AILING INEQUALITY: THE IMPACT OF ECONOMIC INEQUALITY ON HEALTH IN CANADIAN CITIES 2001 - 2011

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ABSTRACT

Background: Previous research investigating the relationship between economic inequality and health finds mixed results, both within Canada and other nations. This may be because the effect is mixed in more equal countries, such as Canada; that most Canadian empirical studies do not use multilevel modeling to separate area and individual effects; and that the association is often only tested at one point in time. This thesis tests the hypothesis that there is an inverse relationship between economic inequality and health using two representative datasets and a multilevel modeling approach at three time points.

Methods: Data from the Canadian Census/National Household Survey and the Canadian Community Health Survey (CCHS) were merged so that more than 125,000 CCHS respondents were nested in 130 cities for census years 2001, 2006, and 2011. The association between economic inequality and self-rated health (SRH) was tested using multilevel logistic regression, adjusted for individual-level and city-level covariates. Economic inequality was calculated using the Gini coefficient of weighted census respondents aged 25-64, with over $1,000 in annual employment income. Other measures of inequality were also considered (Theil Index, 90/10 percentile ratio), along with provincial fixed effects to examine the robustness of the results.

Results: A one unit increase in the Gini coefficient was associated with an increased likelihood of poorer SRH (OR: 1.02; 95% CI 1.00–1.04) in 2001 and 2011, but not in 2006. Compared to those living in cities with lower levels of inequality, respondents living in cities characterized by higher levels of inequality had modestly higher odds of rating their health poorer, except in 2006. Further analysis show that the association between economic inequality and SRH is fairly robust to the choice of inequality metric and but sensitive to the consideration of provincial/territorial effects.

Conclusion: We find that there is variation in economic inequality between cities, but that this variation is not systematically associated with variation in SRH. Higher economic inequality is moderately associated with poorer SRH in Canadian cities in 2001 and 2011, but not in 2006 or when including provincial/territorial effects. Further research should investigate provincial/territorial effects and the differing results for 2006.

RÉSUMÉ

Contexte : Les recherches antérieures examinant la relation entre l'inégalité économique et la santé démontrent des résultats mitigés, tant au Canada qu'à l'étranger. Cela vient peut-être fait que l'effet est mixte dans les pays plus égaux, tels que le Canada; que la plupart des études canadiennes n'utilisent pas la modélisation multiniveau pour séparer les effets de groupe (c'est-à-dire des collectivités) et individuels; et qu'ils sont limités à un point dans le temps. Cette thèse teste l'hypothèse qu'il y a une relation inverse entre l'inégalité économique et la santé en utilisant deux ensembles de données représentatifs de la population canadienne, ainsi qu'une approche de modélisation à plusieurs niveaux, à trois différents moments dans le temps.

Méthodes : Les données du Recensement de la population et l'Enquête sur la santé dans les collectivités canadiennes (ESCC) ont été jumelées afin d'imbriquer les répondants de l'ESCC dans 130 villes entre 2001 et 2011. L'association entre la santé autoévaluée et l'inégalité économique a estimée à l'aide de modèles de régression logistique multiniveau, ajustés pour les caractéristiques individuelles et des villes. L'inégalité économique à été calculé à l'aide du coefficient de Gini mesuré pour les répondants âgés de 25 à 64 ans ayant un revenu annuel d'emploi de plus de 1000$. L'utilisation d'autre mesures d'inégalité, telles que l'indice de Theil, le ratio percentile 90/10, le coefficient de Gini calculé sur le revenu total, couplé avec des effets fixes provinciaux, a permis d'assurer la robustesse des analyses et d'assurer une bonne comparabilité avec d'autres études.

Résultats : L'augmentation du coefficient de Gini d'une unité est associée à une probabilité plus élevé de se percevoir en mauvaise santé (OR: 1,02; IC à 95% de 1,00 à 1,04) en 2001 et 2011, mais pas en 2006. Comparé à ceux vivant dans des villes où le niveau d'inégalité est moins élevé, les répondants vivant dans des villes caractérisées par des niveaux d'inégalité plus élevés avaient une probabilité légèrement plus élevée d'évaluer leur santé comme étant mauvaise. Des analyses ancillaires démontrent que le l'association entre l'inégalité économique et la santé autoévaluée ne varie pas selon l'indice d'inégalité utilisé ainsi que lorsque les effets provinciaux / territoriaux sont considérés.

Conclusion : Il existe une variation de l'inégalité économique entre les différentes villes canadiennes, mais que cette variation n'est pas systématiquement associée à la variation d'une mesure générale de santé, soit la santé autoévaluée. L'inégalité économique est modérément associée à une perception de santé mauvaise en 2001 et 2011, mais pas en 2006, ni lorsqu'on considère les effets provinciaux / territoriaux. De plus amples études sont requises afin d'examiner les effets provinciaux / territoriaux et explorer plus en détail les différences présentes en 2006.

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CHAPTER 1
INTRODUCTION

The growing gap between the rich and the poor is a defining challenge of our time (The World Economic Forum, 2016). Since the 1980s, economic inequality has increased in more than three quarters of the Organization of Economic Cooperation and Development (OECD) countries (OECD, 2011), reaching its peak in 2014 (OECD, 2016). Among these countries, the U.S. has seen a particularly sharp rise in inequality. Alvaredo et al. (2018) find that in the U.S., the income share of the top 1% doubled from 10% to 20% between 1980 and 2016 while that of the bottom 50% decreased from over 20% in 1980 to less than 15% in 2016. In other words, of all income earned in the U.S. in 2016, 20% goes to only 1% of the population and less than 15% goes to half of the population.

While perhaps not as acute, the increase in inequality in Canada is also worrisome, especially as the country's top 1% - like in the U.S. – are also increasingly wealthier than the majority of Canadians. Evidence of this trend can be seen in Figure 1, which provides a long term perspective of inequality in Canada (Veall, 2012). Historically, the top 1%'s share of income was highest in the gilded ages up to the 1920s-30s, before WWII ushered in a period of "great compression", or relative equality where levels of inequality in Canada were low and mainly stable throughout the 1950s to 1970s. However, by the 1980s, inequality began to rise again such that over the last 40 years inequality has reached levels not seen since before the 1940s. The pace at which inequality has increased over the last few decades is a particular cause for concern. Compared to other OECD countries, Canada has experienced the second highest growth in inequality between 1995 and 2014. During this time period, the Gini coefficient grew by 11%, more than five times greater than the 2% average growth of all other OECD countries. This meant Canada ranked 12th in terms of highest levels of inequality among the 35 OECD member countries in 2014 (OECD, 2014, 2016). Much of this steep increase in inequality is attributable to the surge in incomes of the super-rich (defined as the top 0.1%). In 1991, this exclusive group earned about 15 times the Canadian median income; by 2006, this differential had increased to over 25 times more than the Canadian median (Breau, 2014).

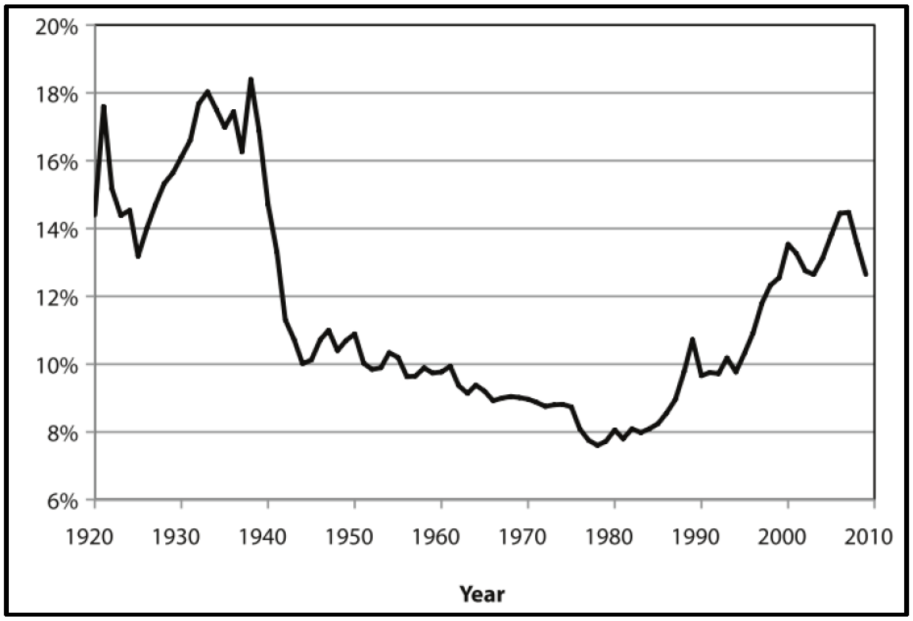

Figure 1: Percentage of Income Going to the Top 1% of Earners in Canada, Reprinted from Veall (2012)

From a geographical perspective, this rapid increase in inequality has in large part been concentrated in Canada's metropolitan areas. Between 1996 and 2006, city-level economic inequality rose by 9.1% compared to a much more modest 2.1% increase in rural areas (Breau, 2015). Moreover, by 2006, Canada's three largest cities had an average Gini coefficient of 45.4 (Bolton & Breau, 2012) which is much closer in value to highly unequal U.S. cities such as Boston (Gini: 48.4) than relatively more equal cities such as Oslo (Gini: 31.4) (Statistics Norway, 2008; United States Census Bureau, 2015).

Scholars are increasingly concerned about the potential negative consequences of a more unequal distribution of incomes. There is now a large body of literature linking growing or high levels of economic inequality to negative outcomes such as health, crime and other social and environmental indicators (Cavanaugh & Breau, 2017). In a now classis book, Wilkinson and Pickett (2009) fervently argued that reducing economic inequality should be the new focus of population health policy. As we will see later on in this thesis, this argument represented a momentous shift from earlier discourses simply linking economic development to improved health.

The history of the debate comes from these early economic development arguments examining World Bank data in the 1930s and 1960s, where national indicators of health tended to increase along with a country's level of economic development as measured by per capita gross national product (GNP). This relationship appeared to hold until a country's income reached a certain point, beyond which the relationship seemed somewhat random (Wilkinson & Pickett, 2009). This is what led Preston (1975) to propose that population health (often proxied by life expectancy) was perhaps not determined by increasing per capita GNP in high income nations but rather by the distribution of income within countries themselves. Twenty years later Wilkinson (1992) expanded on the ideas of Preston (1975), focusing on the strong correlation between economic inequality and health in advanced western nations that had little improvements in life expectancy as national income increased. This is shown in Figure 2, where economic inequality, measured as the percent of national income going to the bottom 70 percent of income earners, explains about two thirds of the variation in life expectancy at the national level for relatively high income nations (Wilkinson, 1992).

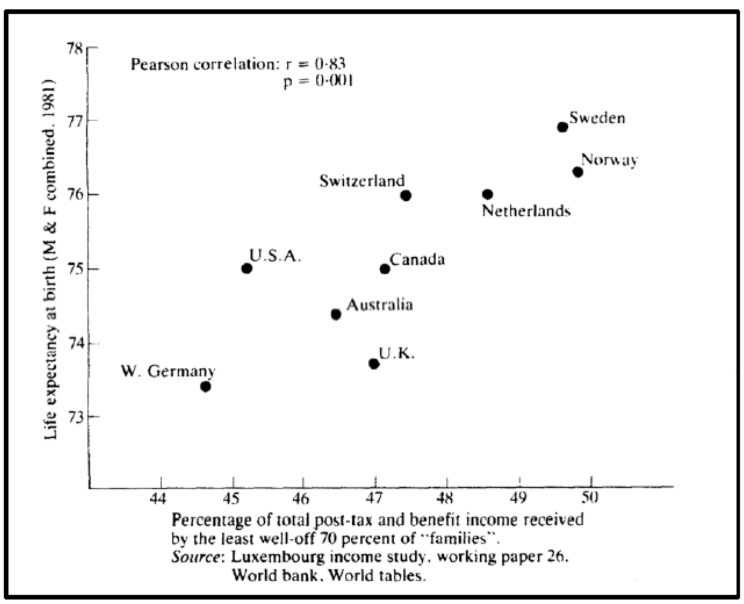

Figure 2: Economic Inequality and Life Expectancy: OECD Countries, Reprinted from Wilkinson (1986)

Such findings therefore "suggest that health in the developed world may now be less a matter of people's absolute material circumstances, than of how their circumstances compare with those of other members of society" (Wilkinson, 1992 p. 1083). As we will see later on in this thesis, the seminal work of Preston (1975) and Wilkinson (1992) provide a foundation for a multitude of theories linking economic inequality and health.

The problem, however, is that from an empirical point of view, results from studies using national datasets do not always line-up neatly, and sometimes contradict the theoretical predictions of Preston (1975) and Wilkinson (1992) due to methodological differences. These inconsistencies are captured by recent meta-analyses that summarize empirical results showing different conclusions of the impact of economic inequality on population health. For instance, the meta-analysis by Kondo et al. (2009), which covers nine cohort studies and 19 cross-sectional studies, suggests that there is a "modest adverse effect of income inequality on health" (p. 1) when the health indicators considered are mortality and SRH. In contrast, the more recent meta-analysis conducted by Ngamaba et al. (2018), which covers a total of 24 different studies than Kondo et al. (2009), concludes that "…the findings of this review do not support a link between income inequality and subjective well-being in general" (p. 592). Part of the challenge here in terms of the lack of consensus in cross-sectional studies lies with problems related to data comparability and measurement issues across national borders. Within-country empirical studies therefore offer fertile ground to advance the debate of whether or not economic inequality has an independent impact on population health.

It is within this context that Canada provides a study region to explore the effect of economic inequality on population health. Indeed, only a handful of inequality-health studies have been conducted in Canada, even though we saw earlier that inequality – especially in cities – has increased to historically high levels. Of these studies, McLeod et al. (2003) and Ross et al. (2000) find no significant association between city-level economic inequality and SRH or mortality . On the other hand, Xi et al. (2005) and Auger et al. (2012) find that living in highly unequal cities is associated with poorer SRH and higher all-cause mortality[1]. These mixed findings most likely result from an array of methodological limitations, including study design,

[1] Auger et al. (2012) only find a statistically significant coefficient for non-immigrant Canadians. More information on this is presented in Chapter 2.

the choice of economic inequality and health metrics, and differences between studies in the scale chosen to measure inequality.

Using Canada as a study region, this thesis seeks to build on previous knowledge and address some of the methodological limitations from earlier research to clarify the relationship between economic inequality and health. Specifically, three questions will guide the research process: *Is economic inequality associated with a general measure of health in Canadian cities? Does this relationship hold when controlling for individual or city socio-economic variables and/or provincial fixed-effects? How does this relationship change over the 2001 to 2011 period?*

To answer these questions, I develop a dataset merging the census and Canadian Community Health Survey (CCHS) for the years 2001, 2006, and 2011 (these are the latest available datasets at the time of writing). Using multilevel logistic regression models, I find that living in cities with higher levels of economic inequality show a modest association with poorer SRH after controlling for individual and city-level socio-economic variables, though inconsistently between years. These results add to the existing body of work on the relationship between economic inequality and health by providing new evidence from Canada and also contributing to the broader debates on how ubiquitous the relationship is globally versus how particular the relationship is to certain contexts.

The remainder of this thesis is organized as follows. Chapter 2 provides an overview of the relevant literature to this research, followed by a detailed description of the research data and methods in Chapter 3. Chapter 4 presents descriptive results, which outline changes in economic inequality at the city-level, the geographical patterning of economic inequality across Canada, and variation in city-level SRH. Chapter 5 presents analytical models for 2001, 2006, and 2011, as well as robustness checks to alternative categorizations of income and economic inequality measures, and three level models to ensure results are robust to provincial variation. Finally, Chapter 6 compares the results to existing research (as presented in the literature review). Chapter 7 concludes by outlining the strengths and limitations of the work, proposes policy options, and suggests areas for future research.

CHAPTER 2
LITERATURE REVIEW

This chapter begins by reviewing the literature that led scholars to question how economic inequality may be linked to or impact people's health. Starting with foundational theory on how individual incomes are tied to health, I proceed with introducing the reasons why a more unequal income distribution, or economic inequality, could impact health. Once the theoretical foundation of the inequality-health link is established, I turn my attention to reviewing the empirical literature on the subject. We will see that while this literature has expanded rapidly over the last two decades, the evidence does not point to a clear consensus that economic inequality does, in fact, negatively impact health. Such a finding also appears to be related to the use of various methodological approaches and inconsistencies across studies. In particular, I identify four key methodological concerns and elaborate on how this thesis proposes to address some of the concerns. In sum, the aim of this literature review is to illustrate the foundation of the hypothesis, provide an overview of previous studies and their limitations, and to frame the research design of this study in order to improve on previous research findings and contribute to the on-going debate.

2.1. Establishing the Link between Economic Inequality and Population Health

Income is one of the primary factors associated with health outcomes, as scholars generally find that health improves when people earn more (Mikkonen & Raphael, 2010). This relationship can be attributed to many individual-level risk factors, e.g. smoking – observed to be higher in low-income individuals (see Link & Phelan, 1995). But income is also seen as a fundamental cause of health as it alters access to resources and may affect the performance of interventions aimed at improving health (Link & Phelan, 1995; Phelan et al., 2010). In this way, it is proposed that "the enduring association [between income and health] results because [socio-economic status (SES)] embodies an array of resources, such as money, knowledge, prestige, power, and beneficial social connections that protect health no matter what mechanisms are relevant at any given time" (Phelan et al., 2010, p. 28). A recent example of this is found in Bor et al. (2017) who show that life expectancy has not changed for poor Americans as it has for middle and high income earners who gained approximately two years in additional life expectancy between 1980 and 2015.

The relationship between income and health can be depicted as in Figure 3 which shows that increases in income provide diminishing returns to health. In other words, as a person's income increases, their health improves but it does so at a decreasing rate (as illustrated by the concave curve).

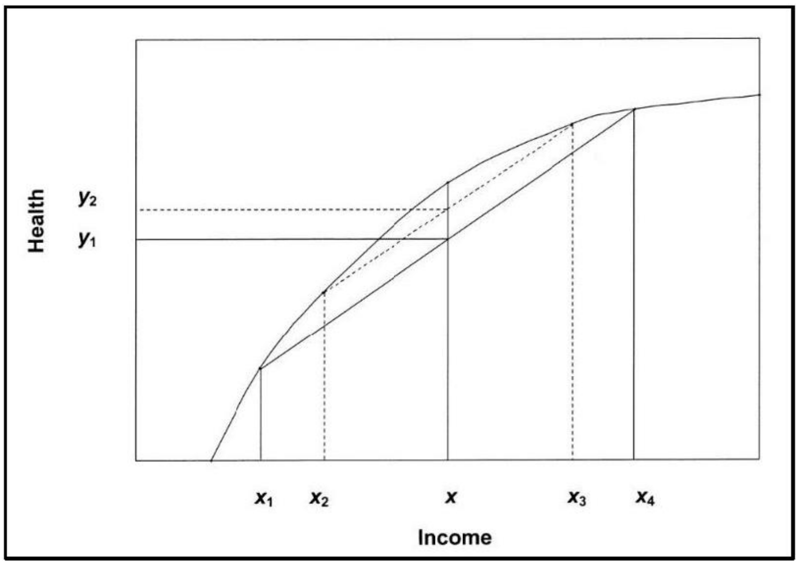

Figure 3: Relation Between Individual Income and Health, Reprinted from Subramanian & Kawachi (2004)

Based on this non-linear relationship, population health improvements are higher when low income earners have an increase in income, moving from x_1 to x_2, for instance, than when high income earners have an increase in income (see movements from x_3 to x_4). Some scholars have argued that this individual concave relationship is the same at the national-level as proxied by aggregate measures of GNP per capita and life expectancy (Preston, 1975; Subramanian & Kawachi, 2004). In fact, when Preston (1975) initially investigated this relationship using national data for a select group of countries, he found evidence of a concave relationship between national per capita income and life expectancy at birth in the 1930s and 1960s (see Figure 4).

Having identified this pattern, Preston (1975) also set-off to investigate if the relationship between average income and average health was causal. Could an increase in average income really cause the differences observed in life expectancy seen in Figure 4? Visually, one could see that countries with higher GNP per capita in both time periods indeed had higher life expectancy, but there were slight changes in the shape of the curve overtime. Once a country reached about $400 USD per capita (in 1963 U.S. dollars), there were essentially no health gains in terms of life expectancy (only marginally more in the 1930s compared to the 1960s).

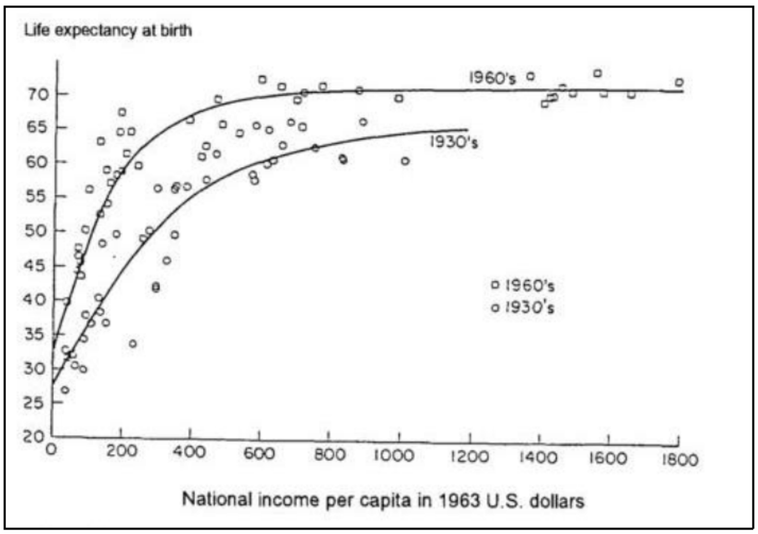

Figure 4: National Life Expectancy and GNP per Capita, Reprinted from Preston (1975)

Overall, the change in national income accounted for about 10-25% of the cross-country variation in life expectancy between 1930 and 1960 (Preston, 1975). Preston (1975) argued that the health improvements came from the shift of the curve upward overtime, and were most likely caused by factors exogenous to economic development. He suggested that health improvements could instead be linked to specific campaigns against diseases (e.g., malaria, the introduction of new public health measures, and health-related technological improvements of various kinds).

Using more recent data, Wilkinson (1992) came to a similar conclusion. By calculating the correlation coefficients between GNP per capita and national life expectancy in a sample of developed OECD countries, he found a correlation of 0.38 for 1970/71 ($p < 0.05$), but this correlation weakened to 0.07 (no significance) in 1986/87. By the 1980s, it became increasingly clear that increases in average income no longer explained average health as GNP per capita was not associated with life expectancy.

In his prescient analysis, Preston (1975) had already proposed that we consider economic inequality within nations as a potential determinant of aggregate health. To understand this link, let us return to the example provided in Figure 3. Here, a transfer of income from a person with an income at x_4 to a person with an income at x_1 changes the income of the individuals to x_3 and x_2. With this income transfer, the health of the high income earner decreases from income x_4 to income x_3, but the health of the low income earner increases substantially more, due to the shape of the concave curve. Given that the curve is steeper at the lower end of the income spectrum, the result of the transfer is an increase in the average health between the two people from y_1 to y_2, improving the overall average health, as gains by the low income earner are larger than the losses from the high income earner (Subramanian & Kawachi, 2004). Although this is only an example of aggregate health between two individuals:

> …researchers have posited that an aggregate relation between the average health status of society and the level of income inequality in a society could be observed if the individual-level relation between income and health (*within* society) is concave… because of the underlying functional form of the individual income-health relation (p.79).

This would expand the theory to relate to population health, where the transfer and movement to a more equal society would impact health. While Preston (1975) aimed to test this hypothesis, the paucity of available data on economic inequality at the time of his study limited his ability to do so.

A few years later, Rogers (1979) was able to piece together data from a larger sample of countries (n = 56). Estimating a set of cross-sectional models, he found that economic inequality was consistently related to a country's average health using multiple measures of economic inequality and different health outcomes. Likewise, with data from the newly assembled Luxembourg Income Study, Wilkinson (1992) found a strong correlation (r = 0.80) between economic inequality and national health. Moreover, he also found evidence of a strong relationship between the change in inequality and change in life expectancy (*r* = -0.73), with increases in the share of income going to the least well-off found to be associated with larger increases in life expectancy.

Beyond these correlations, Wilkinson (1992) argued that more equal countries had increases in life expectancy above what was predicted by the concave relationship shown in Figure 3. In other words, more equality seemed to have gains beyond just income redistribution increasing average health. To quote from Wilkinson (1992):

> … the apparent effect of income distribution on health is too large to be explained by changes in the mortality of a poor minority alone. If the United States or Britain [relatively unequal countries] were to adopt an income distribution more like that of Japan, Sweden, or Norway [relatively equal countries], the indications are that it might add 2 years to average life expectancy. That is considerably more than would be gained even if the health detriment suffered by disadvantaged minorities were wholly overcome. But there are signs that the *majority* of the population might benefit from a more egalitarian income distribution. (Emphasis added, p. 1083)

This was a fundamentally new idea to the literature. Wilkinson (1992) proposed a 'pollution effect', where the state of economic inequality in a place was detrimental to society, and the health of all individuals within it, rather than just a question of income redistribution to equalize health outcomes (Subramanian & Kawachi, 2004). Economic inequality needs to be recognized as a fundamental cause of health status, since "areas characterized by higher inequality also are less equitable in their support of education, affordable housing, good roads, and environmental protection [that]…influence health status" (Daly et al., 1998, p. 319).

In addition to reframing economic inequality as a societal effect, Wilkinson (1992) argued that economic inequality is a *stronger* predictor of population health than absolute national income. He believed that economic inequality was not just part of a mix of factors that predicted health, but a key determinant of population health – a claim that has since become highly debated among health researchers and policy makers.

In theory, this 'pollution' effect of economic inequality is thought to be linked to health through three main pathways: social cohesion, psychosocial, and neo-material hypotheses (Wilkinson & Pickett, 2017). Even as these pathways are still widely debated, there is some evidence giving indication of which hypotheses may be worth more exploration from empirical evidence (Hill & Jorgenson, 2018). Firstly, the *social cohesion* hypothesis posits that more unequal societies decrease community and social relationships, two factors associated with health outcomes. This hypothesis appears to be the most prominently researched pathway. Truesdale and Jencks (2016) describe it as "fray[ing] the social fabric, reducing both social capital and mutual trust"(p. 419). Kawachi et al. (1996) find that social capital declines with increasing economic inequality, and health declines with decreasing social capital. More recent studies completed by Elgar (2010) and Rothstein and Uslaner (2005) also find higher economic inequality to decrease trust, an indicator of social cohesion, when analyzing data from 33 countries and U.S. states. Layte (2012) tests the social capital hypothesis using European data on mental health. Between the three proposed pathways, Layte (2012) finds that the social cohesion hypothesis provides the strongest evidence, reducing the economic inequality coefficient by 55% when added to the model. This is the most widely considered pathway, which is also supported by empirical evidence.

The *psychosocial hypothesis* states that economic inequality increases social comparisons between individuals, which in turn increases stress and leads to poorer health (Bergh et al., 2016). Truesdale and Jencks (2016) describe it as "social comparison to higher-ranking friends and neighbors cause stress and ill-health among people who are poorer than their reference group" (p. 419). In their review of evidence, Wilkinson and Pickett (2017) find that health outcomes associated with economic inequality tend to be those that have negative social gradients, i.e. those that become more prevalent at lower incomes. This suggests that social positioning is important in the link between economic inequality and health. Authors find evidence to show that inequality is also tied to items of social status. Walasek and Brown (2016) find that status goods, such as Lamborghini cars or Prada bags, are more frequently searched on the internet in more unequal states in the U.S. Walasek and Brown (2016) use the number of searches for status goods as an indicator of the psychosocial pressure of individuals in societies that value their rank, concluding that this is an important pathway from inequality to health.

Lastly, the *neo-material hypothesis* states that economic inequality concentrates economic and political power, which in turn changes access and distribution of health and social goods (Hill & Jorgenson, 2018). Truesdale and Jencks (2016) describe it as "material resources at both the individual and community-level affect[ing] health. Larger inequality in material resources produces greater health disparities and … worsen average health" (p. 419). Higher inequality "creates political pressure to cut taxes, deregulate, and limit investments in public resources and social services that promote public health, including, for example, education, consumer protections, health care infrastructure, and environmental regulations" (Hill & Jorgenson, 2018, p. 2). Nonetheless, in the empirical work of Layte (2012) on the inequality and health pathways, there is no evidence that economic inequality in Europe modified state expenditure on health, education, social protection, or number of physicians, indicating that this may be a less fruitful pathway for future research. In their summary of the research on conceptual debates, Hill and Jorgenson (2016) conclude that "…empirical tests provide only modest support for these theories." (p. 428).

Section 2.1 outlined the origins of the hypothesis that economic inequality impacts health and theoretical reasons why (the three hypotheses). The work on economic inequality and health by Wilkinson (1992) was central in shifting the debate to include circumstances of unequal places impacting health through a 'pollution effect', which is the formation of the economic inequality and health hypothesis tested in this thesis. The following sections provide a more detailed review of the existing evidence from empirical studies testing the effects of economic inequality on health both from an international and Canadian perspectives. The focus is on studies using self-rated health (SRH) and mortality indicators since these are the most common health measures considered; other related measures are included in the review.

2.2. For and Against: The Empirical Evidence so Far

2.2.1. An Overview of the Debate from Recent Meta-Analyses

Wilkinson's claim that economic inequality is a stronger determinant of health than absolute income led to an explosion of empirical research throughout the health field. Kondo et al. (2009) summarize some of these findings in a meta-analysis of 28 studies that used SRH and mortality as outcome variables. As we will see, the methods of studies are important in determining an effect, and Kondo et al. (2009) only include a specific subset of studies that used more rigorous methods. To be included in their analysis, the studies had to “use multilevel data—at least two levels of analysis, with individuals nested in one or more higher geographical unit(s); address sample clustering caused by multilevel data structure; adjust for age, sex, and individual socioeconomic status; and be peer reviewed” (p. 2). Kondo et al. (2009) measured relative risk for mortality studies and overall odds ratios for studies using SRH, and used a random effects approach with restricted likelihood estimates to account for the heterogeneity between studies in making overall predictions on health outcomes.

Overall, Kondo et al. (2009) found that there was an effect of economic inequality on health, where the “overall cohort relative risk [of mortality] and cross sectional odds ratio [of poor SRH] (95% confidence intervals) per 0.05 unit increase in Gini coefficient … was 1.08 (1.06 to 1.10) and 1.04 (1.02 to 1.06), respectively” (p.1). As individual studies within their analysis found positive, negative, and mixed effects of economic inequality on health, they also sought to distinguish between studies that observed an effect and studies that did not. When only including studies with higher levels of inequality, with a Gini coefficient $\geq$ 30[2], there was a stronger association between economic inequality and health. This led them to hypothesize that places beyond a certain level of inequality showed a stronger significant effect which may explain some of the previous null findings reported in the literature. Their meta-analysis used a large sample size of about one million observations and found a consistent effect of higher economic inequality on mortality and SRH when parsing the data into different groupings (e.g. levels of inequality), and when including studies that differed from others included in the meta-analysis sample[3].

However, empirical results on the relationship between economic inequality and health are not always clear and sometimes contradict theory. Ngamaba et al. (2018) reached a

[2] The Gini Coefficient is a measure of economic inequality where “If incomes are distributed completely equally, the value of the Gini will be zero. If one person has all the income (complete inequality) the Gini will assume a value of 1.” (Kondo et al., 2009, p. 2). Further described in Chapter 3.
[3] Such as those that did not account for sample clustering, did not include area income and/or regional fixed effects (Kondo et al., 2009).

different conclusion than Kondo et al. (2009) in a similar study which included less restrictive criteria: peer-reviewed studies, use random effects, and report a correlation coefficient. Ngamaba et al. (2018) use about the same number of studies in their meta-analysis (n=24), but instead of reviewing studies using SRH and mortality, they reviewed studies measuring health as subjective well-being (SWB), measured in their study using life satisfaction and happiness (Ngamaba et al., 2018 do not state the questions used to collect this information). Although SWB and SRH are related, it should be noted that these two measures are different and these meta-analysis examples are given to show how scholars reach different conclusions on the 'pollution effect' of economic inequality on society (Siahpush et al., 2006).

Ngamaba et al. (2018) find that "the overall association between income inequality and SWB was almost zero and not statistically significant" (p. 577). They attribute their different results as a difference in the effects of a country's level of development. When countries have a GNP under $12,736 USD per capita (i.e. 'developing countries'), there appears to be a significant negative effect of higher economic inequality on SWB. That said, the opposite is true in 'developed countries', where there is a significant positive effect of higher economic inequality (Ngamaba et al. 2018). One possible reason that the results differ is that Ngamaba et al. (2018) included ecological studies in their meta-analysis, which, as described in the next section, is has limited ability to properly test the effect of income inequality on health. Although Kondo et al. (2009) show robust results using a larger sample and alternative measures of economic inequality, Ngamaba et al. (2018) provide comparable counter evidence.

The question to ask ourselves at this point is why empirical studies lead to such diverging sets of outcomes. The answer, as we will see, lies mainly in the methodological approaches adopted by scholars. In the next section, I present *four* of the most frequently mentioned methodological considerations behind the mixed empirical evidence that characterizes the literature.

2.2.2. Key Methodological Considerations

The meta-analyses by Kondo et al. (2009) and Ngamaba et al. (2018) point to differences in the level of economic development or inequality thresholds as possible explanations for the mixed results regarding the inequality-health relationship. In this section, I expand on four methodological considerations discussed by scholars in the economic inequality and health literature: differences in (A) research design, (B) the scale of economic inequality, (C) the use of different health and economic inequality measures, and (D) the country of study.

A) Research Design

Due to data availability, most early empirical studies were designed using ecological data or aggregated observations to test the impact of economic inequality on health. For reference, Appendix A is a table outlining details on studies by type of study design (ecological, review paper, or multilevel design) and includes information on each study's research location, health outcome, inequality metric(s), results, study years, sample size, and additional notes. Ecological studies using large national datasets and the best methods at the time reached a broader consensus, generally finding a significant relation between higher economic inequality and poorer health, even though results were still debated. On the one side, Wilkinson (1986), Le Grand (1987), Duleep (1995) found that inequality impacted life expectancy between countries and between U.S. states, where studies at the U.S. state level were consistent and robust (Daly, Wilson, & Vasdev, 2001; Kaplan et al., 1996; Kennedy, Kawachi, & Prothrow-stith, 1996; Wilkinson, Kawachi, & Kennedy, 1998). On the other side, Mellor and Milyo (2001), researching changes in inequality and health over a longer time period (1960 and 1990 for countries; 1950 and 1990 for U.S. states), did not find any impact of economic inequality on health as measured by life expectancy. They concluded that "in large part, our findings contradict earlier claims" (p. 487); Judge (1995) and Lynch et al. (2001) also found no significant effect or mixed effects of economic inequality on mortality and SRH.

Researchers critique ecological study designs for their inability to show the independent effect of economic inequality from individuals' economic circumstances (for example, Subramanian and Kawachi, 2004). This critique began shortly after Wilkinson (1992) proposed the 'pollution effect' hypothesis. His ecological association between economic inequality and aggregate health measures at the national-level was deemed insufficient in terms of disentangling the effects of individuals' income versus the distribution of income within a country on health (Subramanian & Kawachi, 2004). In a commentary, Subramanian and Kawachi (2004) described the need to decompose these effects to test if “the distribution of income in society, over and above individual incomes as well as societal average income, matters for population health such that individuals (regardless of their individual incomes) tend to have worse health in societies that are more unequal” (p. 80). These critiques of the ecological study design eventually led scholars to move to multilevel approaches.

Multilevel models account for the fact that individuals within the same place (e.g. cities) may be more similar than individuals within a different place (or city; known as clustering). When individuals are clustered their error terms are correlated, breaking an assumption of linear regression (Luke, 2004). The multilevel design, by adding the source of clustering as a second level in the model, accounts for the correlated error terms.

Multilevel models are able to account for clustering by appropriately attributing sources of variation in health to the correct level in the model (e.g. between individuals vs between cities). These models discern a variable’s independent and relative effect on health compared to other variables within the model (Subramanian & Kawachi, 2004). In this way, individual variables can be specified to account for individual variation (e.g. household income, age, and visible minority status), and area level variables can be specified to account for variation between places (e.g. median city incomes). This makes “a combined model … a “micro” model capturing the between-individual-within-society relation nested within a “macro” model specifying the between-society relation, where “society” is the unit at which inequality is measured (p. 81).

Single level models, such as the ecological models, only have one level of variation. Often this variation is between places and aggregated health variables, and therefore are unable to control for individual variables. This could mean that the relationships found in ecological models are showing effects of, for example, concentrated poverty in that area instead of an effect of economic inequality (further described in Chapter 3).

Multilevel studies still find both negative and positive associations between economic inequality and health. Although we know that multilevel data on the relationship between economic inequality and health show an overall effect such that economic inequality is associated with poorer health from the Kondo et al. (2009) study, it is difficult to discern when looking at single studies. For example, in Europe empirical evidence from multilevel studies does not clarify the relationship between inequality and health. Dahl et al. (2006) and Kravdal (2008) both analyze the impacts of economic inequality on mortality in Norwegian cities (although defined differently: Dahl et al., 2006 use Economic Regions which are groups of neighboring municipalities approximating cities, and Kravdal, 2006 use cities). Using data from 1994 to 1999, Dahl et al. (2006) find a higher mortality risk of 2.8% (95% CI 1.02 – 1.03) for each one unit increase in the Gini coefficient, whereas Kravdal (2008) only finds a negative effect on mortality for older men. Using Swedish data and measuring inequality at the city-level, Henriksson et al. (2006) find no relationship between higher inequality and higher risk of mortality but Rostila et al. (2012) find an impact of high (OR 1.30 95% CI 1.07 – 1.57) and very high (OR 1.29 95% CI 1.01 – 1.69) city-level inequality on poor SRH in Sweden. A study in Switzerland by Clough-Gorr et al. (2015) showed that higher economic inequality at the city-level is "consistently associated with lower mortality risk, except for death from external causes" (p. 627). Clough-Gorr et al. (2015) attribute this to city-level difference in Switzerland's tax structure and their very high life expectancy and income levels. This case also provides an interesting and contradictory set of results to previous evidence and clearly shows how the move to multilevel models, though important in moving forward the debate, has not clarified a general relationship between inequality and health.

Ecological studies researching how economic inequality impacts health were subject to many critiques that multilevel research now addresses. Although ecological studies found a fairly consistent impact of economic inequality on various health measures, there are methodological issues with the ability of the research design to test the hypothesis. Now most scholars use multilevel methods. Kondo et al. (2008) find an overall effect of economic inequality on health when performing a meta-analysis on multilevel studies, but this leads me to ask: why individual studies still show mixed results, and what are other methodological differences are causing different results?

B) Scale of Economic Inequality

The hypothesis that economic inequality impacts population health is fundamentally a geographic question. Economic inequalities exist between individuals in a certain place and between places, therefore, when testing the impact of economic inequality, the definition of the area within which to compare income distribution is important. Scholars compare individuals within many different places, such as within countries, within states, or within cities. It is important to justify the scale of analysis, as the impact and processes of economic inequality at the state-level is most likely different from the city-level, as further explained below.

Scholars have measured economic inequality at a variety of scales. For example in the U.S., studies have used the national, state, county, city, and 'community' as the level of analysis (Fiscella & Franks, 1999; Shi & Starfield, 2000; Lopez, 2004; Daly et al., 1998; Fiscella & Franks, 1997, respectively). Although each study uses a different scale, their conclusions aim to generalize the hypothesis across all places, and often do not discuss scale limitations. Dunn et al. (2007), on the other hand, argue against such generalizability and stress the importance of considering the peculiarity of the chosen scale. They state that "income inequality is a marker for some set of causal processes at a given scale and is therefore a marker for different causal processes at each geographic scale" (p. 12). For example, provincial-level economic inequality could affect how provinces manage health programs, whereas city-level inequality could be linked to levels of segregation between the rich and poor within cities. It may be fruitful for scholars to analyze the specifics of a scale where the relationship between economic inequality and health is present to help create effective policies to mitigate (or eliminate) these different causal processes. The argument here is not that scholars think one scale is better than the other, but that scale discussion, especially on the limitations of interpreting results at certain scales, is critical to moving the debate forward on the impact of economic inequality on health.

There is one exception to the lack of discussion on scale, which is the general agreement that scales have to be large enough to show economic and social differentiation (Ross et al., 2005). In particular, researching neighborhood-level inequality is criticized for being too small a unit of analysis to represent social and economic stratification from inequality (Wong et al., 2009; Dahl et al., 2006; Wilkinson & Pickett, 2006). For example, Wong et al. (2009) tested how the Gini coefficients of Hong Kong neighborhoods were associated with SRH and found no effect. Yet, Lau et al. (2012) find that higher neighborhood-level inequality significantly affects mortality rates in two time periods also using Hong Kong neighborhoods but with a much larger individual sample size (1976 and 2006). They find an increased incident rate ratio of mortality (IRR) of 1.09 (95% CI 1.02 – 1.16) due to increasing inequality between 1976 and 1986, and an increased IRR of 1.24 (95% CI 1.13 – 1.36) between 1991 and 2006. The differing results may be related to differences in sample size, as Wong et al. (2009) only used 25,000 individual observations and 287 neighborhoods to test the impact of neighborhood inequality on SRH, compared to over 190,000 individuals included by Lau et al. (2012).

In this thesis, I choose to investigate the city-level as scholars have theorized the importance of urban processes in peoples' health and wellbeing. Harvey (1985) sees the city as the center of complex interrelations where people learn their place in the social, economic, and political hierarchy. Harvey (1985) argues:

> ... The urban [is] the primary level at which individuals now experience, live out, and react to the totality of … the world around them... It is out of the complexities and perplexities of this experience that we build an elementary consciousness of the meaning of space and time; of social power and its legitimations; of forms of domination and social interaction; of the relations to nature through production and consumption; and of the human nature, civil society and political life. (p. 250-251)

Pushing the analysis further, Krieger (2001) includes the embodiment of our city environments into theories of health. She sees health as a part of an ecosystem, where "… we literally incorporate, biologically, the world around us …" (p. 668). This is important as peoples' living and working conditions in cities have become increasingly worse. Walks (2011) describes "gentrification of the inner city, a loss of affordable rental housing, declining relative incomes for recent immigrants, and the deterioration of public spaces and services" (p. 125) as some of the major on-going changes in Canadian cities.

While the city is clearly an important scale of analysis to better understand the relationship between inequality and health, the existing empirical evidence at this level again offers mixed results. In the U.S., Blakely et al. (2002) found no relationship between different levels of urban economic inequality and health, measured using SRH as the key dependent variable. Sturm and Gresenz (2002) reach the same conclusion using a continuous measure of inequality at the city-level data in the U.S. and SRH. In contrast, Lopez (2004) found that city-level inequality had only a modest effect on health in U.S. metropolitan areas, finding a 4% (95% CI 1.6 – 6.5) increased likelihood of poorer SRH per unit increase in inequality. Such a discrepancy in findings may be explained by the smaller sample size used by Sturm and Gresenz (2002, n = 9,585 individuals) or the time period covered by their analysis. While Blakely et al. (2002) had both very large individual (n =259,762) and city-level (n = 232) sample sizes, providing robust evidence that there is no significant impact on SRH, this study used data from the early 1990s, and economic inequality, especially in metropolitan areas, has increased substantially since then. Lopez (2004) uses data from 2000, thus providing a more recent example of city-level effects in the U.S.

In summary, scale is an important discussion that is often very briefly discussed in the literature relative to its importance. Although Dunn et al. (2007) published this critique in 2007, I see little advancement in scale justification and limits to generalizability. There are, as we have argued, compelling reasons to use the city-scale, and some evidence has suggested a relationship within the U.S. Despite this, evidence at the city scale is dated, not reflecting current relationships, and using small sample sizes. These are issues this thesis will seek to address.

C) Choice of Indicators

The choice of indicators of how to measure health and economic inequality can also impact research findings. In the literature, the trend has been for studies to use only one measure of health and one measure of economic inequality, although increasingly multiple measures are incorporated in the analysis to test the robustness of results to alternate measures (De Maio, 2007).

Among these, Fiscella and Franks (1999) find some effect of changing inequality on SRH but not mortality, reporting a significant relationship of increasing national-level inequality and poorer SRH from 1982 to 1987. Kennedy et al. (1998) and Lochner et al. (2001) indicate that there is a state-level effect using both a subjective and objective measure of health. Kennedy et al. (1998) find that state-level economic inequality, as measured by the Gini coefficient, predicts that residents in the most unequal states are 11% (95% CI 1.04 – 1.18) to 25% (95% CI 1.17 – 1.33) more likely to rate their health as fair or poor while Lochner et al. (2001) find the same when testing state-level inequality and mortality.

Using multiple measures of economic inequality is more common in the literature. Previously in 1997, Kawachi and Kennedy (1997) argued that the choice of inequality metric did not impact the results when investigating if economic inequality impacts health. After performing tests on cross-sectional ecological data using multiple measures of economic inequality, they conclude that "the choice of income distribution measure does not appear to alter the conclusion that income inequality is linked to higher mortality" (p. 1121). Although they find similar results between measures, there are in fact compelling reasons why different economic inequality measures should be used to understand the impact of economic inequality on health. For example, Daly et al. (1998) argued that

> … income inequality can increase in a number of ways and for a range of reasons, all of which could have unique effects on health and mortality … it is possible that increases in inequality resulting from improvements in the middle and upper portion of the income distribution may produce different health and mortality outcomes than those associated with a deterioration of living standards in the lower tail of the income distribution (p. 316-317)

Inequality metrics aim to appoint one number to represent a distribution of income in a place, each measure having its benefits and drawbacks (further described in Chapter 3). Therefore, different measures will be more or less sensitive to changes described by Daly et al. (1998). The effect of using different metrics is shown, where De Miao (2007) provided an updated review of studies finding the opposite of Kawachi and Kennedy (1997): results vary significantly depending on the economic inequality measure. They provide the example of Weich et al. (2002) who find that "regional income inequality, operationalized using the Gini coefficient, was significantly associated with poor health among respondents from low-income groups, but that this relationship was not significant for Generalized Entropy indicators which are more sensitive to inequalities at the top or bottom of the income spectrum" (De Miao, 2007, p. 849). Building on the arguments of Daly et al. (1998), De Miao (2007) concludes that "using a variety of measures enables more meaningful analysis… [as] a situation of large income differences within the bottom, middle, or top of the income distribution are different *kinds* of inequality" (p. 849). One economic inequality measure cannot summarize all of the nuance that comes in income distributions. Using multiple measures helps to understand how income concentration in different parts of the distribution impacts health. In order to increase the robustness of results, and to better understand the reasons why economic inequality impacts health and where to focus future research and policy, this thesis will investigate the relationship using multiple measures of inequality and one measure of health, self-rated health.

D) Country of Analysis

It is possible that the specific context of a country offers some explanation for the mixed results reported in the literature. In an attempt to discern if this is the case, scholars have proposed that the level of economic development of a country may play a central role in determining whether or not economic inequality is detrimental to health (Kondo et al., 2009; Ngamaba et al., 2018). What is puzzling is that so far, studies find mixed results in countries of similar levels of development and inequality. In Europe, there are a number of scholars who find a significant relationship between economic inequality within various countries and health (Craig, 2005; Dahl et al., 2006; Gravelle & Sutton, 2009; Rostila et al., 2012; Weich et al., 2002) while others do not (Gerdtham & Johannesson, 2004; Henriksson et al., 2006; Karlsdotter, Martín, & López, 2012). Similar mixed findings are found across Asian countries (find significant effect: Aida et al., 2011; Lau et al., 2012; Li & Zhu, 2006; Oshio & Kobayashi, 2010; Park et al., 2015; find no effect: Shibuya et al., 2002; Wong et al., 2009). Canadian studies are equally mixed, where Auger et al. (2012) and Xi et al. (2005) find a significant relationship but McLeod et al. (2003) and Ross et al. (2000) find no significant effect (more details in Section 2.3.).

The most consistent results are from studies conducted in the U.S., a developed and economically unequal country. There is general agreement that a negative impact of economic inequality on health exists, especially at the state-level (Fiscella & Franks, 1999; Kennedy et al., 1998; Leclere & Soobader, 2000; Lopez, 2004; Shi & Starfield, 2000; Subramanian, Kawachi, & Kennedy, 2001; Subramanian & Kawachi, 2006; Zheng, 2009, 2012). That said, other scholars have also found null results when using longitudinal research design (Mellor & Milyo, 2003) but also when conducting studies using similar geographical focus, year of data collection, or health outcomes (Blakely et al., 2002; Daly et al., 1998; Fiscella & Franks, 1997; Sturm & Gresenz, 2002).

There is a dearth of information from other regions of the world, which limits our ability to fully understand how development or inequality thresholds manifest using national datasets. In South America, Subramanian et al. (2003) find a significant effect of community level inequality on SRH in Chile. In Costa Rica, Modrek and Ahern (2011) find a significant effect of the change of inequality between 1995 and 2005 on the change of mortality. In New Zealand, Blakely et al. (2003) find no effect between regional inequality and mortality in 1991/4.

Although the thresholds from the meta-analyses of Kondo et al. (2009) and Ngamaba et al. (2018) show differences by level of inequality and development, there are many limits and possibly more nuance to associations within countries. Contradictory evidence is seen in various regions of the world, and even though the meta-analyses tested differences using many studies, they often only divided countries into only two groups. This may also be the product of many countries having few studies, often with methodological limitations.

2.3. Canadian Evidence and Study Justification

Canada provides an interesting and relevant location with which to study the relationship between economic inequality and health. Canada has experienced rising levels of economic inequality in the last 40 years and is struggling, like many other advanced western nations, with stagnant or marginal improvements in national health metrics (The World Bank, 2018). Also, existing studies of the inequality-health relationship in Canada face some of the methodological limitations outlined in Section 2.2. Below, we review the Canadian literature in more detail, paying particular attention to the methods employed, in order to identify some of the gaps that remain.

In a novel approach to researching the inequality-health relationship, Ross et al. (2000) tested how higher levels of provincial/state and city-level economic inequality was associated with mortality rates in Canada and the U.S. Using 1991 data, they compared the association between inequality, operationalized by the proportion of household income going to the less well off 50% of households, and age-standardized mortality rates between the U.S. and Canada using ten provinces and 50 states, and 53 Canadian and 282 U.S. cities. They observed a significant association between higher economic inequality and higher mortality rates for U.S. states and cities, but not for Canadian provinces and cities. This was one of the first studies to examine the income inequality-mortality association using Canadian data. Results suggest that the different context between the two countries can modify the relationship between economic inequality and health. In other words, this study argues that the country of study is an important consideration and asks why the relationship between economic inequality and health is present in the U.S but not in Canada. Ross et al. (2000) included rigorous controls and adjustments to ensure comparability between countries and a study design that aimed to test an independent effect of economic inequality separate from household income. However, the models employed are ecological and all variables aggregated to the city, provincial, or state level. As previously discussed, this limits the ability of the models to test the different relationships between individual effects and aggregate effects (Subramanian and Kawachi, 2004).

Laporte and Ferguson (2003) build on the Ross et al. (2000) article by differentiating between absolute income effects (personal incomes) and relative income effects (area-level inequality) on health, as well as incorporating data across a larger time period with lagged effects of economic inequality (1980-1997; pooled data). Similar to Ross et al. (2000), their data are also aggregated at the provincial-level, but they increase their sample size by including data from multiple years (1980 to 1997). Considering inequality, income, mortality, unemployment, and health care spending at the provincial-level in their statistical models, Laporte and Ferguson find no significant effect of higher economic inequality, as measured by the Gini coefficient, on mortality rates for the cross-sectional and lagged models. This leads them to support the findings of Ross et al. (2000) that economic inequality is not associated with mortality in Canada.

Veenstra (2002b, 2002a) and Auger et al. (2009) focussed on certain Canadian provinces to test the economic inequality-health relationship. Using data from 24 British Columbian coastal communities and testing the association using multiple measures of economic inequality, Veenstra (2002a) finds that higher economic inequality, measured by the percentage of wealth going to the bottom 50% of earners and the difference between the median and mean income, are significantly associated with higher crude mortality rates but not age-standardized mortality rates. Veenstra (2002b) and Auger et al. (2009) also find a significant association between 30 health regions in Saskatchewan and mortality rates and 143 Quebec communities and mortality rates, respectively. These studies use ecological data and focus on single provinces, but provide the first evidence of an association between economic inequality and health in Canada.

McLeod et al. (2003) provides the first evidence in Canada using a multilevel regression design. Their study uses individual-level data (n =6,456) between 1994 and 1998, multiple measures of health (SRH and the Health Utility Index), and the census to calculate measures of economic inequality at the city-level (n=53). They test the effect of economic inequality on cross-sections of data in each time period and when time periods are combined. They observe no significant results for economic inequality; cross-sectional analysis in 1994 show no association between the median share of income and SRH and analysis using all survey years show no evidence of an association. Their conclusion is that policy makers and researchers should focus on absolute income measures to improve health, a similar conclusion to that reached by Laporte and Ferguson (2003).

Xi et al. (2005) also test the effect of economic inequality on health using a multilevel cross-sectional study design in Ontario. Using data from 42 health regions and 30,939 survey respondents in 1996-7, they find an increased likelihood of all respondents rating their health poorer in more unequal Ontarian health regions. Compared to respondents living in more equal health regions, respondents living in highly unequal health regions had an odds ratio of 1.11 (95% CI 0.95 – 1.30) of rating their health as fair/poor in medium inequality regions, and an odds ratio of 1.18 (95% CI 1.01 – 1.37) in highly unequal health regions. This was the first multilevel study in Canada to show an impact of economic inequality on SRH. While the results of this study may be convincing, there is little justification for using the Health Region scale to measure economic inequality. Often people do not have a meaningful connection to their Health Region and there is little reason to believe why a theoretical pathway would exist between economic inequality and health at the Health Region, except possibly the unequal distribution of health services (i.e. the neo-material pathway). More meaningful scales of analysis in Canada are the city-level or regional-level, where people have political and social connections.

Using a more comprehensive dataset than McLeod et al. (2003) and Xi et al. (2005), Auger et al. (2012) test the economic inequality-mortality association using a multilevel study design with a sample of 2 million people followed from 1991 to 2001 in 140 Canadian cities. They find mixed effects of economic inequality on mortality risk. Results of their analysis show that there is a significant association between higher economic inequality and higher mortality risk for Canadian-born people, but not for those who immigrated to Canada. Using a categorized Gini coefficient measure, Auger et al. (2012) find that “high inequality [is] associated with greater working age mortality in men (Hazard Ratio (HR) 1.08, 95% CI 1.04 to 1.13) and women (HR 1.12 95% CI 1.06 to 1.18) non-immigrants” (p. 1). They further assess the robustness of their results by confirming their hypothesis using two more measures of inequality: Atkinson Index and the Coefficient of Variation, finding a similar and significant association between each inequality metric and mortality. Auger et al. (2012) provide robust evidence of the relationship in Canada, however show no effect on the entire population, contradicting work completed outside of Canada.

The goal of this chapter was to frame the history of empirical research on the relationship between economic inequality and health by reviewing key empirical studies in the literature in order to highlight the main on-going debates. This masters thesis aims to build on previous work while addressing identified methodological limitations. Using a multilevel repeat cross-sectional study design, I will address some of the critiques associated with ecological approaches; test the relationship in multiple time points, where social and economic circumstances differed; use more recent data from 2001, 2006, and 2011 that best represent Canada at each time point; conduct analyses at the city-level, which is a meaningful scale of analysis; and use multiple measures of economic inequality. The following chapter introduces the datasets and methods used in this thesis.

CHAPTER 3
DATA AND METHODS

This chapter provides an overview of the thesis datasets and methods, including a detailed discussion on data access and development. It outlines the characteristics of the datasets, model variables, and analytical equations.

There are two datasets used in the following analyses: the Canadian census and the Canadian Community Health Survey (CCHS). Both provide detailed variables, large sample sizes, and are representative of the Canadian population (including the National Household Survey [NHS], which replaced the Census in 2011). All analyses use cities as defined by Statistics Canada. This includes Canadian Metropolitan Area (CMA) and Census Agglomeration Areas (CA)[4], where 83% of Canadians live (Statistics Canada, 2018a). I use multilevel models that have either two or three levels, where CCHS respondents (level 1) are nested in cities (level 2) within provinces/territories (level 3). Census/NHS data are used to calculate city-level measurements of economic inequality, population, and median wages. Data from the CCHS provide all level 1 variables, including the dependent variable SRH (all others are listed in Section 3.4.). Provincial identifiers control for provincial in-group commonalities.

3.1. The Canadian Census

The Canadian census is ideal for calculating economic inequality metrics, median wages and population size at the city-level, as it is a mandatory census[5] distributed every five years to collect socio-demographic data. This thesis focuses on three census years: 2001, 2006, and 2011. Statistics Canada collects census information in two parts: (i) the short-form census (2A), which is mandatory for every Canadian and collects basic information such as number of people in the household, sex, age, and marital status; and (ii) the long-form questionnaire (2B), randomly answered by 20% of the population, which includes more detailed socio-demographic

[4] Canadian Census Metropolitan Areas do not necessarily correspond with municipalities and often includes many municipalities that form a larger metropolitan area. For example, Toronto includes Mississauga and Brampton. For more information see Statistics Canada's website (Statistics Canada, 2015b).

[5] With the exception of the 2011 NHS.

information, including income and wage data. The long-form questionnaire is then weighted to represent the Canadian population as a whole and creates a representative profile of the social and economic status of all Canadians for that year. It is important to note that the voluntary NHS replaced the mandatory long-form questionnaire in 2011, which resulted in lower response rates than previous censuses. Scholars have outlined the many limitations resulting from this change, including unreliable estimates at low geographical scales. However, these data are deemed reliable at larger scales such as the CMA and CA level (Statistics Canada, 2015c).

3.2. The Canadian Community Health Survey

The CCHS is a repeat cross-sectional survey conducted each year by Statistics Canada. The data are collected using a systematic random sample with weights generated to best represent the Canadian population (Statistics Canada, 2015a). The CCHS collects information on a wide variety of health variables to reflect the health status of Canadians, as well as information on their socio-demographic characteristics. Data are collected through phone administered questionnaires and computer-assisted interviewing, in which questions are pre-defined and kept constant each year. The survey is voluntary and information comes directly from the respondent.

The CCHS began in 2001 and was administered to approximately 130,000 respondents every two years until 2007. After 2007, the sample size was reduced to 65,000 respondents per year to provide faster access to up-to-date health data, although the respondents still total about 130,000 every two years. All respondents are aged 12 years or older and live in Canada; 120,000 respondents are over 18 years old, and 10,000 respondents are between 12 and 18 years old.

There are three sampling frames: an area frame, a list frame of telephone numbers, and Random-Digit Dialing (RDD). For the CCHS area frame, Statistics Canada uses a two staged stratified design formed of clusters, or smaller geographic areas, within Health Regions from the Labour Force Survey to select respondents (Statistics Canada, 2018b). Surveys are allocated first to provinces, then to health regions within provinces. Statistics Canada choses clusters using probability proportion to population and systematic random sampling of dwellings (Statistics Canada, 2015a). The list frame is an administrative dataset of phone numbers updated every six months and linked to health regions. Phone numbers are randomly chosen within health regions from the list. Finally, about 1% of surveys are collected using RDD within Health Regions, where telephone numbers are randomly generated from within the region (Statistics Canada, 2015a).

The mix of respondents from each sampling frame changed in 2005. The area frame was the primary data sampling frame from 2001 to 2003 (Statistics Canada, 2007a, 2007b). After 2005, the sampling frame was divided more evenly between the area frame (40% to 50% of the sample) and the list frame (49% to 58% of the sample).

Although Statistics Canada is diligent in ensuring that the CCHS represents the Canadian population, biases still occur. The CCHS is a voluntary survey and participants can therefore choose not to respond. This can lead to potential selection bias and under- or over-representation of certain socio-demographic groups or regions in Canada (see Section 4.2.). The CCHS also excludes about 3% of the Canadian population: those living in First Nations communities (reserves), members of the Canadian Forces, institutionalized populations, and people living in two health regions in Quebec (Région du Nunavik and Région des Terres Cries de la Baie-James). For this thesis, the CCHS is chosen over other health surveys due to the depth of information collected on each participant and the coverage of representation.

I pooled seven CCHS surveys around the three census years to ensure that sample sizes within cities were large enough for statistical analysis and government confidentiality requirements on detailed geographical output. I combined the CCHS 2001 and 2003 for Census 2001; CCHS 2005 and 2007 for Census 2006; and CCHS 2010, 2011, and 2012 for 2011 NHS. This leads to a sample size of 172,855 individuals in 2001, 133,158 in 2006, and 129,522 in 2011.

The CCHS datasets were linked to city-level variables, including economic inequality metrics using unique identifiers for each city. In the complete dataset, each respondent of the CCHS is nested within their city of residence.

3.3. Measures Included in Analysis

The following section reviews the primary unit of analysis and all variables included in the models. I detail the information collection process by Statistics Canada and the coding of each variable used in the analysis.

3.3.1. Unit of Analysis: Cities

Only CMAs and CAs that existed in each time period were kept in the study. CMAs are cities with a "total population of at least 100,000 of which 50,000 or more live in the core", while CAs "must have a core population of at least 10,000" (Statistics Canada, 2015b, p. 1). Therefore, between census years, some areas that have decreased or increased in size are dropped or added to Statistics Canada's list of CMAs and CAs. This analysis includes 97 CAs and 33 CMAs consistently present between 2001 and 2011. Note that the Magog and Sherbrooke CAs in Quebec were merged in 2006 and the respondents from Magog are assigned to Sherbrooke in 2001. This gives a total of 130 consistent cities over the study period.

3.3.2. Dependent Variable: Self-Rated Health

In this thesis, I measure health using self-rated health (SRH). SRH is a measure of a person's health where they are asked to rate their health on an ordinal scale. This measure has been shown to be a strong predictor of general health, and Jylha (2009) recommends this measure for health studies that compare population groups, stating that "in population studies, self-rated health is probably the most feasible, most inclusive and most informative measure of health status" (Jylha, 2009, p. 313). This may be because SRH is a relatively easy health metric to collect and is comparable across different populations, meaning that people of different genders and ethnicities seem to respond to the question similarly (DeSalvo et al., 2005; Chandola and Jenkinson, 2010). Respondents to surveys also seem to answer the question similarly regardless of the number of responses or the way the question is asked (DeSalvo et al., 2005). Critically, SRH is highly correlated with objective measures of health. When reviewing 27 longitudinal studies, Idler and Benyamini (1997) find SRH to be an independent predictor of mortality, even when controlling for other health-related variables.

In the CCHS, SRH is collected by asking respondents "In general, would you say that your health is: Excellent (1), Very Good (2), Good (3), Fair (4), or Poor (5)”. Responses were grouped into two, with the value 0 assigned to Excellent, Very Good, and Good responses, and 1 to Fair or Poor responses. This categorization is commonplace in the literature (see Kondo et al., 2009; Blakely et al., 2002).

3.3.3. Main Independent Variable: Economic Inequality

The main independent variable of interest is economic inequality, measured by the Gini coefficient of earnings/wages. There are three additional metrics to ensure robustness of results: the Theil Index, Percentile Ratios, and the Gini coefficient computed using total income, which includes transfer payments. Results specify when using the Gini coefficient as measured by wages as opposed to the Gini coefficient as measured by total income.

There are different ways of defining incomes and this thesis examines economic inequality using two definitions: earnings and total income. *Earnings* measure a person’s wages and salaries or income from self-employment. *Total income* measures a person’s wages and salaries but includes other incomes from tax and transfer payments, pension income, and investment income (Bolton, 2010). The distinction is important to consider as some of the different sources of income included in total income are used to mitigate social and economic inequalities (such as government transfer payments), and therefore may lead to lower levels of economic inequality. Additionally, Canadian census income data are not top coded, or censored beyond a certain income ceiling, as they are in the U.S. This is a benefit of Canadian income data as top coding can lead to underestimation of economic inequality from excluding very high incomes in the analysis (Burkhauser et al., 2012; Fichtenbaum & Shahidi, 1988; MacPhail, 2000).

In 2006 and 2011, Canadian census respondents could opt out of self-reported income and have Statistics Canada link their survey to their reported income taxes from the Canada Revenue Agency (Statistics Canada, 2011b). Frenette et al. (2009) outline limits in comparability across census years: due to this change total income as reported in the census may differ from what is in tax files as certain incomes are unreported in survey data but accurately accounted in tax files. However, market wages, i.e. earnings, are more reliable over time. As my work uses multiple census years, the focus will be on earnings to maintain consistency, although total income is also reported.

It is important to note that both total income and earnings avoid the larger question of wealth inequality. Wealth includes assets and savings, such as housing property (Alvaredo et al., 2018). Although this is a substantial source of economic inequality, there is currently no way to access wealth information in Canada. Therefore, the focus of the thesis will remain on total income and earnings, as these data are also available at the individual level.

Furthermore, the sample used to calculate all economic inequality metrics is limited to the active labor force, defined as those between the age of 25 and 64 who earn more than $1,000 annually. The base income of $1,000 controls for individuals who may report income losses, such as those who are self-employed (Bolton, 2010).

The primary measure of economic inequality in this thesis is the Gini coefficient, which is derived from the Lorenz curve (Figure 5). The Lorenz Curve illustrates the income distribution by income percentile and proportion of the population (De Maio, 2007). At total equality, one would expect each proportion of the population to hold the same proportion of income, as seen in the 45 degree line. This level of equality, however, is never reached in real populations. Therefore the Gini coefficient represents the ratio of the area between the actual income distribution and the 45 degree line (example shown in Figure 5; the total area between the 45 degree line and the actual distribution divided by the entire area below the 45 degree line). In this analysis, the coefficients range from 31.14 in the Yellowknife to 49.14 in Calgary in 2006. The Gini coefficient is formally expressed as:

$$Gini = 1 + \left(\frac{1}{N}\right) - [\frac{2}{m.N^2}][\sum_{i=1}^{i=n}(N - i + 1)(y_i)] \qquad (1)$$

where N is the total number of individuals, y is the income of the individual i, and m is the arithmetic mean of income[6].

[6] Information received from the Stata™ ineqdeco help file found here.

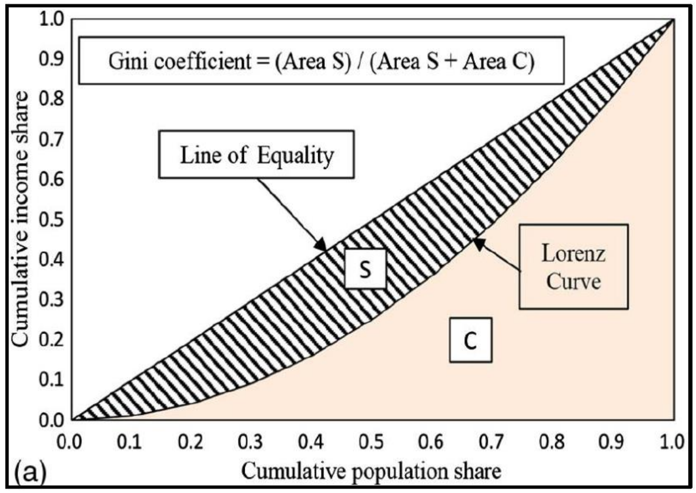

Figure 5: Lorenz Curve, Reprinted from Hu et al. (2015)

Although the Gini coefficient is the most frequently used measure of economic inequality, it has limitations: it only measures the difference in area between the income distribution and the 45 degree line, so very different types of economic inequalities could have a similar Gini coefficients. For example, the Gini is often criticized for being too sensitive to transfers in the center of the distribution, meaning small changes in the percentage of income going to the middle of the income distribution will change the Gini coefficient more than possibly larger changes in the percentage of income going to the top and/or bottom of the income distribution (De Maio, 2007). This is because movement at the center of the distribution changes the area ratio (Area S / Area C) more than movement at the top and bottom corners. Previous work finds that the type of economic inequality indicator can impact whether we observe a significant association with health outcomes. Therefore the Theil Index and Percentile Ratios are calculated to provide robustness to the relationship (Auger et al., 2012; De Maio, 2007).

The Theil Index addresses the critique of the Gini coefficient by providing better estimations of inequality where there are changes at the top of the distribution, when the top either gain or lose a proportion of the national income (De Maio, 2007). As economic inequality has been largely driven by gains in top income earners, the Theil Index provides another dimension to the analysis that is more sensitive to the increasing shares of income earned by the top 1% (seen in Figure 1; Breau, 2014; Veall, 2012). The Theil Index ranges from 0 to infinity, where 0 is a perfectly equal distribution and higher Theil values indicate higher inequality. The Theil Index is formally expressed as:

$$Theil = \sum_{i=1}^{i=n} (f_i) \left(\frac{y_i}{m}\right) \left[\log\left(\frac{y_i}{m}\right)\right] \quad (2)$$

where $f_i = \frac{w_i}{N}$ and N is the sum of weight w_i for the number of individuals i with income y_i, and the arithmetic mean income is m[7].

I further compute a ratio of the total earnings received by the top 10% of earners to the bottom 10% of earners. This ratio is a relatively simple measure that "allows researchers to examine which sections of the income spectrum may be most important as a social determinant of health" (De Maio, 2007, p. 851). All metrics are computed using the Stata™ program ineqdeco developed by Jenkins (2001) and correlation matrixes of the inequality measures can be seen in Appendix B (StataCorp LCC, 2018). The program calculates the Gini coefficient, the Theil Index, and the Percentile Ratios at the city-level using the same individual earnings input file. A second version of the program was run to compute the Gini coefficient using individual total income.

Following the approach defined by Blakely et al. (2002), the 130 cities in the analysis are grouped into four categories: high, medium-high, medium-low, and low inequality. I take the average and standard deviation of the city-level metrics in each year, and divided cities into these groups based on their economic inequality values (Table 1). Economic inequality is considered 'high' inequality when it is above one standard deviation from the mean, and 'low' if it is below one standard deviation from the mean. Medium metrics fall between the average and the low or high standard deviation value. Table 1 indicates the breaking points for each metric in each year. Finally, metrics of economic inequality are stable for small areas between census years due to the design of the census being very representative of the Canadian population (see Section 3.1).

[7] Information received from the Stata™ ineqdeco help file found here.

Table 1: Inequality Metric Breaks: High, Medium-High, Medium-Low, and Low

	2001	***2006***	***2011***
Gini Coefficient: Earnings			
High	Greater than 38.5	Greater than 40.4	Greater than 39.8
Medium-High	36.4 – 38.5	37.7 – 40.4	37.4 – 39.8
Medium-Low	36.4 – 34.2	37.7 – 35.0	37.4 – 35.0
Low	Lower than 34.2	Lower than 35.0	Lower than 35.0
City-Level Average	*36.4*	*37.7*	*37.4*
Gini Coefficient: Total Income			
High	Greater than 35.8	Greater than 37.4	Greater than 36.3
Medium-High	33.6 – 35.8	34.3 – 37.4	33.5 – 36.3
Medium-Low	31.4 – 33.6	31.2 – 34.3	30.7 – 33.5
Low	Less than 31.4	Less than 31.2	Less than 30.7
City-Level Average	*33.6*	*34.3*	*33.5*
Theil Index			
High	Greater than 28	Greater than 33	Greater than 30.3
Medium-High	23.9 – 28	26.6 – 33	25.3 – 30.3
Medium-Low	19.8 – 23.9	20.2 - 36.6	20.3 – 25.3
Low	Less than 19.8	Less than 20.2	Less than 20.3
City-Level Average	*23.9*	*26.5*	*25.2*
Percentile Ratio (90/10)			
High	Greater than 8.62	Greater than 8.57	Greater than 9.03
Medium-High	7.39 – 8.62	7.56 – 8.57	7.59 – 9.03
Medium-Low	6.17 – 7.39	6.55 – 7.56	6.36 – 7.59
Low	Less than 6.17	Less than 6.55	Less than 6.36
City-Level Average	*7.39*	*7.56*	*7.59*

Note: Breaks based on Blakely et al. (2002)'s methodology

3.3.4. Other Independent Variables

The models include individual and city-level covariates to control for other possible determinants of health. The individual variables from the CCHS are: sex, age, household income, unemployment status, visible minority identification, and marital status.

Household income is determined by asking respondents "What is your best estimate of the total income, before taxes and deductions, of all household members from all sources in the past 12 months?" Responses are continuous and transformed to a log 10 format to control for a positive skew from very high-income earners. In each year, many respondents did not answer this question, and therefore sample size is reduced when using the continuous metric (non-response is 16% or 42,258 in 2001 and 2003; 19% or 37,461 in 2005 to 2007; and 8% or 15,152 in 2010, 2011, and 2012). I run separate models using a categorized income variable to keep non-responses in the models and check robustness of results (see section 5.2). The categorized income variable is divided based on Statistics Canada's census income brackets (Statistics Canada, 2017a); breaks at $0, $5,000, $10,000, $15,000, $20,000, $25,000, $35,000, $50,000, $75,000, $100,000, $150,000, $200,000, and $250,000, with an addition category for missing incomes. Sex is not re-coded, where 0 is a man and 1 a woman, and age is a continuous variable. Unemployment is derived from the question "Did you work at a job or business in the past 12 months". Unemployed respondents are coded 1, and those who are employed are coded 0. Since this variable only includes respondents in the active labor force, an additional category (coded 2) was created to retain those not in the labor force or did not respond to the question. Marital status contrasted those in a married or common law relationship (1) versus others, coded 0 (widows, separated couples, divorcees, singles, and those who never married). The question: "People living in Canada come from many different cultural and racial backgrounds. Are you..." determines if the respondent identifies as a visible minority. There are multiple response categories, and those who identify as 'white only' are coded 0, and all other responses are coded 1. Those who did not respond to the questions above or are not in the labor force are added as an extra response category (coded 2), to maintain sample size (Subramanian & Kawachi, 2007).

At the city-level, models include population size and median wages, derived from the census/NHS. Statistics Canada provides population sizes at the Census Sub-Division (CSD) level, which are fully nested within CMA/CAs. Therefore, I aggregated the CSD population counts to each city. Because of non-responses, 2011 population counts are not provided at the CSD level. Therefore, I use the census individual statistical weight provided by Statistics Canada to calculate population at the city-level for 2011. Population is transformed to a log 10 format to control for the skewness of very high population cities, e.g. Toronto. To be consistent with other income variables, I use the active labor force to calculate median wages. Using the same methods as the inequality metrics, median wages is divided into four categories for each year[8]. It is important to include both population size and median wages in the calculations to ensure

[8] 2001 break points, creating four groups: 27,446.33; 31,557.77; 35,669.21. 2006 breaks: 30,329.47; 36,044.11; 41,758.75. 2011 breaks: 33,429.687; 41,584.65; 49,739.62

that I capture the true effect of the change in economic inequality rather than changes in city-level median wages or population size (Breau, 2015; Subramanian & Kawachi, 2004).

3.4. Data Access and Confidentiality

For this analysis, I required access to individual-level data along with geographical identifiers for both the CCHS and Census/NHS. Such microdata files are deemed confidential and the Canadian government restricts their access. Through the Data Liberation Initiative, confidential data are available in networked Research Data Centers (RDC) on university campuses across Canada. In order to gain access to a RDC, one must have their project approved by the *Canadian Initiative for Social Statistics - Access to the RDC Program*, receive Government of Canada Security Clearance, sign a 'deemed employee' contract with Statistics Canada, and follow Statistics Canada research guidelines (Bolton, 2010). This is required to access both the census and CCHS. There are further limitations on release of data from each dataset, such as meeting minimum cell count requirements in order to be released. This is most apparent in Figure 8 where few respondents in several cities meant that values are omitted from the figure. No data are omitted from the analytical models.

3.5. Data Analysis

This thesis uses multilevel logistic modeling to account for the multilevel structure of the data. Models include people nested in cities characterized by levels of economic inequality. Weights are not applied to people in the study for modeling, as the CCHS weights are aggregated to the Health Region and the city-level.

3.5.1. Rational for Using Multilevel Modeling

Multilevel modeling distinguishes between individual and group/area level effects on the dependent variable (Subramanian & Kawachi, 2004). This distinction is particularly important in geographical research where people are often exposed to influences of their neighborhood, cities, urban or rural regions, states, or provinces. Therefore, multilevel models partition the portion of the variation in an outcome variable (SRH) attributable to differences between people and to differences between places. Multilevel modeling also accounts for bias from in-group commonalities that arise when data are nested. This is called intra-class correlation, where some data gather in 'groups'. Multilevel models are preferred over ordinary least squares regression for nested data, as ordinary least squares regression requires that the error terms are independent. However, if the data are grouped, the error terms will correlate with each other. This is not the case in multilevel models, where intra-group variability is accounted for (Luke, 2004).

3.5.2. Equations

I specify multiple models for each time period that include a random intercept at the city-level to account for between-city differences (random effects) (Blakely et al., 2002). The basic structure of the model is:

Level 1: $$y_{ij} = \pi_{0j} + \pi_{1j}(x_{ij}) \qquad (3)$$

Level 2: $$\pi_{0j} = \beta_{00} + \beta_{01}(x_j) + r_{0j}$$

where y_{ij} is the health of individual i in city j; x_{ij} is the individual variable i in city j; and x_j is the level of economic inequality in city j, with x_J estimating the effect of societal economic inequality on individual health (Subramanian & Kawachi, 2004). The un-modeled variability coming from the second level j (i.e. between cities) is r_j . This models "between-individual-within-[city] relation nested within a macro model specifying the between-[city] relation" (Subramanian & Kawachi, 2004, p. 31).

The primary models use the Gini coefficient as measured by earnings. Three alternative measures of economic inequality (Theil Index, Percentile Ratios, and the total income Gini coefficient) are subsequently tested using Equation 3 as the baseline. Finally, to ensure that provincial clustering doesn't impact results, additional models are run that include provinces/territories as the third level. Presented below is the model with a third provincial-level variable:

Level 1: $$y_{ijk} = \pi_{0jk} + \pi_{1jk}(x_{ijk}) \qquad (4)$$

Level 2: $$\pi_{0jk} = \beta_{00k} + \beta_{01k}(x_{jk}) + r_{0j}$$

Level 3: $$\beta_{00k} = \gamma_{000} + u_k$$

where all variables from the base model are the same but include a third level k to account for provincial intercepts and un-modeled variability coming from the third level u_k (i.e. between provinces/territories).

This chapter reviewed the datasets, measures, data access, and the models estimated in this thesis. The Canadian Census/NHS and CCHS provide representative data at the required scale to test how economic inequality impacts population health in Canada. Multilevel logistic modeling is the best analytical method for grouped data as it separates economic inequality at the city-level from health at the individual level, avoiding complications that arise from making inferences on ecological data (Subramanian & Kawachi, 2004).

CHAPTER 4
DESCRIPTIVE RESULTS

The following section describes the sample characteristics of the cities, the main socio-demographic characteristics of the CCHS respondents, and trends in economic inequality between 2001 and 2011.

4.1. Characteristics of CCHS Sample

The CCHS sample is limited to those who reside in the 130 cities defined in all three time periods: 2001, 2006, and 2011. Table 2 defines the sample used for descriptive statistics and analytical models. An increasing percentage of respondents who reside in cities are excluded through time, from 0.59% to 1.02%, due to changes in CMAs and CAs by Statistics Canada between 2001 and 2011. This means that respondents who reside in excluded cities are not in the sample ("live in cities; excluded from thesis").

Table 2: Defining the Sample: Pooled CCHS Respondents

Census year:	***2001***		***2006***		***2011***	
CCHS years:	*2001, 2003*		*2005, 2007*		*2010, 2011, 2012*	
	Count	Frequency	Count	Frequency	Count	Frequency
Included in Thesis	172,855	65.89%	133,158	66.95%	129,522	68.59%
Live in cities; excluded from thesis	1,563	0.59%	1,914	0.96%	1,921	1.02%
Non-city respondents	91,983	34.53%	63,821	32.09%	57,393	30.39%
Total Respondents	266,401	100%	198,893	100%	188,836	100%

Note: counts included in this table are unweighted survey responses

Table 3 shows a summary of responses from the CCHS throughout the ten-year period. The prevalence of participants reporting their health as fair or poor remained stable at about 13%. The range in the number of participants per city remained relatively stable as well. The largest number of participants live in Toronto in each time period, decreasing from 34,400 respondents in 2001 to 26,800 in 2011.

Table 3: CCHS Sample Characteristics

Census year:	***2001***	***2006***	***2011***
CCHS years:	*2001, 2003*	*2005, 2007*	*2010, 2011, 2012*
Level-1 Individuals	n=172,855	n=133, 158	n=129,520
Range in number of respondents per city (fewest/largest)[9]	50 / 34,400	50 / 27,300	50 / 26,800
Outcome: Poor or Fair SRH	13.4%	13.2%	13.3%
Excellent, Good, and Very Good SRH	86.6%	86.7%	86.5%
Missing	0.1%	0.1%	0.2%
Household Income ($ CAD)			
Under $35,000*	36.9%	31.9%	35.9%
$35,000 - $100,000	35.0%	35.1%	43.4%
Over $100,000	3.3%	4.7%	8.9%
Missing	24.7%	28.3%	11.8%
Employment Status			
Employed	48.8%	50.3%	46.7%
Unemployed	11.8%	11.7%	11.9%
Not in Labor Force or No Response	39.3%	38.0%	41.4%
Age			
Under 25 years	19.4%	17.9%	17.4%
25-65 years	61.6%	61.4%	57.5%
Over 65 years	19.0%	20.8%	25.2%
Sex			
Man	45.5%	45.4%	44.6%
Woman	54.5%	54.6%	54.4%
Visible Minority			
No	87.0%	84.0%	81.6%
Yes	11.3%	12.3%	11.6%
Missing	1.7%	3.8%	6.9%
Married/Coupled			
No	50.5%	50.8%	50.9%
Yes	49.4%	49.1%	48.9%
Missing	0.2%	0.1%	0.2%

Note: percentages in this table are unweighted survey responses; *approximation of household low-income cutoff (Statistics Canada, 2017b).

Other socio-demographic variables of the population are fairly consistent through each time period. The most notable change is in the number of respondents in the highest income group. Few respondents earn incomes above $250,000 in 2001 and 2006, however this number increases almost a full percent to be 1.7% of all respondents in 2011, therefore increasing the

[9] Due to confidentiality, samples had to be released rounded to base 50 and are therefore modified numbers on the smallest and largest sample sizes per city.

proportion of respondents in the above $100,000 income bracket. This is because after 2011, Statistics Canada began imputing income data that was missing (Statistics Canada, 2015a).

The CCHS sample distribution of household incomes differs from the broader Canada-wide demographics. In 2001, about 3.3% of Canadians had a total household income above $150,000, compared to 3.9% in the CCHS sample (Statistics Canada, 2001). In 2001, about 36.9% of the population had incomes below $35,000, compared to 24.4% of the CCHS sample (Statistics Canada, 2001). The proportional differences are comparable for other census years (Statistics Canada, 2011a). In general, this means an underrepresentation of low-income Canadians in the CCHS sample, which limits inference to the overall population and may mask variation in poor SRH, which is more prevalent among low-income groups. In previous studies, scholars find a higher impact of economic inequality on low-income people (Subramanian et al., 2001). Using a sample of mostly middle income respondents may therefore suppress an underlying relationship (Subramanian et al., 2001). There could also be a non-response bias due to underreporting of household income by CCHS respondents (Table 3). In 2006, almost 30% of the sample did not report their household income. Those who responded may differ from those who did not, further limiting estimates and ultimately inference to the broader Canadian population. Acknowledging this bias, all models in Table 6 through Table 8 only include respondents who did report their income and models are run to include a category for missing household income (Table 10).

4.2. Characteristics of Cities

Table 4 provides a summary of key socio-demographic characteristics of included cities. Ontario has the largest number of cities at 40, and Northwest Territories (NWT) and Yukon have the fewest, with only one per territory. For the purpose of this research, there are no cities in Nunavut.

Median wages and population size vary by city. Median earnings tend to be highest in cities in the territories and Alberta. Wood Buffalo, AB has the highest median wages at $99,435, followed by Yellowknife, NWT at $72,953. The cities with the lowest median wages are concentrated in eastern provinces, with cities in Nova Scotia, Quebec, and Prince Edward Island having the lowest average city median wages. However, Elliot Lake, ON has the lowest median wages overall, at $28,741. The largest city in the sample is Toronto, ON followed by Montreal, QC, and Vancouver, BC; the smallest cities are Elliot Lake, ON, Dawson Creek, BC, and Hawkesbury, ON.

Table 4: City Characteristics by Province/Territory, 2011

Province / Territory	Number of Cities	Average City Median Earnings	Min/Max Median Earnings	Min/Max Population
Newfoundland and Labrador	3	$39,323	$36,542/$44,228	13,480/193,830
Prince Edward Island	2	$36,690	$35,794/$37,585	16,120/63,010
Nova Scotia	5	$35,804	$33,000/$42,495	26,030/384,540
New Brunswick	6	$37,750	$34,890/$41,025	21,070/135,520
Quebec	27	$36,524	$30,177/$46,253	11,960/3,752,470
Ontario	40	$41,476	$28,741/$52,847	11,170/5,521,230
Manitoba	4	$44,151	$39,846/$55,567	12,390/714,640
Saskatchewan	8	$43,859	$38,000/$55,613	12,630/256,430
Alberta	11	$54,046	$42,204/$99,435	12,050/1,199,130
British Columbia	22	$41,601	$36,658/$52,602	11,240/2,280,700
Yukon	1	$55,032	$55,032	25,570
Northwest Territories	1	$72,953	$72,953	18,830
National	130	$40,247	$28,741/$99,435	Mean: 205,146

Overall, the level-2 sample size provides a diversity of cities with which to understand predictors of health at the city-level. These 130 cities allow me to compare different levels of economic inequality between cities with similar population sizes and similar median wages, discerning exactly how changes in economic inequality, holding other things constant, relate to health.

4.3. Economic Inequality in Canada, 2001 to 2011

There are various temporal and geographic patterns to economic inequality in Canada between 2001 and 2011. Average city-level economic inequality increased from a Gini coefficient of 36.4 in 2001, to 37.7 in 2006, but then slightly decreased between 2006 and 2011 to 37.4 following the Great Recession of 2008. Figure 6 shows the distribution of city-level economic inequality between the three time periods; each point represents a city.

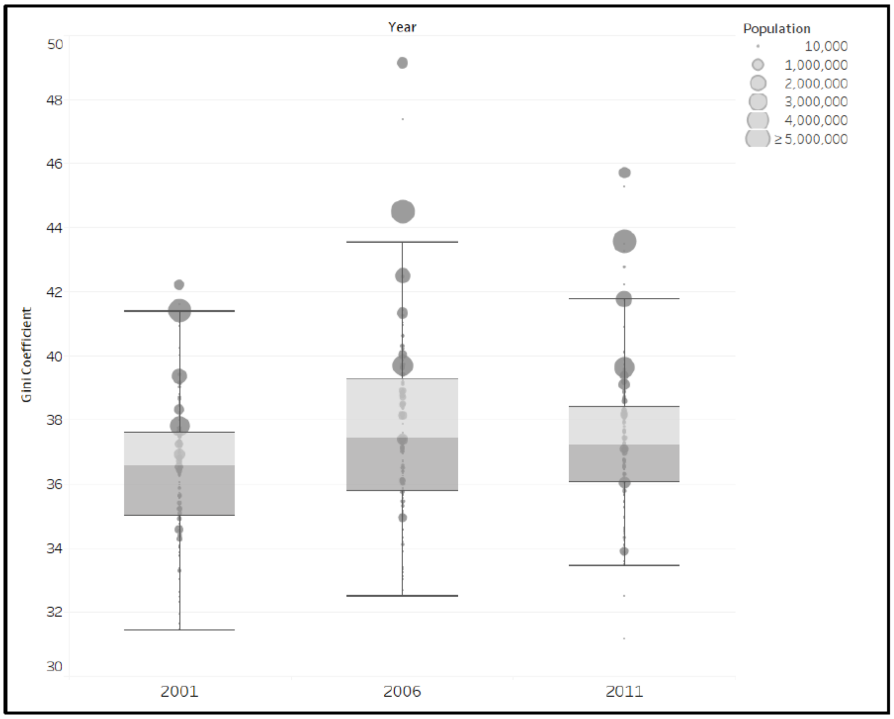

Figure 6: Distribution of City-Level Gini Coefficients by Year

The range and distribution of values vary between years. The largest standard deviation in inequality is in 2006 (2.70) and 2001 has the lowest (varying by 2.14). In addition to having the highest average city Gini coefficient, 2006 also appears to have many cities that were well above average inequality levels. This includes three abnormally high outlier points, which are determined by their values being more than 1.5 times the interquartile range (Rogerson, 2015). The city with the highest Gini coefficient in 2006 at 49.1 is Calgary, AB. Table 5 shows that this city remains the most unequal in Canada in 2011 (and was the most unequal in 2001, with a Gini coefficient of 42.2).

Some city-level Gini coefficients in 2011 have abnormally low values. Yellowknife, NWT and Thetford Mines, QC have the lowest levels of economic inequality with Gini coefficients of 31.1 and 32.5, respectively. However, unlike Calgary, these cities are not the most equal in 2001 and 2006. In 2001, the most equal city in Canada was Portage la Prairie, MB, with a Gini coefficient of 32.5; in 2006, the most equal city was Stratford, ON with a Gini coefficient of 31.4.

Table 5 lists the most equal and unequal cities in Canada. Topping the list of most unequal cities in 2011 are three of Canada's largest cities, Calgary, Toronto, and Vancouver. Bolton and Breau (2012), who also study economic inequality at the city scale, also find Calgary to be the most unequal. Where Bolton and Breau (2012) find that Toronto and Vancouver have the second and third most unequal distribution of earnings in 2006, this thesis finds that for the same time period there are other Canadian cities whose values fall between Calgary, Toronto and Vancouver. However, Bolton and Breau (2012) use a reduced number of cities in their study (n = 87). It appears as though they exclude smaller cities, as those with high levels of economic inequality that are omitted from their results are small cities, including the smallest city in this study, Elliot Lake, ON, which ranks as having the second most unequal distribution of earnings in 2011. This is seen especially when mapping the Gini coefficients in Canada.

Table 5: Highest and Lowest Levels of Economic Inequality, 2011

	City Name	2001	2006	2011	Percent Change: 2001 – 2011
1	Calgary, AB	42.2	49.1	45.7	8.3%
2	Elliot Lake, ON	41.6	38.2	45.3	8.8%
3	Toronto, ON	41.4	44.5	43.6	5.2%
4	Lloydminster, AB/SK	38.0	41.0	43.5	14.5%
5	Camrose, AB	38.5	40.1	43.3	12.5%
6	Sarnia, ON	38.7	41.2	42.8	10.5%
7	Estevan, SK	35.2	37.5	42.2	20.0%
8	Port Hope and Hope, ON	34.9	37.2	41.8	19.6%
9	Vancouver, BC	39.3	42.5	41.8	6.1%
10	Collingwood, ON	35.5	47.4	41.7	17.4%
121	Kenora, ON	34.6	33.2	34.1	-1.6%
122	Baie-Comeau, QC	32.6	34.3	34.0	4.1%
123	Quebec, QC	34.6	35.0	33.9	-2.0%
124	Sainte-Hyacinthe, QC	32.3	33.0	33.9	4.9%
125	Drummondville, QC	33.3	35.3	33.9	1.8%
126	Victoriaville, QC	35.2	34.9	33.6	-4.8%
127	Portage la Prairie, MB	33.4	32.5	33.5	0.4%
128	Rimouski, QC	35.3	35.9	33.4	-5.1%
129	Thetford Mines, QC	31.4	33.1	32.5	3.4%
130	Yellowknife, NWT	31.5	35.0	31.1	-1.0%

As observed previously, larger cities and cities located in Ontario and Alberta tend to have higher levels of economic inequality. Conversely, smaller cities and cities located in Quebec tend to have lower levels of economic inequality (Bolton & Breau, 2012; Breau, 2015).

A more complete picture is presented in Figure 7 where cities are mapped across Canada. The size of the points indicate population size in 2011, while the shades indicate levels of Gini coefficients in 2011; darker shades indicate high levels of economic inequality, and lighter shades lower levels of economic inequality.

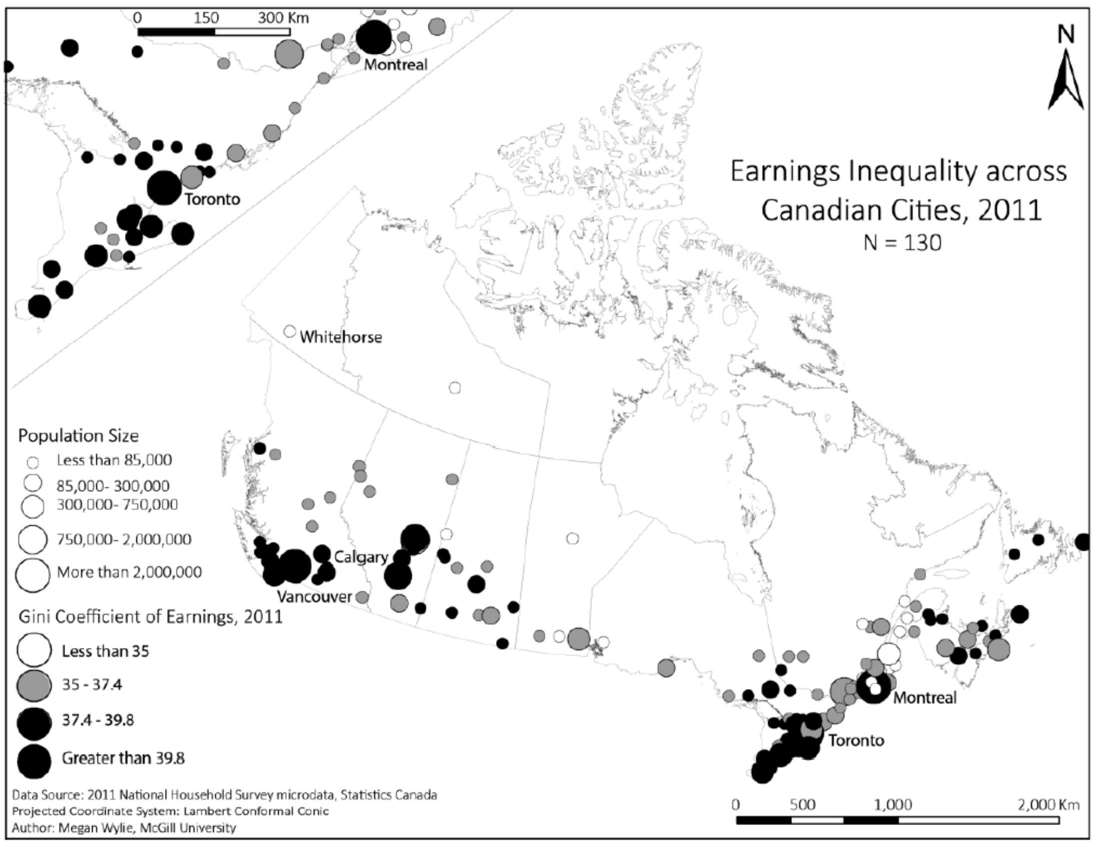

Figure 7: City-level Economic Inequality and Population, 2011

Scanning the map from East to West, there are two trends worth noting. The first broad trend is seen at the provincial level, where Quebec and the Maritime Provinces show generally lower levels of inequality compared to Ontario, Alberta, and British Columbia where higher levels of inequality are observed. Secondly, high Gini coefficients are predominantly found in larger urban areas, and concentrated in three regions: the Windsor – Toronto corridor (see the top left inset map), lower British Columbia, and the Calgary-Edmonton corridor. Moreover, two of the three largest cities in Canada are categorized in the high Gini coefficient group (Toronto and Vancouver) and Montreal in the medium-high Gini coefficient category in 2011. Exceptions are present; Grand Falls - Windsor, NL, Estevan, SK, and Lloydminster, AB experience high levels of inequality despite being relatively small cities.

4.4. Variation in City-Level Economic Inequality and Self-Rated Health

To visualize variability in SRH, Figure 8 displays city-level economic inequality and the proportion of respondents in each city that rated their health fair or poor. The size of each point indicates the population for each city and the transparency of the point indicates the level of inequality. The red line shows the overall proportion of CCHS respondents who rated their health fair or poor (entire sample), and the red 'x' values indicate the city averages by province. Data confidentiality meant that city-level values were rounded to the nearest base 50[10]. About one third of cities (38%) are rounded to zero respondents rating their health poorer, including each city in Yukon and Northwest Territories. Proportions are calculated from the CCHS sample, meaning that the total number of respondents who rated their health as fair or poor is divided by the total number of CCHS respondents in that city. Caution is warranted when interpreting the results from this figure due to the excluded data. There is no age standardization for these points; age is accounted for in the modeling in Chapter 5.

Of the cities included in Figure 8, the counts ranged from a minimum of 100 CCHS respondents and maximum of 26,800 respondents per city. A minimum of 50 respondents rated their health as fair or poor and a maximum of 3,300 rated their health fair or poor per city, a range of 7.1% to 50% of respondents rating their health fair or poor per city[11]. Points cluster around the national sample average of 13%, although, possibly due to the excluded cities with less than 50 respondents rating their health fair or poor, the points are generally above the national average.

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[10] Therefore, values under 25 were rounded to zero, and values over 25 to 50 (or the closest value divisible by 50).

[11] The outliers of Quesnel, Penticton, Cranbrook, Pembroke, and Kentville had 50% of respondents rate their health as fair or poor. Upon data release, each of these cities had only 100 rounded responses for good, excellent, and very good health and 50 responses for fair and poor health, leading me to suspect that results are skewed from the data rounding requirements of the confidentiality protocol for this survey.

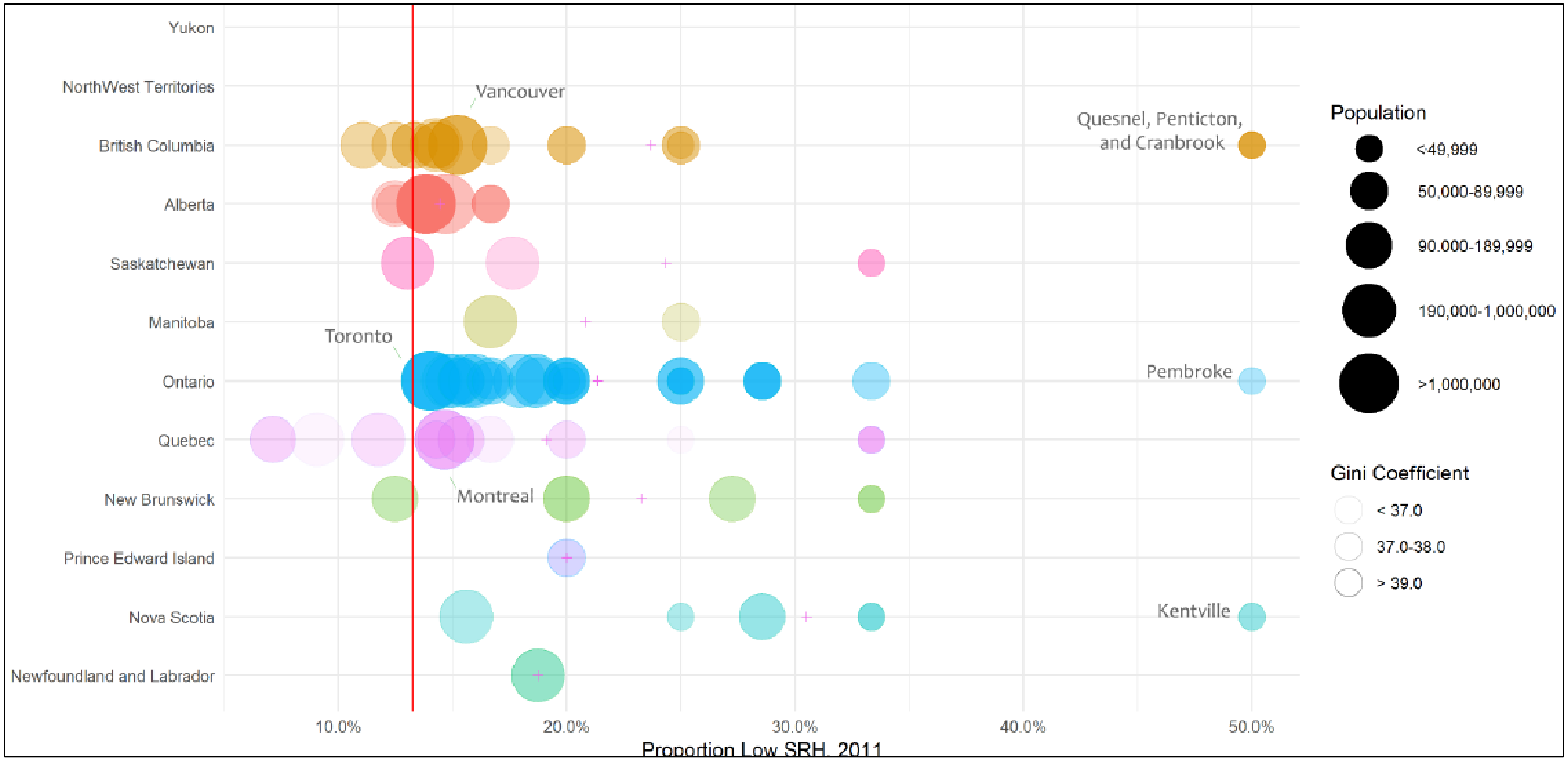

Figure 8: Percent of Respondents Who Rated their Health as Fair/Poor in Each City by Province, 2011

There is variation in proportion of those who rate their health fair or poor by province. Cities that have a very high proportion of respondents' rating their health as fair or poor also have varying levels of economic inequality, including cities grouped in a relatively low level of economic inequality (see far right of figure). Conversely, some cities with the lowest proportion of respondents rating their health fair or poor had relatively high levels of economic inequality, including some in the medium Gini coefficient category (see left side of figure, especially cities in Quebec). It is acknowledged that there may be some clustering of SRH values by province due to cultural (e.g. language) or structural differences (e.g. health care service differences). As described in Chapter 3, provincial clustering is accounted for in the multilevel models.

Focusing on the provinces that showed higher levels of economic inequality in Figure 8, cities in Alberta tend to cluster around the SRH national average, cities in Ontario have levels generally above the SRH national average, and cities in British Columbia show substantial variation, where most cities clustered around the SRH national average, but two of these cities had very high proportions of fair or poor health. Corresponding to earlier geographic patterns showing low inequality levels in Quebec, Quebec also has the largest number cities below Canada's average proportion fair or poor health (three cities).

This chapter provided an overview of the dataset I constructed for the thesis and descriptive analysis of inequality and SRH. The datasets provide a large and diverse sample of both cities and CCHS respondents throughout the 130 Canadian cities. Descriptive results indicated that, overall, economic inequality increased since 2001, but decreased between 2006 and 2011. We also see that there is variation in SRH between cities, corresponding to varying levels of economic inequality.

CHAPTER 5
ANALYTICAL RESULTS

This chapter outlines the analytical results investigating economic inequality and SRH across 130 Canadian cities in three time periods. The results focus on economic inequality as measured by the Gini coefficient of earnings, then checks the robustness of results to alternate measures of economic inequality, i.e. the Gini coefficient of total income, the Theil Index, the 90/10 Percentile Ratio[12], alternate coding of household income, and models which include provinces/territories fixed effects in a third level.

5.1. Primary Models

Four models are specified in each time period using Equation 3, where SRH is the dependent variable. Results are reported in Odds Ratios (OR), indicating the odds that a respondent would report their health as either fair or poor (SRH=1; referred to here as 'poorer health'), or good, very good, or excellent (SRH=0). ORs above one indicate that an outcome of poorer health is more likely. Models are presented parsimoniously in Tables 6 through 8, from Model A to full specification Model C and D. Model A only includes a continuous city-level Gini coefficient. To control for other possible confounding factors, subsequent Model B includes city-level median wages, population size, and individual-level household income. Fully specified Models C and D include all city-level and individual-level variables (see Section 3.3.). The final model includes the categorized Gini coefficient for comparability to other studies. Note that the magnitude of categorized coefficients cannot be directly compared to the continuous coefficient, as the categories compare four distinct groups and the continuous coefficient represents a unit increase in the inequality metric (Rabe-Hesketh & Skrondal, 2012).

Results using 2001 data: Table 6 presents the 2001 cross-sectional models. In Model A, the Gini coefficient is not significant, although its direction indicates that higher inequality is associated with greater odds of poorer SRH. This changes in Model B, where the Gini coefficient becomes

[12] The amount of income going to the top 90% of earners divided by the amount of income going to the bottom 10% of earners.

Table 6: Results of Multilevel Logistic Association between the Gini coefficient and Self-Rated Health, 2001

	Model A + Gini Coefficient OR (95% CI)	Model B + City Controls and Household Income OR (95% CI)	Model C [a] + Individual Controls OR (95% CI)	Model D [a] Categorized Gini Coefficient OR (95% CI)
Observations				
Individuals	130,495	130,495	130,495	130,495
Cities	130	130	130	130
Variables: City-Level				
Gini Coefficient:				
Continuous	1.01 (0.99-1.04)	1.02* (1.00–1.04)	1.02* (1.00-1.04)	
Categorical				
Low				1.00
Medium-Low				1.15* (1.02-1.30)
Medium–High				1.16* (1.03-1.30)
High				1.17* (1.02-1.35)
Median Wages:				
Low		1.00	1.00	1.00
Medium-Low		0.89† (0.78–1.02)	0.91 (0.81-1.03)	0.91 (0.81-1.02)
Medium-High		1.02 (0.89–1.16)	1.06 (0.94-1.19)	1.04 (0.93-1.18)
High		0.97 (0.83-1.13)	1.14† (0.99-1.31)	1.14† (0.99-1.31)
Population Size[b]		0.87** (0.81–0.94)	0.86** (0.81-0.92)	0.86** (0.81-0.92)
Individual Level				
Household Income[b]		0.25** (0.24–0.26)	0.44** (0.42-0.46)	0.44** (0.42-0.46)
Variation				
Constant	0.10** (0.04-0.21)	80.81** (38.02-171.76)	0.97 (0.50-1.89)	1.83** (1.29-2.60)
City-level Variation	1.06** (1.04-1.07)	1.03** (1.02–1.05)	1.02** (1.01-1.03)	1.02** (1.01-1.03)

** $p<0.01$, * $p<0.05$, † $p<0.1$

[a] Fully specified model. Includes visible minority status, marital status, age, sex, and employment status.

[b] Variable is log transformed to base 10.

statistically significant predictor of poorer SRH, when the model is adjusted for population size, median incomes, and individual-level household income. Fully specified Model C shows the odds ratio of reporting poorer health is 1.02 (95% CI 1.00 – 1.04) for each unit increase in the Gini coefficient. These results suggest a modest association between city-level economic inequality and SRH in adjusted models.

The results remain significant when using a categorized Gini coefficient. We observe higher odds of reporting poorer health among respondents living in a highly unequal city (OR 1.17; 95% CI 1.02 – 1.35), medium-high inequality (OR 1.16; 95% CI 1.03 – 1.30), and medium-low inequality (OR 1.15; 95% CI 1.02 – 1.30), compared to respondents in the reference group of low city-level inequality.

At the individual-level, higher household income decreases the odds of respondents rating their health poorer. In all models, the OR for household income is below 0.5, where for every 10% increase in household income, the odds of a respondent rating their health poorer decreases (Model C; OR 0.44; 95% CI 0.42-0.46; interpretation differs from others as household income is log transformed). However, the addition of other level-1 control variables reduces its protective effect on health, likely indicating its intersection with other predictors of personal health.

Other level-2 variables change the odds of poorer SRH. Larger population size is consistently associated with better health across all models. In the fully adjusted Model C, the odds of a respondent rating their health poorer decreases for each 10% increase in population size (OR 0.86; 95% CI 0.81 – 0.92; population is measured on the logarithmic scale). Median wages at the city-level do not show a consistent relationship with SRH. In the fully adjusted Model C, higher median wages appears to elevate the odds of respondents rating their health poorer, although not significantly.

In addition to the coefficients, the unexplained variation at the individual and city-level provides information on how important certain characteristics are to predicting SRH. In Model A, the constant indicates that respondents have lower odds (OR: 0.10) of evaluating their health as poorer when the Gini coefficient is zero (i.e. perfect equality). The direction of the effect aligns with the hypothesis: perfect equality is associated with better health. However, since not all coefficients have a zero value that corresponds to reality (ex. a city with no population), the constant is often meaningless (Rabe-Hesketh & Skrondal, 2012). Level-2 variation remains strongly significant within each model, indicating the hierarchy of the data structure and some unexplained variation at the city-level. Adding population and median wages to Model B explains some of the variation, reducing the coefficient from an OR of 1.06 to 1.03. The unexplained variation in Models C and D indicates that there may be other city-level factors excluded that explain between city variation in SRH.

Overall, there is a modest association between city-level economic inequality and self-rated health in adjusted models. Categorizing the Gini coefficient shows that respondents in medium-low, medium-high, and highly unequal cities are more likely to rate their health poorer.

Results using 2006 data: Table 7 presents findings from the 2006 cross sectional models. Overall, higher economic inequality indicates an elevated odds of poorer SRH, although the association does not reach statistical significance. The association is non-significant when using a continuous Gini coefficient, and inconsistent when using the categorized coefficient. In Model D, cities with medium-high levels of inequality show a significant relationship with poorer SRH, where the OR of reporting poorer health is 1.17 (95% CI 1.02 – 1.34) compared to those who lived in low levels of inequality. Differing from 2001 results, 2006 results provide weak evidence in favor of the economic inequality and health hypothesis.

Results using 2011 data: As seen in Table 8, a one unit increase in the Gini coefficient is associated with a higher odds of poorer SRH; the association is statistically significant below the $p<0.05$ level in all models, except in Model A as observed for 2001 data. The Gini coefficient in Model B is significant at the 1% level, indicating high confidence that a one unit increase in the Gini coefficient is associated with an increased OR of 1.03 (95% CI 1.01 – 1.04). The fully adjusted Model C shows that for every one unit increase in the Gini coefficient, the OR of reporting poorer health increases by 1.02 (95% CI 1.00 – 1.04).

Table 7: Results of Multilevel Logistic Association between the Gini coefficient and Self-Rated Health, 2006

	Model A + Gini Coefficient OR (95% CI)	Model B + City Controls and Household Income OR (95% CI)	Model C [a] + Individual Controls OR (95% CI)	Model D [a] Categorized Gini Coefficient OR (95% CI)
Observations				
Individuals	95,521	95,521	95,521	95,521
Cities	130	130	130	130
Variables: City-Level				
Gini Coefficient:				
Continuous	0.99 (0.97-1.01)	1.01 (0.99-1.03)	1.01 (0.99–1.02)	
Categorical				
Low				1.00
Medium-Low				1.07 (0.94-1.23)
Medium-High				1.17* (1.02-1.34)
High				1.09 (0.92-1.29)
Median Wages:				
Low		1.00	1.00	1.00
Medium-Low		0.99 (0.86-1.15)	0.99 (0.86-1.14)	0.99 (0.86-1.14)
Medium-High		1.10 (0.94-1.27)	1.10 (0.95-1.28)	1.11 (0.96-1.28)
High		0.92 (0.78-1.10)	1.05 (0.88-1.24)	1.07 (0.90-1.27)
Population Size[b]		0.90** (0.84-0.97)	0.91* (0.85 - 0.98)	0.91** (0.85-0.97)
Individual Level				
Household Income[b]		0.19** (0.18-0.20)	0.37** (0.35-0.40)	0.37** (0.35-0.39)
Variation				
Constant	0.21** (0.11-0.41)	323.46** (74.18-600.68)	2.62** (1.43-4.81)	3.39** (2.22-5.19)
City-level Variation	1.05** (1.03-1.07)	1.03** (1.01-1.04)	1.02** (1.01-1.03)	1.02** (1.01-1.03)

** $p<0.01$, * $p<0.05$, † $p<0.1$

[a] Fully specified model. Includes visible minority status, marital status, age, sex, and employment status

[b] Variable is log transformed to base 10.

Table 8: Results of Multilevel Logistic Association between the Gini coefficient and Self-Rated Health, 2011

Variables	Model A + Gini Coefficient OR (95% CI)	Model B + City Controls and Household Income OR (95% CI)	Model C [a] + Individual Controls OR (95% CI)	Model D [a] Categorized Gini Coefficient OR (95% CI)
Observations				
Individuals	114,167	114,167	114,167	114,167
Cities	130	130	130	130
City-Level				
Gini Coefficient:				
Continuous	1.01 (0.99-1.03)	1.03** (1.01-1.04)	1.02* (1.00-1.04)	
Categorical				
Low				1.00
Medium–Low				1.31** (1.15-1.50)
Medium–High				1.38** (1.20-1.58)
High				1.24* (1.04-1.47)
Median Wages:				
Low		1.00	1.00	1.00
Medium-Low		0.92 (0.76-1.13)	0.96 (0.78-1.18)	0.94 (0.77-1.14)
Medium-High		1.06 (0.86-1.30)	1.11 (0.89-1.37)	1.07 (0.88-1.32)
High		0.98 (0.78-1.23)	1.18 (0.93-1.49)	1.23† (0.98-1.54)
Population Size[b]		0.87** (0.80-0.93)	0.88** (0.81-0.94)	0.87** (0.82-0.93)
Individual Level				
Household Income[b]		0.19** (0.18-0.20)	0.36** (0.34-0.38)	0.36** (0.34-0.38)
Variation				
Constant	0.10** (0.05-0.20)	321.56** (62.79-635.19)	3.44** (1.70-6.98)	5.90** (3.83-9.09)
City-level Variation	1.05** (1.03-1.07)	1.03** (1.02-1.04)	1.03** (1.02-1.04)	1.02** (1.01-1.04)

** $p<0.01$, * $p<0.05$, † $p<0.1$

[a] Fully specified model. Includes visible minority status, marital status, age, sex, and employment status.

[b] Variable is log transformed to base 10.

The categorized Gini coefficient in Model D appears to be larger in magnitude than in 2001. Compared to low inequality cities, respondents are more likely to rate their health poor in highly unequal, medium-high inequality, and medium-low inequality cities (OR 1.24: CI 1.04 – 1.47; 1.38: CI 1.20 – 1.58; 1.31: CI 1.15 – 1.50, respectively). These coefficients appear higher than those in previous time periods and have confidence intervals that do not include one, providing support for the argument that economic inequality has an effect on SRH in Canada. Association with other variables remain similar to those in previous time periods.

To summarize these findings, the top of Table 9 provides an overview of the economic inequality coefficients for the fully specified models in each time period. Models show mixed results, and the 2006 results appear to contradict those found in 2001 and 2011.

5.2. Robustness Checks

To check the robustness of results, I re-run models with alternate inequality metrics and household income coding (categorized to include non-responses). Results are presented in Table 9.

5.2.1. Alternative Economic Inequality Measures

Table 9 lists the results for the Gini coefficient representing economic inequality using total income. This Gini coefficient on total income takes into account transfers and estimates lower overall economic inequality than earnings (see Table 1). Results of analysis using the Gini coefficient of total income are similar to those using the Gini coefficient on wages.

The Theil Index provides a measure that better represents transfers at the top of the income distribution (Galbraith et al., 1998), whereas the Gini coefficient is more sensitive to the middle of the distribution (Lopez, 2004). Models using the Theil Index produces mixed results. When measured as a continuous variable, the strength of the association with SRH is higher than when inequality is measured using the Gini coefficient on earnings (OR 1.81 Theil Index versus OR 1.02 Gini Coefficient in 2001), yet the association is not statistically significant. When the categorized Theil Index is used, however, there is indication of an association between higher inequality and poorer SRH, but this association is only seen in and in 2001, living in cities categorized in the medium-low or in medium-high inequality and not in higher inequality cities.

In 2011, coefficients are also similar to those found using the Gini coefficients, although of smaller magnitude. Deviating from results using the Theil Index in other years, the 2011 results show significance at the p<0.05 level for medium-low and medium-high inequality cities. Unlike the 2001 results, the confidence intervals no longer pass a zero value. Results for the Theil index for 2006 are consistent with previous metrics, finding no significant relationship.

Table 9: Association between Inequality and Self-Rated Health using Different Measure of Economic Inequality

	2001	***2006***	***2011***
Observations			
Individuals	130,495	95,521	114,167
Cities	130	130	130
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Gini: Earnings			
Continuous	1.02* (1.00-1.04)	1.01 (0.99-1.02)	1.02* (1.00-1.04)
Categorized:			
Low	1.00	1.00	1.00
Medium – Low	1.15* (1.02-1.30)	1.07 (0.94-1.23)	1.31** (1.15-1.50)
Medium – High	1.16* (1.03-1.30)	1.17* (1.02-1.34)	1.38** (1.20-1.58)
High	1.17* (1.02-1.35)	1.09 (0.92-1.29)	1.24* (1.04-1.47)
Gini: Total Income			
Continuous	1.03** (1.01 - 1.05)	1.01 (1.00 - 1.03)	1.02** (1.01 - 1.04)
Categorized:			
Low	1.00	1.00	1.00
Medium-Low	1.15* (1.01-1.31)	0.96 (0.84-1.10)	1.27** (1.11-1.45)
Medium-High	1.17* (1.02-1.33)	1.02 (0.88-1.17)	1.29** (1.12-1.49)
High	1.20* (1.03-1.41)	1.00 (0.84-1.19)	1.29** (1.08-1.55)
Theil Index			
Continuous	1.81 (0.69-4.73)	1.20 (0.63-2.31)	1.92 (0.78-4.76)
Categorized:			
Low	1.00	1.00	1.00
Medium-Low	1.15† (1.00-1.32)	1.02 (0.86-1.22)	1.23** (1.05-1.45)
Medium-High	1.18* (1.02–1.37)	1.09 (0.91–1.32)	1.27** (1.08-1.51)
High	1.15 (0.96–1.39)	1.06 (0.86–1.31)	1.20† (0.97-1.49)
Percentile Ratios			
Continuous	1.04** (1.01-1.08)	1.03 (0.98-1.07)	1.05* (1.01-1.08)
Categorized:			
Low	1.00	1.00	1.00
Medium-Low	1.24** (1.10–1.39)	1.14* (1.01–1.29)	1.28** (1.13-1.45)
Medium-High	1.26** (1.11–1.43)	1.09 (0.96–1.23)	1.33** (1.17-1.51)
High	1.30** (1.10–1.53)	1.14† (1.00–1.31)	1.31** (1.09-1.57)

** p<0.01, * p<0.05, † p<0.1; models with the continuous and categorized coefficients are run separately and control for household income, age, sex, employment status, visible minority status, and marital status.

Percentile Ratios provide a picture of the percentage of earnings going to the top 10% of income earners compared to earnings going to the bottom 10%. Overall, Percentile Ratio measures have a similar pattern than the Gini Coefficient. There is an increased odds of a respondent rating their health poorer in 2001 (OR 1.04; 95% CI 1.01-1.04) and in 2011 (OR 1.05; 95% CI 1.01-1.08) for each unit increase in the Percentile Ratio.

By using alternative metrics of economic inequality, I find that results are generally robust to the choice of the measure of income inequality. The Gini coefficient using total income and Percentile Ratios returned very similar results to the Gini coefficient calculated using earnings. Although the continuous Theil Index results are not significant, once categorized into different levels of inequality they followed a similar pattern to results using the Gini coefficient of earnings, especially in 2011. Overall, these results indicate that the relationship between inequality and poorer health holds across different metrics of economic inequality, which is not surprising given the high correlation between these metrics (see Appendix B; the correlation matrix does not include percentile ratios).

5.2.2. Alternative Household Income Measure

Models C and D are also run using categorized household income at the individual-level, where categorization is based on Statistics Canada’s income brackets. This categorized household income includes respondents who did not answer the household income survey question in a separate category to increase sample size. Table 10 presents the results using the categorized household income and the Gini coefficient of earnings. Including non-responses to the household income question did not change the overall results.

Table 10: Association between Inequality and Self-Reported Health with Categorized Level-1 Household Income

	2001	***2006***	***2011***
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Observations			
Individuals	172,753	132,982	129,319
Cities	130	130	130
Gini coefficient:			
Continuous	1.02* (1.00-1.03)	1.01 (0.99-1.02)	1.02* (1.00-1.04)
Categorized			
Low	1.00	1.00	1.00
Medium-Low	1.12* (1.01-1.25)	1.09 (0.97-1.24)	1.33** (1.17-1.50)
Medium-High	1.14* (1.03-1.27)	1.18* (1.04-1.33)	1.39** (1.22-1.58)
High	1.13† (1.00-1.29)	1.09 (0.93-1.27)	1.24** (1.05-1.46)

** p<0.01, * p<0.05, † p<0.1; models with the continuous and categorized coefficients were run separately and control for household income, age, sex, employment status, visible minority status, and marital status.

5.2.3. Three-level Provincial/Territorial Models

In Canada, there are social, economic, and cultural differences between provinces, including the provision of health care. In this section we control for such provincial-level effects by re-estimating the fully specified models of section 5.1 with a third provincial/territorial level using Equation 4. In Table 11, individuals are nested within cities within provinces/territories. There are a maximum of 40 cities a minimum of one city per province/territory (see Table 2).

Table 11: Association between Inequality and Health: Three-Level Provincial/Territorial Models

	2001: Model A	***2001:*** Model B	***2006:*** Model A	***2006:*** Model B	***2011:*** Model A	***2011:*** Model B
Observations						
Individuals	130,495	130,495	95,520	95,520	114,165	114,165
Cities	130	130	130	130	130	130
Provinces/Territories	12	12	12	12	12	12
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
City Characteristics						
Gini Coefficient:						
Continuous	1.01 (0.99-0.93)		0.99 (0.98-1.01)		1.00 (0.99-1.02)	
Categorized:						
Low		1.00		1.00		1.00
Medium-Low		1.10 (0.98-1.23)		1.01 (0.88-1.16)		1.18* (1.03-1.34)
Medium-High		1.10 (0.98-1.24)		1.02 (0.87-1.18)		1.18* (1.02-1.38)
High		1.10 (0.95-1.27)		0.94 (0.78-1.13)		1.09 (0.91-1.30)
Random Parameters						
Level-1 between individual variation	1.28 (0.65-2.52)	1.84** (1.31-2.56)	4.12** (2.17-7.81)	3.19** (2.12-4.79)	6.12** (3.11-12.06)	6.10** (4.08-9.11)
Level-2 between city variation	1.01** (1.01-1.02)	1.01** (1.01-1.02)	1.01** (1.00-1.02)	1.01** (1.00-1.02)	1.02** (1.01-1.03)	1.02** (1.01-1.02)
Level-3 between province/territory variation	1.01 (1.00-1.01)	1.01 (1.00-1.01)	1.01 (1.00-1.03)	1.01 (1.00-1.03)	1.01† (1.00-1.03)	1.01† (1.00-1.02)

** p<0.01, * p<0.05, † p<0.1; models with the continuous and categorized coefficients were run separately and control for city-level median wages, population , individual-level household income, age, sex, employment status, visible minority status, and marital status.

After including provinces/territories as a third level in the multilevel model, the association between economic inequality and SRH no longer reach statistical significance, except for the categorical measure of income inequality measured in 2011. In this model, in comparison to living in cities with lower levels of inequality, living in cities with medium-low or medium-high inequality (but not in cities characterized by high inequality) is associated with greater odds of poorer health.

Overall, adding third-level provinces/territories to the models seems to weaken the effect of economic inequality. However, as sample size is an important factor in reaching statistical significance, it is important to note that Canada has few provinces and territories, where only 12 are included in these models. Further there are limited sample sizes in certain provinces and territories: five level-3 units have had less than five cities, including the two territories, which have only one city each. This may reduce the ability of the models to detect significance; these five are Manitoba, Yukon, Northwest Territories, Prince Edward Island, and Newfoundland and Labrador. The limitations of these models are fully explored in Chapter 6 and I suggest further research avenues to clarify how provincial variation might impact the association between economic inequality and SRH.

The results exploring the association between economic inequality and health in Canada are mixed. Consistently, 2001 and 2011 cross-sectional results indicate a significant relationship between higher economic inequality and poorer SRH. But I do not observe such association for 2006. These results are robust to alternative measures of economic inequality and household income categorization, but the effect disappears once adding provinces/territories to the models. The next section explores these results in comparison to the literature.

CHAPTER 6
DISCUSSION

This study used merged data from the Canadian Census and the CCHS to investigate the association between economic inequality and SRH within Canadian cities. The findings provide further evidence to the body of literature investigating whether or not economic inequality impacts population health internationally and narrows in on Canada, where the scientific evidence are mixed. The descriptive results show how economic inequality is changing in Canada, where cities have, in general, experienced increases in economic inequality between 2001 and 2011. After exploring data at the city-level, multilevel logistic regression models provide answer the research question "*Is economic inequality associated with a general measure of health in Canadian cities?*" The main findings are as follows.

Economic inequality grew at a more moderate rate between 2001 and 2011 compared to previous decades in Canada

The descriptive results on economic inequality are in line with other research, but suggest that economic inequality is growing at a slower rate than previous time periods and possibly leveling off following the 2008 Great Recession. Figure 1 by Veall (2012) on p. 2 illustrates how income going to the top 1% of earners has gone through substantial changes since 1920. As seen on the right side of Figure 1, there is a general plateau in values after 2000, with small increases and decreases relative to previous changes. The descriptive data in this thesis show that economic inequality between 2001 and 2011 went through similarly small fluctuations to those found by Veall (2012), although differing in measurement (national vs city-level, and percentiles vs. the Gini coefficient). In this analysis, peak city-level economic inequality comes in 2006, the second highest level in 2011, and the lowest levels in 2001. This could indicate a leveling off of economic inequality in the 21st century. However, published data of the percent of all national income going to certain income group (i.e. the top 10% or bottom 10% of earners) from the 2016 Canadian census, however, indicate that economic inequality increased between 2011 and 2016 (Jackson, 2017). Data from the 2016 census will be important to understanding how economic inequality impacts health most recently, as the quality of data in 2011 is not as strong as previous census years (although 2016 data were unavailable at the time of writing; Statistics Canada, 2015c).

This thesis finds comparable sub-national patterns of economic inequality to previous research. Breau (2015) observes that economic inequality rose 9.1% between 1996 and 2006 for urban Census Divisions. Bolton and Breau (2012) find that economic inequality increased 3.8% between 1996 and 2006 using fewer CMAs and CAs. Updating the analysis to 2011, this study finds that city-level economic inequality increased by 3.0% between 2001 and 2011, slightly lower than both Breau (2015) and Bolton and Breau (2012). Again, this mirrors the overall trend that economic inequality in Canada seems to be plateauing at current levels.

From a spatial perspective, urban economic inequality mirrors results found by Breau (2015) and Bolton and Breau (2012). In his spatial analysis of economic inequality at the Census Division level, Breau (2015) finds Quebec, the Yukon, and the Northwest Territories to have substantially lower economic inequality than the rest of the country. At the city-level, Bolton and Breau (2012) find the same. As argued in Chapter 4, the most equal cities in Canada in 2011 were located in Quebec and included a city in the NWT, Yellowknife. As Bolton and Breau (2012)'s analysis included data up to 2006, this thesis finds that cities with the lowest inequality in 2006 have remained relatively equal in 2011.

Findings for the size of cities are also comparable. Bolton and Breau (2012) find that larger cities in Canada tend to have higher levels of economic inequality. In this thesis, two of the three largest cities in Canada are in the top ten most unequal cities in 2011, Toronto and Vancouver (see Table 5). Further, the most unequal city in the study is Canada's fourth largest city, Calgary. Our results on economic inequality trends are thus similar to previous findings.

Multilevel logistic regression results find a moderate association between higher economic inequality and poorer self-rated health, differing from previous Canadian studies

This study built upon previous work by using a large, up-to-date dataset that differentiated between individual and city-level effects over a ten-year time period. The main findings are that models detect an association between higher economic inequality and poorer SRH after adjusting for individual-level income and other covariates, as well as for city-level characteristics such as population size. However, results are not consistently found in each time period.

Contradictory to previous Canadian studies, this thesis observes a relationship between economic inequality and population health. Only one multilevel study in Canada, Xi et al. (2005), previously found an association between economic inequality and SRH. The authors use a categorical Gini coefficient to find an OR of 1.20 in highly unequal Ontario health regions. This is similar to my findings, where people living in a highly unequal city in 2001 were 17% more likely to rate their health as poor, and 24% more likely in 2011. Xi et al. (2005) use data from the 1996 census and Ontario Health Survey, and their higher OR indicates that highly unequal health regions in Ontario increase the odds more than highly unequal cities in all of Canada in 2001, the most comparable time period in this analysis.

Several studies find modest effects on SRH. Most cross-sectional studies using SRH find an association between higher economic inequality and poorer SRH (Aida et al., 2011; Craig, 2005; Fiscella & Franks, 1999; Kennedy et al., 1998; Li & Zhu, 2006; Lopez, 2004; Oshio & Kobayashi, 2010; Shi & Starfield, 2000; Subramanian & Kawachi, 2006; Subramanian et al., 2001; Subramanian et al., 2003; Xi et al., 2005), although some additional studies find mixed or no effects (Blakely et al., 2002; Carlson, 2005; Gravelle & Sutton, 2009; Karlsdotter et al., 2012; Leclere & Soobader, 2000; Lorgelly & Lindley, 2008; McLeod et al., 2003; Mellor & Milyo, 2003; Quon & McGrath, 2014; Rostila et al., 2012; Shibuya et al., 2002; Sturm & Gresenz, 2002; Weich et al., 2002; Wong et al., 2009; Zheng, 2009). This thesis finds mixed effects, as the association was observed in 2001 and 2011, but not in 2006.

The magnitude of effect in previous studies varies, although the study design differed (see Appendix A for study details). When studies use continuous metrics of economic inequality the OR generally remains under 1.10 for each unit increase in the economic inequality metric. For example, the most comparable results were those found by Lopez (2004) in U.S. cities. Lopez (2004) finds an increased odds of 1.04 for every unit increase in the Gini coefficient. In this thesis, the 2001 and 2011 results are associated with an increased odds of 1.02 for each unit increase in the Gini coefficient. Lopez (2004) uses city-level economic inequality measures, corroborating evidence that the city-level may be an important scale at which processes of economic inequality can impact health. However, other evidence still contradicts our findings. Blakely et al. (2002) in the U.S. and Sturm and Gresenz (2002) find no association between a categorized Gini coefficient and SRH at the city-level after controlling for average city income. It is possible that Sturm and Gresenz (2002) do not find an association due to the relatively small sample of individuals in their study (9,585 individuals), but this does not explain the null results of Blakely et al. (2002).

Categorical results in this study are similar in magnitude and direction to previous studies. Kennedy et al. (1998) detects that those who live in medium-low inequality are at an increased odds in highly unequal U.S. cities to rate their health poorer. In the U.S., Shi and Starfield (2000) reported a stronger effect at the state-level. Shi and Starfield (2000) run their models to test the odds of higher good, very good, and excellent health responses, as opposed to most studies that test the odds of poorer health (including this thesis). They find an odds of reporting better health ranging from 16% in medium-low inequality to 33% in low inequality relative to high inequality: the same direction and magnitude found in this thesis.

Previous studies find mixed results using data that cover all of Canada in a multilevel framework. McLeod et al. (2003) find no relationship between city-level economic inequality and SRH, and Auger et al. (2012) find mixed effects on mortality. Auger et al. (2012) find that the effects of economic inequality on mortality are not present on the entire Canadian urban population, but only those who were born in Canada. As discussed by Auger et al. (2012), immigrants are generally healthier than the Canadian born population and largely reside in cities. Because of this, Auger et al. (2012) tested the relationship between economic inequality and mortality on samples including and excluding immigrants. They find no effect of economic inequality on mortality when recent immigrants (past ten years) are included, but do find a strong and robust effect on Canadian-born people. In my thesis, I observe an association for the whole sample of participants.

Using a repeat cross-sectional dataset with three time points added to the multilevel evidence. The association is observed in two of the three time points only, 2001 and 2011, when adjusted for individual and city level covariates such as household income and population size. The fact that economic inequality only becomes a significant predictor once we adjust for household income, population size, and median income (Model B), also indicates the necessity to consider both individual- and city-level variables in this research. It is once these variables are included that researchers can isolate the effect of economic inequality: holding household income, population size, and median income constant to see how economic inequality impacts health (or SRH in this thesis). This is important, as the theory outlined earlier in this thesis shows that excluding individual-level income can result in other interpretation of the economic inequality coefficient (i.e. measuring concentrated poverty). Results differed in the 2006 models; this may be due to this year's smaller sample size or possibly result from different socio-economic conditions in 2006 (further discussed later; Subramanian & Kawachi, 2007). This study adds to the growing body of literature testing economic inequality and health using multilevel models, especially in the Canadian context where few scholars use the multilevel design on a national dataset (Auger et al., 2012; McLeod et al., 2003).

This thesis contributes evidence about the importance of city-level processes between economic inequality and health. Harvey (1985) proposed that cities are "the primary level" where people learn their place in society. This research focuses on the city-level to explore broadly if city-level characteristics can change the social and political relations in a way to impact the residents' health. Harvey's comments show how city-level economic inequality relates to the pathways of the psychosocial, neo-material, and social capital and pathways influencing health. Particularly his comment regarding "forms of domination and social interaction" shows how cities influence social cohesion, and "the relations of nature through production and consumption; and of human nature, civil society and political life" which reflects city-level capitalist distribution of goods that could be beneficial or deteriorating to health, the neo-material hypothesis. Further research is required to explore how these city-level processes may explain the inequality-health association in Canada in order to identify potential mitigation policies.

Exploring characteristics of cities in the descriptive analysis brought forward questions on the potential presence of other differentiating factors that are particular to certain cities, such as urbanization or population size, that could modify the effect of economic inequality on health (Blakely et al., 2002; Dunn et al., 2007). For example, Alberta is experiencing some of the highest levels of inequality and is also located in a province heavily reliant on the oil industry (Okkola & Brunelle, 2018). The rapid growth in jobs and income from the oil industry has led to a change in the labor structure with results in housing affordability (Okkola & Brunelle, 2018) and larger gender pay gaps (Harris et al., 1986; Treasury Board & Office of Statistics and Information Status on Women, 2017). However, the largest city in Alberta, Calgary, also has very high median income (~$52,000 in 2011) and as a large city has good access to health services (Sibley & Weiner, 2011). A few small cities also ranked high in economic inequality, such as Elliot Lake. It is possible that people in smaller cities with high levels of inequality but without these established service may feel the pathways to poorer health earlier, such as mental health (Pickett & Wilkinson, 2010) and decreasing social cohesion (Kawachi et al., 1996). Although this study does not investigate geographic peculiarities in depth, the descriptive results indicate potential differences between types of cities and new ‘threshold’ or differentiating factors beyond development and level of inequality that should be further investigated (particularily population; Dunn et al., 2007).

Another debate relates to the country of analysis, where within-country relationships between economic inequality and health are not observed systematically in relatively more equal countries. Studying Canada provides evidence from a country with moderate levels of economic inequality compared to other nations and suggests that even countries with modest levels of economic inequality can experience sub-national effects of economic inequality.

The association between economic inequality and health is robust to alternate measures of economic inequality

Another methodological debate in economic inequality and health studies is the choice of the inequality metric. Models in Section 5.2 included alternate measures of economic inequality. These additional analyses test if the relationship holds when using different metrics of economic inequality sensitive to different parts of the income distribution, and provide points of comparison with other studies using alternative measures. In addition to using the Gini coefficient, other studies also use the Theil Index, and/or the 90/10 Percentile Ratio to examine the association with SRH and/or mortality. As total income results are comparable to earnings results in this thesis, I do not compare studies using the Gini coefficient of total income.

I find that there is a significant association between higher economic inequality as measured using the Theil Index and poorer SRH when the Theil Index is categorized in 2011 and partly in 2001, but not in 2006. Using the Theil Index, Karlsdotter et al. (2012) and Weich et al. (2002) did not observe an association with SRH. Zheng, however, finds a significant relationship between higher inequality and poorer SRH (2009) and higher mortality rates (2012). Zheng (2012) uses data over time to find that compared to their main economic inequality metric, the Gini coefficient, the Theil Index has a statistically significant effect on mortality in earlier years than the Gini coefficient. Yet, when Zheng (2009) tests how the Theil Index compared to the Gini coefficient using SRH data over time, they find a smaller effect size. Zheng (2009)'s study predicts an increased odds of 1.09 from 1972 to 2004 (a period of increasing inequality), and an increased odds of 1.04 using the Theil Index.

This research found that the 90/10 Percentile Ratio showed values that were significant at the $p<0.01$ level in both the continuous and categorized Gini coefficients in 2001 and 2011 (except the 2011 continuous coefficient) and had larger OR than comparative coefficients using other metrics in the same year. Other scholars found similar results. Craig (2005), who uses both the Theil index and percentile ratio, stated that "using [them] instead of the Gini coefficient made no difference to the other estimated parameters" (p. 2482), concluding that "methodological choices regarding the ways of estimating the association between self-assessed health…. and area-level income inequality may not make a substantive difference to the results…" (p. 2477). However, they did not specifically report the coefficient and confidence intervals for their 90/10 estimates, so it is difficult to know how their ratio compared to their Gini coefficient estimate. Lorgelly and Lindley (2008) do not find the 90/10 ratio to change their null results between SRH and regional economic inequality in Britain.

Of the previous Canadian studies, only Auger et al. (2012) uses multiple measures of economic inequality to check robustness. Auger et al. (2012) uses the Atkinson Index and the

Coefficient of Variation. Their results are not robust to the Coefficient of Variation, but were to the Atkinson Index, which is a measure that includes sensitivity to a pre-specified part of the income distribution, in their case to differences at the bottom of the distribution. It could be that in Canada, results are more sensitive to changes at the bottom of the income distribution (i.e. the amount of national income going to the bottom 10% of earners).

The sensitivity measures included in this thesis allow for more comparisons to other studies and to understand different parts of the income distribution. It is difficult to directly compare these measures to other studies, as often results for the robust measures are not reported in as much depth as the Gini coefficient. That said, it seems that other studies finding a strong consistent relationship with the Gini coefficient also often lack results that are robust to alternative measures (De Maio, 2007). In this thesis, statistical significance was lost when using the continuous Theil Index as a measure of economic inequality, whereas results were similar when using the percentile ratios. Future research in Canada should include measures specifically sensitive to the bottom of the distribution, as there seems to be a particular effect when there are changes in the amount of income going to low-income people.

Higher economic inequality is associated with poorer SRH in 2001 and 2011, but not 2006

This thesis examines whether the association between economic inequality and health varies over a ten-year period. To my knowledge, this is the first repeat cross-sectional research in Canada and shows how the association differs for different time periods and also as the overall composition of the urban population changes. In addition to the results showing that higher levels of economic inequality are associated with poorer health status in cities, the results show that this is the case in two time periods in Canada, providing stronger evidence for the hypothesis. The effect also seemed to be strongest in 2011, yet confidence intervals between all of the time periods overlap. Nonetheless, it is possible that the survey design of the CCHS or a voluntary response to the NHS explains this difference. The 2011 models include respondents with higher income and fewer missing data from household income; only 11% of respondents did not report their income compared to 25% and 28% in the earlier time periods (see Table 3). However, it could also be that after the 2008 Great Recession economic inequality's impact on health increased, especially since the sample is limited to the labor force population and by including respondents' employment status.

Analyzing the economic inequality and health hypothesis in different time periods also suggests nuances to the association. The 2001 and 2011 data represent economic cycles that are more similar, whereas the 2006 data represent Canada pre-recession, when certain provinces, such as Alberta, were experiencing great economic gains. As 2006 shows as an anomaly, scholars can begin to test why, and whether or not there are certain political or social circumstances that masks the association found in 2001 and 2011. For example, why do the 2006 results consistently reject the economic inequality and health hypothesis? Is the association more pronounced in post-recession time periods than during pre-recession economic booms? If this is the case, it may explain some of the variation in overall results that are found both in Canada and internationally. It may also help to narrow potential pathways between economic inequality and health defined in the conceptual debates. For example, if economic inequality truly decreases social cohesion, it may be in post-recession times that the impacts of inequality are felt more strongly than in pre-recession times where people are more able to provide for themselves and their families. Although, it is also possible that the 2006 results are the outcome of a peculiarity in representation of the CCHS dataset.

Provincial-level fixed effects obfuscate the previously found association

Provinces are included to account for the shared cultural, social and economic circumstances and policy between cities in the same provinces/territories (Breau, 2015). The models including provinces/territories as a third level with a random intercept indicate that clustering at the provincial/territorial level may explain the variation in SRH that was previously attributed to economic inequality. After including the third level, only the categorized Gini coefficient in 2011 maintained significant values.

However, Jones (1991) calls attention to how including levels with few groupings can limit the power of the model to detect significant relationships. Jones (1991) states that "the precision of the estimate depends on the number of units at [each] level" (p. 25). Therefore, as there are few provinces/territories included in the model (n = 12), there may be limits in understanding how provincial and territorial variation in health impacts the relationship at the city-level. Further, the two territories had only one city observation each: Yukon and Northwest Territories, and three provinces had less than five cities: Manitoba, Newfoundland and Labrador and Prince Edward Island. I plan to explore this issue in further analyses, as the provincial geography plays an important role in health in Canada.

There seems to be a complicated relationship between economic inequality and SRH in Canada. With a goal of increasing population health in Canada, these results are in line with a broader literature suspecting a degrading effect of economic inequality on society (e.g. Pickett & Wilkinson, 2015). The thesis provides more evidence from Canada, evidence that should encourage researchers to further investigate why 2006 does not consistently find higher economic inequality to be related to poorer health.

CHAPTER 7
CONCLUSIONS

This thesis contributes to the overall debate on the economic inequality and health hypothesis by providing specific insights into the Canadian context in several ways. Previous studies focused on one time period, limiting the sample and context. As discussed, the three time periods analyzed in this thesis test the economic inequality and health hypothesis in different social, economic, and political circumstances and the changing demographics of Canada. The 2006 results remain peculiar, and future studies should examine why, as it may provide more evidence to the null associations found elsewhere.

This study also adds evidence using a multilevel data structure at the city-level. Only four previous Canadian studies use a multilevel structure, which is now considered the gold standard to test the economic inequality and health hypothesis (Auger et al., 2012; McLeod et al., 2003; Quon & McGrath, 2014; Xi et al., 2005). To my knowledge, no other previous scholars merge the CCHS dataset and the census to create a large dataset testing the hypothesis using SRH at the city-level over three time periods. Although two of the four multilevel studies in Canada use the city-level, they come to different conclusions. This work indicates that city-level economic inequality may have important pathways to health. This could be especially important in Canada, as most people live in cities (Statistics Canada, 2018a).

This study also uses two other measures of economic inequality to test how different parts of the income distribution impact health. It is important to understand what changes in the distribution cause the biggest impact, and only one other Canadian study uses multiple measures to test differences (Auger et al., 2012). The Gini coefficient is not always a good indicator for changes at the top and bottom of the income distribution and the Theil Index or Percentile Ratios represent these changes. Knowing where changes in the income distribution impact population most leads to different policy approaches. Results reported in this thesis suggest that economic inequality that is sensitive to changes in the amount of income going to the bottom of the income distribution has the most consistent effect, using the percentile ratios, and is fairly consistent using the Gini coefficient that is sensitive to the middle of the distribution.

Limitations

While working on this thesis, I encountered limitations that could be addressed in future research. First is the quality of the 2011 NHS data in Canada. The 2011 NHS was voluntary, and may not be representative of the population, especially in some of the smaller cities in the sample. In order to be defined as a city, the population has to be over 10,000, but if response rates are low, this could create non-representative measures of economic inequality at the city-level. This is of particular concern, as the results of this thesis in 2011 point strongly to economic inequality impacting health and thus may be bias. To ensure this accurately represents the Canadian situation, further research should use the updated data from the 2016 Canadian census to check robustness of results.

There are further data limitations from the CCHS datasets. As stated in Section 4.1., the CCHS data did not represent the mix of economic status in the Canadian population. There are more middle-income respondents than low and high-income respondents in the CCHS, which is most likely due to the voluntary nature of the survey. This limits inference of results to the broader population. Often researchers use CCHS weights to create a more representative sample, however these weights are used to create estimates at the Health Region level and not the city-level and therefore were not applied in this research. Possibilities exist to use the health region level to test the hypothesis, although measuring inequality at this level lacks theoretical justification.

Policy implications

The results of this thesis find a modest effect of economic inequality on health for 2001 and 2011, building evidence on why to add economic inequality to health policy. Beyond the modest association found in this thesis, there are further reasons to promote economic equity based on principals of fairness (see, for example, Smith, 1994).

Researchers generally investigate tax reform as a strategy to mitigate economic inequality. Alvaredo et al. (2018) suggest progressive taxation on the top income earners, which they claim mitigates both pre-tax income (earnings in this study) and post-tax inequality (total income in this study). Alvaredo et al. (2018) also advocate for a global financial registry to prevent tax avoidance by companies and top income earners. At the moment, drastic changes are not being made to Canada's tax system. Boadway and Cuff (2013) describe how Canadian tax policies are impacting the poorest citizens because they are less re-distributive than in the past. Some changes they cite are savings plans that only incentivize middle and higher income Canadians to save, how real welfare income has fallen significantly, and how the elimination of the inheritance tax "reduces progressivity at the upper end" (p. 353).

There are other policy options to mitigate economic inequality. Policy could include higher minimum wages, and better working benefits to increase the share of income going to the bottom of the income distribution. Many movements across Canada advocate these changes, and one prominent example is the previous Liberal government of Ontario that passed policy to increase the minimum wage to $15 (a movement that is also popular in Quebec). Other opportunities to mitigate economic inequality include better investment in social programs such as education (Alvaredo et al., 2018).

This research can also influence health policy. Discussions on the pathways between economic inequality and general health call attention to gaps in healthcare such as access to healthcare (neo-material hypothesis), mandated vacation allowing time to spend with family and friends (social cohesion hypothesis), and better investments in mental health and support services (psychosocial factors). The policy implications of these pathways are vast, and much more research has already been done on the specifics of health promoting (or deteriorating) factors.

Future research

This work leads to many possibilities for future research. Within-city research could explicitly tie economic inequality to certain processes that impact health, such as gentrification or availability of affordable housing (Walks, 2011). This will provide specific and achievable policy goals for governments, especially as the economic inequality and health hypothesis can seem out of reach to governments who have restricted jurisdiction.

Secondly, this research could benefit from further analysis at different scales, benefiting both the Canadian and broader literature. Although the provincial scale is limited by sample size, more work to understand why provincial fixed effects remove the relationship between economic inequality and health could benefit researchers trying to answer this complex hypothesis. Blakely et al. (2002) studies the difference between urban and rural economic inequality, and finds rural areas with higher economic inequality to have a stronger association with health. This is an interesting distinction, and one that should receive more attention.

Further work could be fruitful in determining which health outcomes and health-related risk factors are most impacted by economic inequality and the pathways through which economic inequality influence health. This thesis uses SRH, but associations might have been stronger with other health outcomes. Knowing specifically what part of overall health is most effected could lead to better mitigation and preventive measures, and draw insight into the pathways between economic inequality and health. To my knowledge, there is no work specifically on the pathways between economic inequality and health in Canada.

Finally, research further examining changes in different parts of the wage distribution (decreasing middle class, increasing relative poor) and its impact on SRH may provide a clearer picture on how to mitigate the small, yet seemingly present relationship between economic inequality and health. Both this study and Auger et al. (2012)'s study found economic inequality changes at the bottom of the distribution to have an impact on health. Therefore this may be an important aspect in understanding the Canadian relationship between inequality and health. This domain of research still has much to be done, and I encourage researchers to continue to explore its many facets.

APPENDIX A

Table 12: Detailed Information on Articles from Literature Review

	COUNTRY, SCALE	HEALTH OUTCOME(S)	INCOME INEQUALITY MEASURE(S)	RESULTS [a]	STUDY YEARS	SAMPLE SIZE	NOTES
INTERNATIONAL STUDIES							
Ecological Studies							
Daly et al. (2001)	U.S., States; Canada; Provinces			Significant Effect			
Duleep (1995)	International Comparison	Mortality	Gini	Significant Effect	1977	37 Countries	
Judge (1995)	International and Britain	Life Expectancy	Gini	No Effect	Mid 1980s; 1961 to 1991	9 Countries	
Kaplan et al. (1996)	U.S., State	Mortality	Percentage of Income going to the Bottom 50% of Income Earners (P50)	Significant Effect	1980 and 1990	50 States	
Kennedy et al. (1996)	U.S., State	Mortality, Infant Mortality	Robin Hood Index and Gini	Significant Effect	1989-1991	50 States	
Le Grand (1987)	International Comparison	Mortality	P20	Significant Effect	1982	32 Countries	
Lynch et al. (2001)	International Comparison	Mortality; SRH	Gini	Mixed Effect	1989-1992	16 Countries	
Mellor and Milyo (2001)	Countries; U.S., States	Life Expectancy, Infant Mortality + Others	Gini	No Effect	1960-1990; 1950-1990	30 Countries; 48 States	Used many health outcomes at the state level

Preston (1975)	International Comparison	Mortality	N/A	N/A	1900, 1930, and 1960	10, 38, and 57 Countries	Investigation of country GNP and mortality only at three time periods
Rogers (1979)	International Comparison	Mortality	Gini; Income Quintile	N/A	Unclear	56 Countries	
Wilkinson (1986)	International Comparison	Life Expectancy	Unclear	Significant Effect	1971	9 Countries	No statistics; just association
Wilkinson (1990)	Britain, Occupational Leagues (not geographical)	Mortality	Proportion unemployed; Proportion on low relative earnings	Significant Effect	1971 and 1981	64 Occupations	
Wilkinson (1992)	N/A	N/A	N/A	N/A	N/A	N/A	Commentary piece – reviews others evidence
Wilkinson et al. (1998)	U.S., States	Race-specific Homicide, Firearm Homicide, Firearm Assault, Firearm Robbery	Robin Hood index	Significant Effect	1986 to 1990	39 States	
Systematic Reviews and Meta-Analyses							
Kondo et al. (2009)	Various	SRH, Mortality	Various	Significant Effect	Various	Various	
Ngamaba et al. (2018)	Various	Subjective Well-Being (including SRH)	Various	Mixed Effect	Various	Various	

Pickett and Wilkinson (2015)	Various	Not Specified	Various	Significant Effect	Various	Various	
Subramanian and Kawachi (2004)	Various	Mortality, SRH (among other)	Various	Mixed Effect	Various	Various	Strongest in countries with overall higher levels of inequality
Multilevel Studies							
Aida et al. (2011)	Japan, Local Districts	SRH	Gini	Significant Effect	2003	79 Districts; 3451 Individuals	
Backlund et al. (2007)	U.S., State	Mortality	P50	Mixed Effect	1989	50 States; 521,248 Individuals	Only the population under 65 showed a significant effect
Blakely et al. (2002)	U.S., Cities	SRH	Gini grouped into four categories (mean +/- standard error)	No Effect	1990 Gini; 1996/8 SRH	232 Cities; 259, 762 Individuals	
Blakely et al. (2003)	New Zealand, Regions	Mortality	Gini	No Effect	1991-4	35 Regions; 1.4 million Individuals	
Carlson (2005)	Russia, Regions	SRH	Gini	Mixed Effect	1998	38 Regions; 7,696 Individuals	Significant effect only on men
Clough-Gorr et al. (2015)	Switzerland, Cities	Mortality	Gini grouped into five categories (quintiles)	Opposite Effect	2000	2,740 Cities; 35.5 million Individuals	Included urbanization, nationality, and language as second-level control variables.

Craig (2005)	Scotland, Cities	SRH	Gini, 90/10 percentile ratio, Theil Index	Significant Effect	1999, 2000	32 Cities; 18,466 Individuals	
Dahl et al. (2006)	Norway, Economic Regions	Mortality	Gini	Significant Effect	1994-9	88 Regions; > 2 million Individuals	
Daly et al. (1998)	U.S., State	Mortality	Percentiles: P10, P20, P50, P80, P90	No Effect	1980-90		Not explicit multilevel framework
Fiscella and Franks (1997)	U.S., Communities	Mortality	P50	No Effect	1971-5, 1987	105 Communities ; 14,407 Individuals	Communities were a modified county
Fiscella and Franks (1999)	U.S., National	SRH, Mortality	P50	Mixed Effect	1982-7	14,407 Individuals	Significant effect on SRH, not mortality
Gerdtham and Johannesson (2004)	Sweden, Communities	Mortality	Gini	No Effect	1980-6	Not stated; Over 40,000 Individuals	
Gravelle and Sutton (2009)	U.K, Regional and National	SRH	Gini	Mixed Effect	1979-2000	19 Regions; 231,208 Individuals	Significant effect in Regions
Henriksson et al. (2006)	Sweden, Cities	Mortality	Could not find.	No Effect	Missing	284 Cities; > 2 million Individuals	
Karlsdotter et al. (2012)	Spain, Regions	SRH	Gini, Theil Index, Atkinson Index	No Effect	2007	17 Regions; 28,023 Individuals	
Kennedy et al. (1998)	U.S., States	SRH	Gini grouped into four categories (mean +/- standard error)	Significant Effect	1990-2 Income; SRH 1993-4	50 States; 205,245 Individuals	

Kravdal et al. (2008)	Norway, Cities	Mortality	Gini	Mixed Effect	1980-2002	431 Cities; uncertain, states 50 million person-years	Not explicit multi-level framework: used municipal dummies
Lau et al. (2012)	Hong Kong, Neighborhood	Mortality	Gini	Significant Effect	1976-1986 and 1996-2006	190 Neighborhoods; 193,741 Individual5	
LeClere and Soobader (2000)	U.S., Counties	SRH	Gini grouped into four categories (quartiles)	Mixed Effect	1990	Not stated; about 160,000 Individuals based on tables	Significant effect on young white population
Li and Zhu (2006)	China, Communities	SRH	Gini	Significant Effect	1993	180 Communities; 7,286 Individuals	
Lochner et al. (2001)	U.S., States	Mortality	Gini grouped into five categories	Significant Effect	1991-3 Income; Mortality 1979-86	48 States; 546,888 Individuals	
Lopez (2004)	U.S., Cities	SRH	Gini	Significant Effect	2000	Not stated; 108,661 Individuals	
Lorgelly and Lindley (2008)	Britain, Regional and National	SRH	Gini, Atkinson Index, 90/10 Percentile Ratio	No Effect	1991-2004	19 Regions; 8,645 Individuals	
Mellor and Milyo (2003)	U.S., State	SRH	Gini	No Effect	1995-9	Not stated; ~ 62,000 Individuals	Tested lagged effects

Modrek and Ahern (2011)	Costa Rica, National and Regional	Mortality	Gini	Mixed Effect	1995 – 2005	81 Regions; 6,006 Individuals	No effect on the population over the age of 60
Oshio and Kobayashi (2010)	Japan, Prefectures	SRH	Gini	Significant Effect	2001-7	141 Prefectures; 4,466 Individuals	
Osler et al. (2002)	Denmark, Cities	Mortality	P50	No Effect	Mortality 1980-99; Income 1985-99	149 Cities; 25,728 Individuals	Pooled mortality to compare between cities
Park et al. (2015)	Korea, Cities	Mortality	Gini, Robin Hood Index, 80/20 percentile ratio	Significant Effect	2010-12	157 Cities; 172,398 Individuals	
Rostila et al. (2012)	Sweden, Cities and Neighborhoods	SRH	Gini	Mixed Effect	2002	22 Cities; 709 Neighborhoods; 28,092 Individuals	Only significant at the urban level
Shi and Starfield (2000)	U.S., State	SRH	Gini	Significant Effect	1996	Not stated	
Shibuya et al. (2002)	Japan, Prefectures	SRH	Gini	No Effect	1995	Not Stated; 80 899 Individuals	
Sturm and Gresenz (2002)	U.S., Cities	SRH	Gini	No Effect	1997-8	60 Cities; 9,585 Individuals	
Subramanian et al. (2001)	U.S., States	SRH	Gini	Significant Effect	SRH 1993-4; Income 1986-90	39 States; 144; 692 Individuals	

Subramanian et al. (2003)	Chile, Communities	SRH	Gini	Significant Effect	2000	285 Communities ; 98,344 Individuals	
Subramanian and Kawachi (2006)	U.S., States	SRH	Gini	Significant Effect	SRH 1995-7; Income 1970-90	50 States; 201,221 Individuals	
Weich et al. (2002)	Britain, Regions	SRH	Gini, General Entropy Measures (Including the Theil Index), grouped into four categories (mean +/- standard error)	Mixed Effect	1991	18 Regions; 8,366 Individuals	
Wong et al. (2009)	Hong Kong, Neighborhoods	SRH	Gini	No effect	2002-5	287 Neighborhoo ds; ~25,000	
Zheng et al. (2009)	U.S., National	SRH	Gini, Atkinson Index, Theil Index	Mixed Effect	1972-2004	308,819 Individuals	Significant effect only found on men
Zheng (2012)	U.S., National	Mortality	Gini, Atkinson Index, Theil Index	Significant Effect	1986-2006	701,179 Individuals	
CANADIAN STUDIES							
Ecological Studies							
Auger et al. (2009)	Canada, Communities	Mortality	Coefficient of Variation, Median Share, and Decile Ratio	Mixed Effect	Mortality 1999-2003; Income 2001	143 Communities	Quebec communitie s
Laporte and Furgeson (2003)	Canada, Province	Mortality	Gini	No Effect	Mortality 1980-1997; Income 1980-1997		Include time lagged effects

Ross et al. (2000)	Canada and U.S., States/Provinces and Cities	Mortality	P50	Mixed Effect	US: 1990 Income; 1989-91 Mortality Data; Canada: 1991 Income; 1990-2 Mortality Data	10 Provinces, 50 U.S. States, 53 Canadian Cities, and 282 U.S. Cities	Significant effect in the US; Canada showed no effect
Veenstra (2002b)	Canada, Health Districts	Mortality	Difference between the median and mean income	Significant Effect	Mortality 1993	n = 30	Saskatche-wan population
Veenstra (2002a)	Canada, Communities	Mortality	P50; difference between the median and mean income	Mixed Effect	Income 1996; Mortality 1994-8	n= 24	Coastal British Columbia population; only significant on crude mortality rates, not age-standardize d mortality rates
Multilevel Studies							
Auger et al. (2012)	Canada, Cities	Mortality	Gini, Atkinson Index, Coefficient of Variation (CV); all grouped into population weighted tertiles	Mixed Effect	1991-2001	140 Cities; 2 million Individuals	Only significant effect on non-immigrants

McLeod et al. (2003)	Canada, Cities	SRH	P50	No Effect	1994-8	53 Cities; 6,456 Individuals	
Quon and McGrath (2014)	Canada, Provinces	SRH	Gini	Mixed Effect	1994-1995	10 Provinces; 11,899 Individuals	Finds significant relationship for certain health outcomes
Xi et al. (2005)	Canada, Health Regions	SRH	Gini grouped into three categories (tertile)	Significant Effect	1996-7	42 Health Regions; 30,939 Individuals	Ontario population

[a] *Significant*, supports economic inequality-health hypothesis; *Mixed Effect*, some results support hypothesis; *Opposite*, results contradict economic inequality-health hypothesis; *No effect*, no results were significant

APPENDIX B

Table 13: Correlation Matrixes of Inequality Measures

	Gini Coefficient, 2001	Gini Coefficient, 2006	Gini Coefficient, 2011
Theil Index, 2001	0.8693		
Theil Index, 2006		0.9286	
Theil Index, 2011			0.9159

* Percentile ratios were not released from the confidential data center. These are available upon request.

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