncorrelated with ν, and homoskedastic), is denoted by ε_{it}. Taking the average of **(3)** for each unit yields **(4)**:

$$\bar{y}_i = \alpha + \beta_1 \bar{x}_i + \beta_2 x_i + \nu_i + \bar{\varepsilon}_i \quad \textbf{(4)}$$

This is the *between* estimator. Note that the time-invariant effects ($\beta_2 x_i$ and ν_i) remain unchanged from **(3)**. As these effects are considered fixed over time, they are constant within a unit (and the average of a constant is that constant itself). Finally, the *within* estimator is obtained by subtracting **(4)** from **(3)**. Any time-invariant effects are cancelled out, as shown in **(5)**:

$$(y_{it} - \bar{y}_i) = \beta_1(x_{it} - \bar{x}_i) + (\varepsilon_{it} - \bar{\varepsilon}_i) \quad \textbf{(5)}$$

Equation **(5)** is now free of both the measured ($\beta_2 x_i$) and unmeasured (v_i) time-invariant effects. Fixed-effects regression amounts to performing OLS on **(5)**. These methods can estimate the effects of SEP on health net of *unmeasured* factors that affect an individual's propensity for ill-health, such as genetic composition, early life experiences, and parental SEP.

The random-effects estimator is a (matrix) weighted average of the estimates produced by the *between* **(4)** and the *within* **(5)** estimators. When the identity link function, Gaussian distribution and exchangeable correlation structure are specified in GEE, the estimator is identical to the random effects estimator (upon which OLS is performed), where θ is a function of σ_v^2 and σ_ε^2:

$$(y_{it} - \overline{\theta y}_i) = (1-\theta)\alpha + (x_{it} - \theta\bar{x}_i)\beta + \{(1-\theta)v_i + (\varepsilon_{it} - \theta\bar{\varepsilon}_i)\} \quad \textbf{(6)}$$

The advantage to using random effects or GEE is that the estimates are more efficient, as they include the additional *between* information. However, random effects estimation has the limitation that it assumes that the covariates, x_i, are uncorrelated with the unobserved time-invariant characteristics, v_i. A further distinction is that both random effects and fixed effects models provide interpretation at the individual level, whereas GEE is interpreted as the average change across the population. Given the nature of the research question, the GEE models were deemed theoretically more appropriate and statistically, they were the most efficient.