Work, Well-being and Wealth: The Indirect Cost of Socioeconomic Health Inequalities for Canadian Society

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I. Executive Summary

Framing Question

The framing question for this study is: *What would be the societal gains in output and health-related quality of life if individuals in lower socioeconomic quintiles had the same health as the highest quintile?* As the question suggests, these gains are of two forms: 1) gains in market output due to higher levels of labour-market participation and productivity associated with improved health, and 2) gains in health-related quality of life associated with improved social role functioning and the intrinsic value of health.

Findings

Our estimate for calendar year 2007of the gains in market output due to higher levels of labour-market participation and productivity is $5.1 billion (including employer social contributions). This amount is approximately 0.34% of GDP. Values are based on leveling up to quintile 5 (the highest status group).

Our estimate of the gains associated with reductions in morbidity is $57.7 billion, or 3.77% of GDP. As might be expected, the largest gains are realized by the first quintile. The amount is $31.1 billion, or 2.03% of GDP for that group. The higher quintiles have progressively lower gains. For quintile 2 they are $14.5 billion (0.95% of GDP), for quintile 3 $7.9 billion (0.51% of GDP), and for quintile 4 $4.2 billion (0.28% of GDP). The gains are reasonably comparable between men and women ($27.5 billion for women and $30.2 billion for men).

Total gains from leveling up mortality rates to that of the highest quintile are $97.3 billion, or 6.36% of GDP. The gains from mortality reductions are somewhat larger than morbidity reductions. For quintile 1 they are $47.9 billion (3.13% of GDP), quintile 2 are $24.0 billion (1.57% of GDP), quintile 3 $15.0 billion (0.98% of GDP), and quintile 4 $10.4 billion (0.68% of GDP). The gains are larger for men than women ($57.8 billion and $39.6 billion, respectively).

Discussion

Our estimate of the total gains from eliminating socioeconomic health inequalities consists of $5.1 billion in output gains and $155.1 billion in health-related quality of life gains, for a total of $160.2 billion (10.47% of GDP). Caution should be taken in adding the two parts together; as there is likely some overlap in the measurement of constructs within them. The total amount identified is comparable to a recent study by Mackenbach et al. (2011) that estimated similar gains for Europe. In that study, educational attainment was used as the key measure of socioeconomic status, rather than permanent family income quintile. The Mackenbach et al. (2011) study identified a total gain of 10.73% of GDP, comprised of 1.35% in gains from labour-market earnings and related social contributions, and 9.38% in gains from improvements in health-related quality of life. Our findings for the first component, gains from labour-market earnings and related social contributions, is somewhat lower, possibly due to our use of permanent family income as a measure of socioeconomic status. In a supplemental analysis (found in Appendix 2) we use educational attainment and find the gains to be larger (0.75% of GDP). Another difference with the Mackenbach et al. (2011) is that they consider individuals 16-64, whereas we only consider individuals 25-54. Though their sample frame is more inclusive of the population, including the very young and older individuals may bias estimates due to different labour-market engagement patterns of these individuals compared to the core working age population. Based on these differences, it is safe to say that we likely underestimate the true gains due to the smaller sampling frame. In contrast, our estimates of the gains from improvements in health-related quality of life are larger, even though we use a smaller monetary value for a year in perfect health ($50,000 per quality-adjusted life-year compared to $US100,000 in the Mackenach study).

Many other potential gains are not captured in this study. For example, we have not included the impact on premature mortality on paid labour-force output. The approach likely underestimates the true impact of health on output for other reasons. Some fraction of organizational profits may be attributable to labour-market activity of individuals, but we do not attempt to account for this. Another aspect not captured is the effect of health on aggregate level productivity at the organizational level (e.g., team-based and time sensitive production processes). Other phenomena not considered are the impact of health on educational attainment, savings and capital accumulation. Also not considered is the impact of health on other individuals in the family and community (i.e., on their earnings and time use).

In addition to not capturing all categories of gains, there is another key limitation to our study. Our market output analysis only considers supply side aspects of the economy (i.e., the availability of a healthy labour force). On the demand side, increases in labour supply may result in lower wages due to increased competition for jobs. More generally, prices in the economy may change due to improved health and longer life expectancies. As a result, values in monetary terms in the new world of reduced or eliminated socioeconomic health inequalities may be different. Our estimates are based on prices as they exist today. Nonetheless, we believe our study provides a reasonably conservative estimate due to it not capturing all categories of gains.

A final limitation is that our study does not provide insights into the types of programs that would be the best means by which to reduce or eliminate socioeconomic health inequalities. The burden of disease/cost of illness approach that we use provides information on potential gains to be realized. It is a separate exercise to identify candidate programs and evaluate their effectiveness and cost-effectiveness.

Overall, the study substantially advances the measurement of the burden of socioeconomic health inequalities in Canada. It is the only such study based on Canadian data, and only one of two internationally.

Conclusions

Our estimate of the gains from eliminating socioeconomic health inequalities is **$160.2 billion or 10.47% of GDP.** These estimates are conservative in that there are a number of categories of gains that we have not included in this estimate. The study provides insights into the subgroups where the largest gains could be realized (e.g., specific socioeconomic status levels, health status levels, gender) through programs directed at improving health. Our findings suggest that there is potential for substantial societal level gains in market output and health-related quality of life through investment in population health programs that reduce socioeconomic health inequalities.

II. Introduction

There is a growing body of evidence suggesting that social and economic conditions have an important impact on health and health inequalities of populations, even for developed countries with universal health care systems such as Canada (Marmot and Wilkinson, 2006; Raphael, 2004; Link and Phelan, 1995). Both morbidity and mortality are affected by the socioeconomic position (McSweeny et al., 1982; Brekke et al., 1999; Bradley and Spreight, 2002; Brown et al., 2004). Socioeconomic health inequalities result in a substantial burden both directly through the costs of health care provided to treat adverse health conditions, and also indirectly through less than optimal productivity and output levels of the working age population (Burton et al., 1999; Druss et al., 2001; Rapoport et al., 2004). The latter may be associated with lower skills and educational attainment, absenteeism and presenteeism, health-related unemployment and labour-force disengagement, and premature mortality (Newacheck and Halfon, 1998; Burton et al., 1999; Sin et al., 2002; Reginster, 2002). Also compromised as a result of health inequalities are the fulfillment of social roles outside of the paid labour force–roles such as parenting, home care, community involvement and leisure activities. Both morbidity and mortality are affected by the socioeconomic position (McSweeny et al., 1982; Brekke et al., 1999; Bradley and Spreight, 2002; Brown et al., 2004). Furthermore, good health has value in and of itself; it makes all activities and pursuits more enjoyable. This aspect of health is sometimes described as the intrinsic value of health.

There is a longstanding interest in identifying ways by which to improve the health of populations due to the view that health is a driver of economic growth. Historically, public initiatives have played an important role in the advancement of societies. In general, the health of populations is known to be closely linked to the prosperity of nations. Fogel's research in economic history (1991, 1994) highlights the importance of population health for productivity growth. More recent work by the World Health Organization Commission on Macroeconomics and Health (Commission 2001), identified health improvements as central to economic growth and poverty reduction in low and middle income countries. The macroeconomic benefits of improvements in population health are not just a phenomenon of less developed countries. Evidence suggests they are also relevant for developed countries (Suhrcke et al., 2006; Tompa 2002).

A number of studies at the macro level have focused on the relationship between health at the population level and its impact on output and productivity (e.g., Acemoglu and Johnson, 2007; Barro and Sali-i-Martin, 1995; Bhargava et al., 2001; Bloom, et al., 2001; Knowles and Owen, 1995, 1997; Rivera and Currais, 1999a, 1999b). Fewer studies have investigated economic impacts of health within a population, though it is well known that health disparities exist and that they are often related to socioeconomic status. The few studies that have been undertaken suggest that there are economic gains to be had by reducing health disparities (e.g., Dow and Schoeni, 2008; Mackenbach et al., 2007, 2011). Hence, there is good reason for public health agencies to focus on reducing health inequalities.

The burden of socioeconomic health inequalities is different than the broader burden of health inequalities. Socioeconomic health inequalities are only one source of health inequalities. Indeed, health inequalities exist even within a group that has the same socioeconomic status. Therefore, even if socioeconomic health inequalities were eliminated, some level of health inequalities would continue to exist. Furthermore, differences in socioeconomic status would also still exist. It is possible to have different levels of socioeconomic status, however measured, within a society but have similar health profiles in each level.

This report, prepared for the Public Health Agency of Canada, presents a study based on a methodology developed to estimate the gains to be realized from eliminating socioeconomic health inequalities in Canada (Tompa 2010). In the sections that follow, we present a conceptual framework, methods, data sources, results and discussion about the study and related analysis.

III. Conceptual Framework

Relationship between Socioeconomic Status and Health

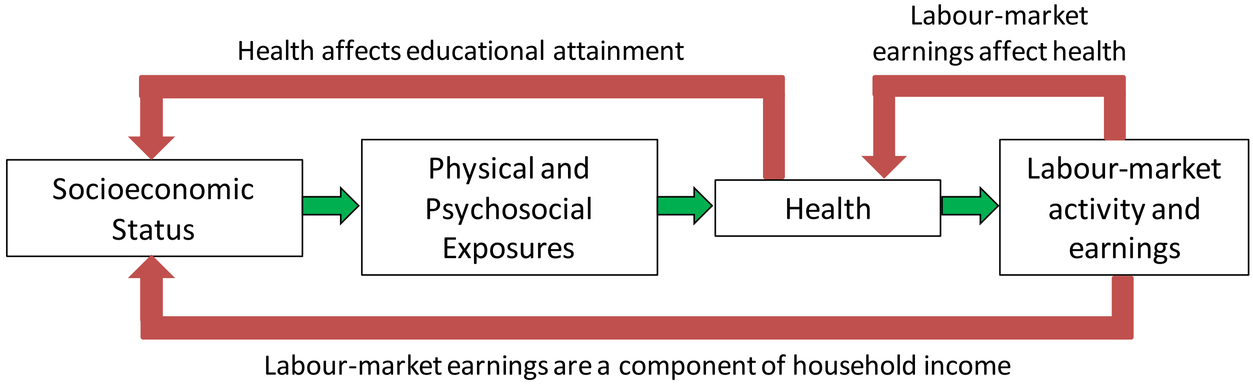
The relationship between socioeconomic status and health has been investigated by many researchers using different measures for socioeconomic status such as educational attainment, occupation, and income (Kelly et al., 2007; Link and Phelan, 1995; Mackenbach et al, 2007, 2011; Marmot and Wilkinson, 2006; Raphael, 2004). This literature has quite soundly established that position in society, however measured, is an important determinant of health. Higher socioeconomic position has been found to be associated with better health in most cultures, over many time periods, and for many measures of health and function (Marmot 2005).

Lower socioeconomic groups generally have lower health levels because they are more exposed to health hazards in the physical environment (Evans and Kantrowitz, 2002). These exposures may be at work (e.g., working in more physically demanding jobs) and/or in the community (e.g., living in neighbourhoods with more crime or more noise pollution). They are also more likely to have unhealthy behaviours in terms of diet/nutrition, exercise, smoking, and alcohol consumption (Pampel et al., 2010). In general, socioeconomic status, particularly as it relates to educational attainment, may bear on health literacy and the ability to maintain and improve health. Lower socioeconomic groups also experience more psychosocial stressors that manifest themselves as physical and mental health issues (Baum et al., 1999). They also have fewer resources to mitigate stressors (e.g., get-away vacations, ability to take decompression breaks from work and non-work role demands). As a result, they are more likely to experience morbidities over the life course, as well as have shorter life expectancies. There may also be intergenerational effects of being in a lower socioeconomic group. Specifically, lower socioeconomic status of parents may result in lower levels of health not only for themselves, but also for their children. Socioeconomic status and educational attainment of parents is known to impact child health and educational attainment (Machin, 2009).

The relationship and causal pathway between socioeconomic status and health can run in both directions. In this study we are interested in the effect of socioeconomic status on health, but health may also affect socioeconomic status. For example, lower health in childhood or early adulthood may result in lower levels of educational attainment. Similarly, lower levels of adult health may reduce labour-market engagement and earnings, which in turn will reduce household income. This reverse relationship—from health to socioeconomic status—is known as *selection effects* (it is also known as *endogeneity* or *reverse causality*). See Figure 1 for a representation of these relationships and pathways.

Poor health has implications for health care usage, particularly in countries with universal health care coverage that provide health care services to all individuals in need. Since there are substantial socioeconomic health inequalities, health care needs and related consumption costs will likely be larger for lower socioeconomic groups. In a country with publicly funded health care, these health care costs are direct costs to society.

Figure 1: Causal Pathways and Selection Effects



There are also indirect losses for individuals and society associated with health inequalities. Some indirect losses can be immediate (e.g., lost output due to sickness absence), while others unfold over longer periods of time (e.g., reduced capital accumulation due to reduced savings over the life course). One of the principal indirect losses associated with adverse health of the working age population is reduced productivity and output. The effect of health on labour-force participation and earnings is sometimes described as *health as a capital or investment good*, because it is seen as a stock of capital that one can draw on over time to earn a livelihood (Grossman, 1972). Reduced productivity and output associated with health may arise through health-related absenteeism and presenteeism, or reduced labour-force engagement such as unemployment or non-participation due to poor health (Sharpe and Murray, 2010). More generally, health may affect labour quality, i.e., healthy adults have higher energy levels and mental acuity than less healthy adults, and therefore may be more productive. At the organizational level, absenteeism and presenteeism may affect team productivity and output (Pauly et al., 2002; Nicholson et al., 2006). Other contributions at the organizational level to output, such as social contribution (i.e., payroll taxes) and profits, may also be affected by lower levels of productivity and output as measured by the wages of workers.

Longer run pathways by which health may affect productivity and output include child health and its association with educational attainment; reduced saving and its implications for capital accumulation; and socio-demographic implications such as fertility levels and female participation in the paid labour force (Bloom and Canning, 2000; Bloom and Sachs, 1998). Premature mortality will also affect labour-force size and output. Sharpe and Murray (2010) suggest that for developed countries only the first of these longer run pathways is likely to be relevant. For Canada specifically, it already has low fertility rates and high level of female labour-force participation. The pathway through savings and capital accumulation is associated with life expectancy, and Canada's life expectancy is already quite high. The greatest opportunity for return on health investment for Canada would then be through impact on labour quality and incentives for education investment and attainment, though these pathways also have saving and capital accumulation implications. Table 1 summarizes the various pathways by which health might impact output.

Table 1: Summary of pathways from health to output via the paid labour force

Adult health and output	**current health ---> presenteeism, absenteeism, employment, labour-force participation, size of the labour force** **- output per hour due to presenteeism (team production may also be affected)** **- output per person due to absenteeism (team production may also be affected)** **- output per labour-force participant due to health-related non-participation** **- output per working age population due to health-related non-participation** **- size of the labour force due to premature mortality**
Child health, educational investment and output	**child health ---> educational attainment ---> human capital ---> productivity and output over life course**
Life expectancy, savings, and capital investment	**life expectancy ---> savings for retirement ---> capital investment ---> productivity and output**
Child heath demographic effects	**child health ---> fertility ---> size of the working age population ---> output** **child health ---> fertility ---> female participation in the paid labour force ---> output**

Poor health can also compromise participation in activities outside of paid work. These roles may include parenting, home maintenance, community involvement, religious activities, and leisure activities. The impact of health on such participation might be described as *health as a consumption good*, as per Grossman (1972). The Grossman model of the demand for health, which is used widely in health economics, is less refined about social roles outside of the paid labour force, since it is designed around the traditional economic paradigm of work and leisure. A more holistic approach to the impact of health on individuals is provided by Nagi (1965, 1991) and the World Health Organization (WHO) (1980, 2001) who separately developed a framework that combines the medical and social models of health. The vocabulary currently used to describe the impact of health on activities and participation comes from the most recent conceptual framework developed by the WHO.

Health also has intrinsic value in and of itself. Being healthy allows one to enjoy life more fully in all social roles, whether in the paid labour force or outside of it. This intrinsic value of health is sometimes called *health-related quality of life*, and would also be put under the category of *health as a consumption good*.

Time spent seeking care may also take individuals away from paid work and/or participation in other social roles. Other individuals in the family unit and in the community may also be affected by an individual's health. Family, friends and neighbours may provide informal care giving. There may also be some substitution in the roles of family members, such as a spouse entering the paid labour force if an individual is unable to participate in this role due to poor health. Quantifying the monetary value of time spent seeking care and time use of other individuals can be a challenge, and is therefore not often included in studies.

To summarize, Table 2 highlights the various aspects of indirect losses associated with adverse health.

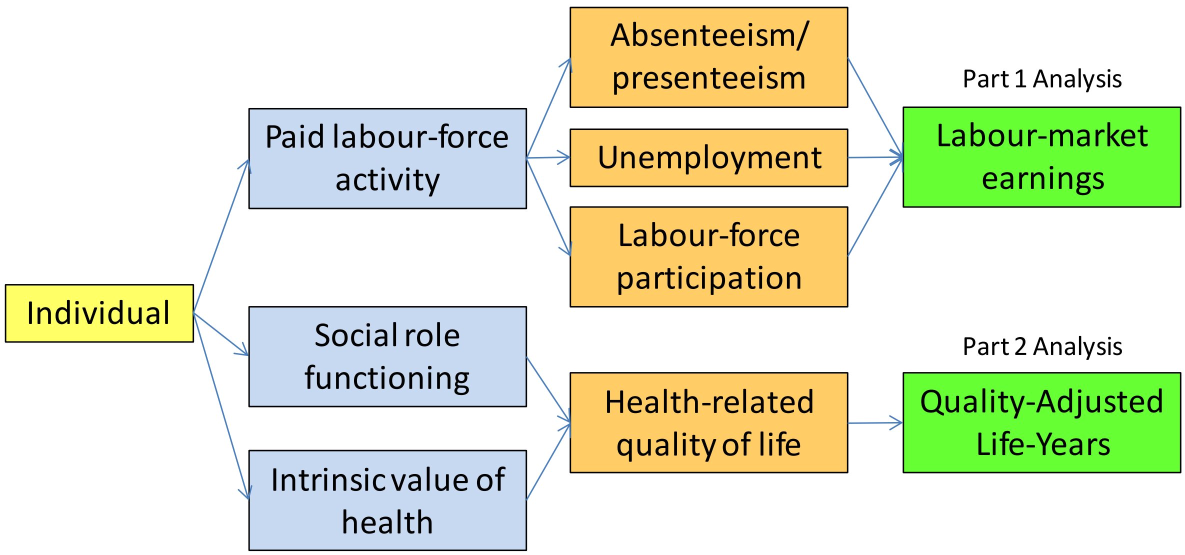
Table 2: Aspects of Indirect Losses Associated with Adverse Health

Output of paid labour force	**- adult health, productivity and output (including organizational and societal level effects)** **- child health, educational attainment, productivity and output** **- savings, productivity and output** **- demographics, fertility, mortality size of the paid labour force and output**
Participation in social roles	**- work** **- parenting** **- home care** **- community involvement** **- religious activities** **- education** **- leisure activities**
Health-related quality of life	**- intrinsic value of health**
Time use of other individuals	**- family/community time in care giving** **- family role substitution**

The impact of individual health on paid labour-force output is an important component of the indirect loss estimates of socioeconomic health inequalities. Also important is the impact of individual health on participation in roles outside of work and health-related quality of life, which are relevant for all ages. Time use of other individuals in the family and community would also be relevant, but would likely be of a smaller magnitude and more difficult to quantify. Therefore, we focus on three components: 1) individual health and its impact on paid labour-force output; 2) individual health and its impact on participation in social roles (including work); and 3) health-related quality of life. Components two and three are collapsed into one measurement exercise. We summarize the key component of this focus in Figure 2. In the figure we also identify two distinct analyses (Part 1 and Part 2) that need to be undertaken to quantify these indirect losses.

Part 1 Analysis and Part 2 Analysis in the figure identifies the two separate measurement exercises to be used in this study, and is consistent with the measurement approach prescribed by others (Drummond et al., 2005; Tompa et al., 2008; Weil, 2001). Health-related productivity and output implications associated with the paid labour force (i.e., health as a capital good) are generally measured separately from the value of health in social roles and the intrinsic value of health (i.e., health as a consumption good). In the economic evaluation of health technologies, it is customary to capture the latter two through utility-based measures of health. We use the term 'utility-based' to refer to health-related quality of life measures that combine the quality and quantity of health. These include Quality-Adjusted Life-Years (QALYs) and variants such as Healthy Year Equivalents (HYEs), Disability-Adjusted Life Years (DALYs), and preference-based multi-attribute health status classifications systems, such as Quality of Well-Being, and Health Utility Index (HUI).

Figure 2: Conceptual Model of Indirect Losses of Adverse Health at the Individual Level



Measures of Socioeconomic Status

Understanding the construct of socioeconomic status, what it represents and how it can affect health provides a basis by which to determine what measure of socioeconomic status is best for any given investigation. Socioeconomic status might be thought of as a proxy for differences in underlying exposures, both physical and psychosocial, that affect individuals in different social locations in society. It also serves as a proxy for differences in resources to address adverse health exposures and abilities to mitigate potential exposures. Exposures and resources may vary by context, therefore some proxy measures may be better for some investigations than for others. Political, cultural, institutional and other contextual factors all bear on how social location within a society might affect health.

Lynch and Kaplan (2000) provide a good overview of the construct of socioeconomic status and the different conceptual underpinnings that have contributed to an understanding of social location. As they note, stratification of society into different status groupings can be based on economic, political, symbolic, psychosocial, and behavioural factors. Theorists have constructed notions of socioeconomic status based on different principles. Three broad underpinnings of the construct are distinguished by Lynch and Kaplan (2000): 1) the individualist approach associated with Weber (1958); 2) the class structure approach associated with Marx (1991); and 3) the pragmatist approach associated with several American theorists (Davis and Moore, 1945; Warner, 1960; Parsons, 1970). Weber's individualist approach (which is most closely aligned with the epidemiologic literature) focuses on economic determinants, honour and power aspects of social stratification. Traditional measures of socioeconomic status such as education, income and occupation are consistent with the individualist approach.

There are strengths and weaknesses to the three traditional measures—education, income and occupation. Educational attainment represents an important individual marker of socioeconomic status that separates an individual from her/his parents upon reaching adulthood. Since educational attainment does not vary dramatically for adults once they enter the labour force, it is less subject to health selection effects. It is also correlated with occupation, labour-market earnings, work conditions, quality of housing, and characteristics of the neighbourhood of residence. But educational attainment does not carry the same weight for different demographic groups based on race, ethnicity and gender. Another issue is that education has different values in different cultures and time periods. Furthermore, most studies that use educational attainment as a measure of socioeconomic status do not/are not able to identify the quality of education. A good measure based on educational attainment would distinguish between differences in cognitive, material, social and psychological resources across individuals gained through education over their lifetime (Lynch and Kaplan, 2000).

Occupational category as a measure of socioeconomic status serves as good measure for adults since a larger fraction of most adults' time is taken up by work. It serves as the link between education and income. There are multiple pathways by which work can affect health through the physical and psychosocial environment. In general, it serves as a good measure of exposures and resources to mitigate exposures in different work environments. The epidemiologic literature has found health differences in different occupational groups, as well as between broad occupational categories such as white collar and blue collar work. One of the key shortcomings of occupational category as a measure of socioeconomic status is that not all adults are in the paid labour force, therefore a more refined concept of occupation needs to be identified that is applicable to all adults (Lynch and Kaplan, 2002).

Income (household or individual) is directly associated with command over material resources (e.g., housing, food, clothing, transportation, medical care, leisure opportunities) that can affect health. The relationship between material resources and health is the basis of public health initiatives that began in the 19th century in urban environments. These initiatives and their health impacts are well documented (e.g., Fogel, 1991, 1994). In contemporary developed societies, command over material resources still has a bearing on health, even in cases where material deprivation is not an issue for most individuals. Many studies have found a significant gradient in health based on income even in populations with comfortable income levels. This neo-material effect of income on health is tied to psychological states, health behaviours and social circumstances (Lynch and Kaplan, 2000). Each increment in income can bring health benefits at every age, even after retirement (Wolfson et al., 1993). It can also affect the lives of future generations through the provision of opportunities for children that monetary resources can command. There are several shortcomings to income as a measure of socioeconomic status. For one, income varies over time and can be volatile. Second, there is a potential for reverse causality. Lastly, income may not be as relevant as wealth, particularly for individuals who are retired. Even amongst working adults, there can be substantial differences in wealth across individuals with similar incomes.

Proposed Framing Question

Based on the conceptual framework described above and the objective of the study, we have formulated the following overarching question to guide the analysis:

What would be the societal gains in output and health-related quality of life if individuals in lower socioeconomic quintiles had the same health as the highest quintile?

The focus of this framing question is the impact of individual health on labour-market earnings, participation in non-paid work roles and the intrinsic value of health. In the counterfactual analysis, lower status groups would have the health status distribution of the highest group, which would affect the groups' labour-market earnings, role functioning outside of the paid labour force, and health-related quality of life.

The approach we use to estimate gains in market output and health-related quality of life is similar to that used in *burden of disease studies*. We might describe the estimate as the *burden of socioeconomic health inequalities*. Below we describe the conceptual and methodological underpinning of the approach.

Estimating the Burden of Socioeconomic Health Inequalities

Burden of disease studies provide information on the total loss of healthy time (i.e., morbidity and mortality) from a particular disease (or poor health in general), the costs of treating individuals with the disease (i.e., health care and related costs), and the impact of the disease in terms of undesirable consequences (e.g., the financial burden in terms of lost productivity to society). They generally consider the prevalence of disease in a particular calendar year and its morbidity and mortality impacts for that year. They also identify the financial costs associated with the disease for that year in terms of direct health care costs and indirect losses such as lost productivity (in the case of this study we are focusing only on the indirect loss component). Conceptually, burden of disease studies identify the amount of resources that would be saved if individuals in a population in a particular year did not have the disease.

If the burden to be considered was cast more broadly to incorporate all adverse health conditions in a particular group, then a comparator would need to be identified in order to assess the burden (i.e., the values gained if the group had better health). Since indirect losses are assessed by socioeconomic status, the natural comparator would be the highest socioeconomic status group. The burden of interest would then be the value gained if everyone had the health profile of the highest group.

Figure 3: Estimate of Aggregate Indirect Losses

Changes in labour-market earnings due to reduced morbidity in a calendar year	**+**	**Changes in company social contributions and profit due to healthier labour force in a calendar year**	**=**	**Total impact on output of reduced mortality in a calendar year**	**Part 1 Analysis**
				+	
Changes in QALYs due to reduced morbidity in a calendar year	**X**	**Value of a QALY**	**=**	**Total value of reduced morbidity in a calendar year**	**Part 2 Analysis Component 1**
				+	
Lifetime changes in QALYs due to reduced mortality in a calendar year	**X**	**Value of a QALY**	**=**	**Total value of reduced mortality in a calendar year**	**Part 2 Analysis Component 2**
				Aggregate indirect costs	

The broad categories of gains from eliminating socioeconomic inequalities include reduced health care costs and indirect values associated with increased market output and health-related quality of life. In the indirect values category are the items described above (i.e., paid labour-force output, participation in roles outside of paid work, and the intrinsic value of health). For reduced health care costs, one would consider differences in health conditions and related costs, as well as general health care usage (e.g., physician visits, specialist visits) between each of the first four quintiles compared to the highest quintile. This measurement task was completed by Statistics Canada in 2010. For indirect values, we focus on three components: 1) the total impact of better health on output in a calendar year; 2) the total value of reduced mortality; and 3) the total value of reduced morbidity in a calendar year. Figure 3 provides a summary of these components and their translation into a summary burden measure.

IV. Methods

In this section we provide an overview of the methods used in this study. For more details on the methods, i.e., including all mathematical calculations and statistical formulations used in the analyses, we refer readers to Appendix 1.

Part 1 Analysis

Health and Labour-force Participation

There is a large literature on the effects of health on economic outcomes at the macro and micro level (Sharpe and Murray, 2010). Health is similar to education in that it is a form of human capital that bears on participation in the paid labour force and on labour-market earnings. Health capital can impact conventional measures of productivity through presenteeism, i.e., productivity while at work, and absenteeism. Health capital can also impact social productivity measures through unemployment and labour-force participation. The literature also identifies other pathways. Specifically, four broad pathways have been described (Bloom and Canning, 2000). The above noted impacts on conventional measures of productivity identified by Sharpe and Murray (2010) fall under the category of the direct impact on labour quality. A second category is the impact of health on educational investment. A third category is the impact on savings and capital accumulation. A fourth category is demographic effects, which is primarily about survival rates of children, the size of the working age population, fertility and female participation in the paid labour force. The social productivity measures identified by Sharpe and Murray (2010) might be placed under category one or four.

In the modeling for *Part 1 Analysis*, we are estimating the impact of health on paid labour-force participation and productivity, not educational investment, savings/capital accumulation. In this modeling, we are assuming that an individual's labour-market earnings reflect the value of an individual's productivity and out. In turn, the aggregate of individual output across the entire paid labour force is assumed to reflect the value of market activity. We are considering only the value of output in the paid labour force to estimate market activity. The value of participation in social roles, including work, is taken into consideration in Part 2.

In our approach to valuation in *Part 1 Analysis* we are considering only supply side factors, whereas a number of demand-sided factors also bear on paid labour-market earnings. For example, with more people in the labour due to better health profiles, the wage rate might decrease due to increased competition for jobs. Over the long run, the better health profiles within a population would give rise to multiple changes in society as described above, ultimately a new general equilibrium. The proposed models might be thought of as reduced form models, since we are not modeling supply and demand side factors through a structural equations modeling approach.

The objective of the modeling is to estimate the effects of health on labour-market outcomes. We build into the analysis the role of socioeconomic status by estimating separate models for different levels of socioeconomic status. We also attempt to estimate separate models for women and men, where possible. In the modeling we need to minimize the possibility of reverse causality (i.e., the effects of earnings on health). This is addressed through temporal sequencing in which explanatory variables, particularly health, are taken from a time period prior to the outcome variable of interest. This requires longitudinal/panel data at the individual level.

The regression model parameters are used to estimate a counterfactual scenario in which the impact of health inequalities associated with socioeconomic status are eliminated. This counterfactual analysis relies on individual data, but ultimately is estimated at the aggregate (i.e., national) level. It should be noted that eliminating socioeconomic health inequalities is different from eliminating socioeconomic status or eliminating health inequalities. In the counterfactual scenario socioeconomic status differences continue to exist, and health inequalities also continue to exist. Only health inequalities due to socioeconomic status are eliminated.

Primary Data Source

Data for the study is drawn from the Canadian Survey of Labour and Income Dynamics (SLID), a nationally representative longitudinal labour-market survey based on a stratified, multi-stage design that uses probability sampling. The sample frame for the SLID is individuals aged 16 and older who reside in one of the ten Canadian provinces. The SLID excludes residents of the Yukon, the Northwest Territories and Nunavut, residents of institutions, and persons living on Indian reserves. Overall, these exclusions amount to less than three percent of the population (Statistics Canada, 1997). The SLID is composed of six-year overlapping panels. The first panel began in 1993, a second in 1996, a third in 1999, and a fourth in 2002. The response rate for SLID is considered within the good to very good range. For the present study, we use the fourth panel which spans the period from 2002 to 2007. For the fourth panel, the response rate was approximately 80% in the first year, decreasing slightly by the final wave. Each panel comprises approximately 15,000 households. Information is collected annually from all household members with one individual selected for a more in-depth labour and income interviews. For this individual, detailed information is collected on the characteristics of up to six jobs annually. One of the jobs is identified as the individual‘s main job, based on the greatest number of hours, or highest earnings in the reference year. Individuals are also asked about socio-demographic characteristics, income sources and amounts at the individual and family level, and information on their general health at the time of the survey.

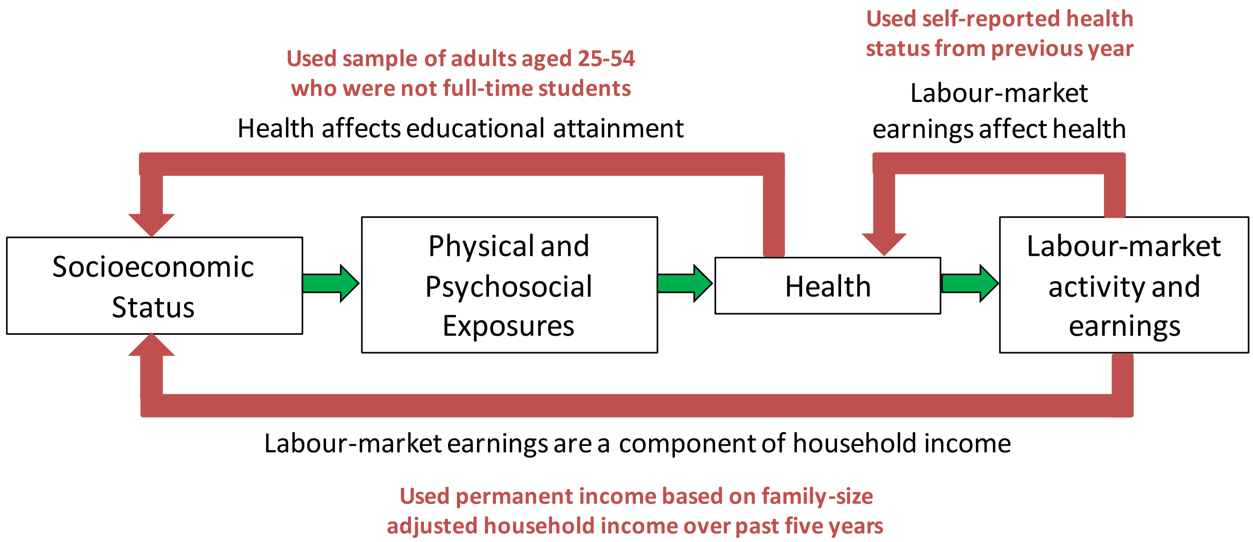
Sample Selection

Given that the objective of *Part 1 Analysis* is to identify the total impact of better health of working age adults on output in a calendar year, the subsample of individuals to be selected for analysis should be prime-age working adults (i.e., 25 to 54), excluding full-time students and unpaid family workers. A starting age of 25 is suggested in order to capture individuals at a point when they have completed most of their formal education. This sample includes individuals with zero labour-market earnings. In the first iteration of the analysis we include only those individuals who have labour-market income. The inclusion of individuals with zero labour-market earnings result in lower estimates of average labour-market earnings for the sample.

Measures

The primary indicator of socioeconomic status for the proposed study is pre-tax household income adjusted for family size.[1] Income quintiles are created based on the distribution of family income, with the category 1 representing the lowest socioeconomic status and 5 the highest. We note that the use of this variable introduces the possibility of endogeneity due to the fact that household income is determined in part by total labour-market earnings, the primary outcome measure of interest. In other words, while the focus of our analysis is the impact of health on labour-market earnings, we risk capturing the reverse relationship—namely, the impact of socioeconomic status (measured by household income quintile) on health. This is because household income is determined, in part, by labour-market income. Unlike education, which is reasonably unchanged for most individuals after a certain age, household income can change dramatically over time for working age adults. The concern is that if health changes income, it may also change socioeconomic status, which in turn bears on health. To address the issue of endogeneity of income we use average household income over a period of years prior to the year of the outcome variable. This might be thought of as a measure of permanent household income. Figure 4 provides a summary of the various ways we attempt to address endogeneity/selection effects.

Figure 4: Methods used to Minimize Selection Effects



Drawing on data from panel four of the SLID, we use average household income, adjusted for household size and composition[2], over the years 2002 to 2006 to identify socioeconomic status in a model with the outcome (labour-market earnings) taken from 2007.

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[1] The family definition used in the SLID is the economic family. An economic family is composed of two or more persons living together related by blood, marriage, adoption or common-law.

[2] We use an adjustment for family size derived from Statistics Canada's calculation of the Low Income Measure. Adjusted family size is determined as follows: the first adult is counted as one (1.0) person with each additional adult counted as 0.4 of a person and each child (under 16 years of age) as 0.3 of a person. If the family is comprised of only one adult, the first child is counted as 0.4 of a person (Statistics Canada, 1999).

Individuals are allocated to a socioeconomic status quintile based on the range of permanent household income values identified in the SLID. For each quintile, separate labour-market earnings regression models are estimated.

The outcome variable for this analysis is total annual labour-market earnings from all sources, which constitutes a widely used measure of productivity based on the notion that individuals are paid at the rate of their marginal product of labour. Labour-market earnings are comprised of gross employment and net self-employment earnings from all sources. The log transformation of labour-market earnings is undertaken prior to use in the models in order to improve the symmetry of the overall distribution of this variable within the sample.

The key explanatory variable in the modeling is self-reported health status. This self-report of general health is collected annually in the SLID. It consists of a single-item taken from a question that reads as follows:

> *In general, how would you describe your state of health? Would you say it is excellent, very good, good, fair or poor?*

Responses are scored on a five-point Likert scale ranging from excellent to poor (1 to 5, respectively). The measure is used as a categorical variable (i.e., with five distinct categories of self-reported health).

Self-reported health is considered a valid measure of acute and chronic conditions, physical functioning, and to a lesser extent health behaviours and mental health problems (Cott et al., 1999; Krause and Jay, 1994). Self-reported general health is also a strong independent predictor of subsequent illness and premature death (Idler and Benyamini, 1997; McCallum et al., 1994).

As is the case with socioeconomic status, health may also be endogenous. To minimize the possibility of endogeneity, self-reported health status from the prior year is used in the modeling.

Other explanatory variables included in the analysis are level of education (three categories), age, age squared, gender, marital status, children under 16, province of residence, and rural/urban residence. For educational bracket we use less than high school, high school and some post-secondary, post-secondary degree/diploma. Table 3 provides details on the explanatory variables used in the analysis.

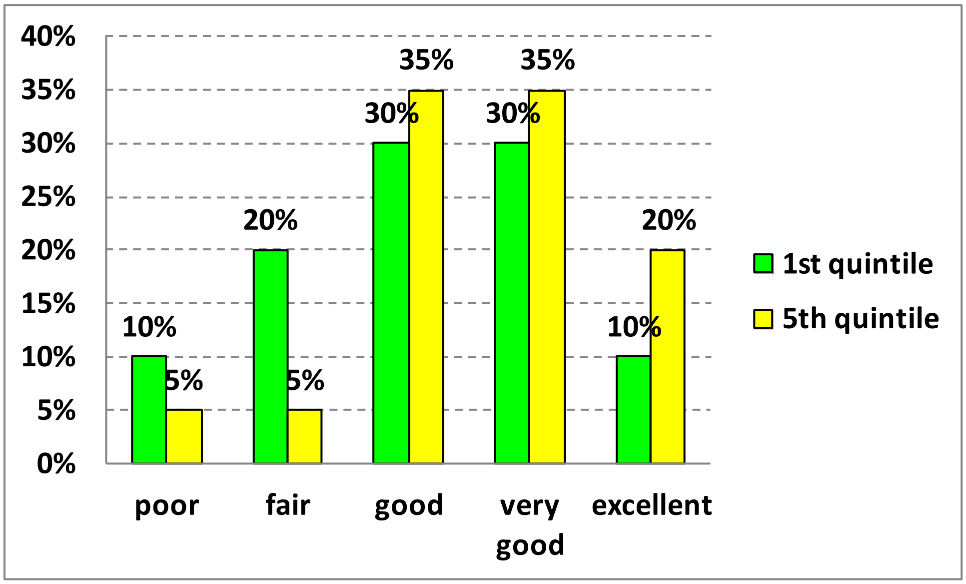
Table 3: Explanatory Variables Used in the Modeling

Variable (SLID variable name)	***Specification***	***Details***
Health Status (crhlt26)	*health status (poor, fair, good, very good, excellent)*$_{t-1,i}$	Set of dummy variables indicating the level of self-reported health status—one level serves as the comparator
Educational attainment (hleved18)	*education (less than high school, high school or some post-secondary, post-secondary degree/certificate)*$_{t-1,i}$	Set of dummy variables indicating educational attainment category—one category serves as the comparator
Age (age26)	$age_{t-1,i}$ $age^2_{t-1,i}$	Age Age squared
Gender (sex99)	$gender_i$	Dummy variable indicating sex
Marital Status (state4)	$married_{t-1,i}$	Dummy variable indicating individual is married or living common law as opposed to single/divorced, widowed
Children (nbsa26)	$children_{t-1,i}$	Dummy variable indicating the individual has children under 16 in the family unit
Province of Residence (pvreg25)	*province (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland)*$_{t-1,i}$	Set of dummy variables indicating province of residence—one province serves as a comparator
Urban/Rural Residence (urbrur25)	$rural_{t-1,i}$	Dummy variable indicating rural as opposed to urban residence

Counterfactual Analysis

Counterfactual analysis is based on the assumption that if socioeconomic health inequalities are eliminated, then the distribution of health will be the same in each of the lower four quintiles as in the highest quintile. In Chart 1 we depict a hypothetical example comparing the health profiles of the 1st and 5th quintiles for a particular gender and age bracket.

Chart 1: Example of Health Profiles for the 1st and 5th Quintiles



Let us assume that average labour-market earnings for the 1st quintile for poor, fair, good, very good, and excellent health are $1,000, $9,000, $12,000, $15,000, and $19,000 respectively. In the counterfactual analysis, the 1st quintile would have the health profile of the 5th quintile, therefore the proportion of individuals with poor, fair, good, very good and excellent health would be 5%, 5%, 35%, 35% and 20% respectively. Labour-market earnings for the 1st quintile in the counter factual analysis would be determined by multiplying the mean labour-market earnings in each health status level (as estimated in the original scenario) times the number of individuals in that health status level as determined by the new proportions. If there are 1,000 individuals in the 1st quintile, the calculation would be as follows:

$$Total\ labour\ market\ earnings\ gains\ from\ improved\ health_{first\ quintile} = 1{,}000\ \times\ (\$1{,}000\ \times\ 5\% + \$9{,}000\ \times 5\% + \$12{,}000\ \times 35\% + \$15{,}000\ \times 35\% + \$19{,}000\ \times 20\%)$$

This approach to estimating the counterfactual scenario preserves the relationship between explanatory variables in the model estimates, and hence the model parameters for each of the regression models also remain the same. Furthermore, the socioeconomic status of individuals should remain unchanged, even though labour-market earnings may increase for some, because we are using earnings specific to the quintiles. Essentially the relative ranking of individuals in socioeconomic quintiles remains unchanged.

Estimation of Aggregate Earnings Gains

The total labour-market earnings increase attributable to the elimination of socioeconomic health inequalities can be estimated directly from the numbers identified above. There are several reasons why this total may underestimate the true value. First, the survey which is being used for this analysis, the SLID, does not include individuals in institutions, on reserves, in the military or living in the territories. Second, it does not include labour earnings elements paid for by employers such as payroll taxes, also known as employer social contributions. To accommodate this factor, we use the proportionate increase in labour-market earnings and multiplying it by the labour income component of gross domestic product (GDP. The labour income component of GDP is comprised of two broad items: 1) labour-market earnings, and 2) supplementary labour income. The latter is employers' social contributions (either compulsory or voluntary). Data for estimating these contributions comes from Statistics Canada's CANSIM database (Table 382-0006) (Statistics Canada, 2010).

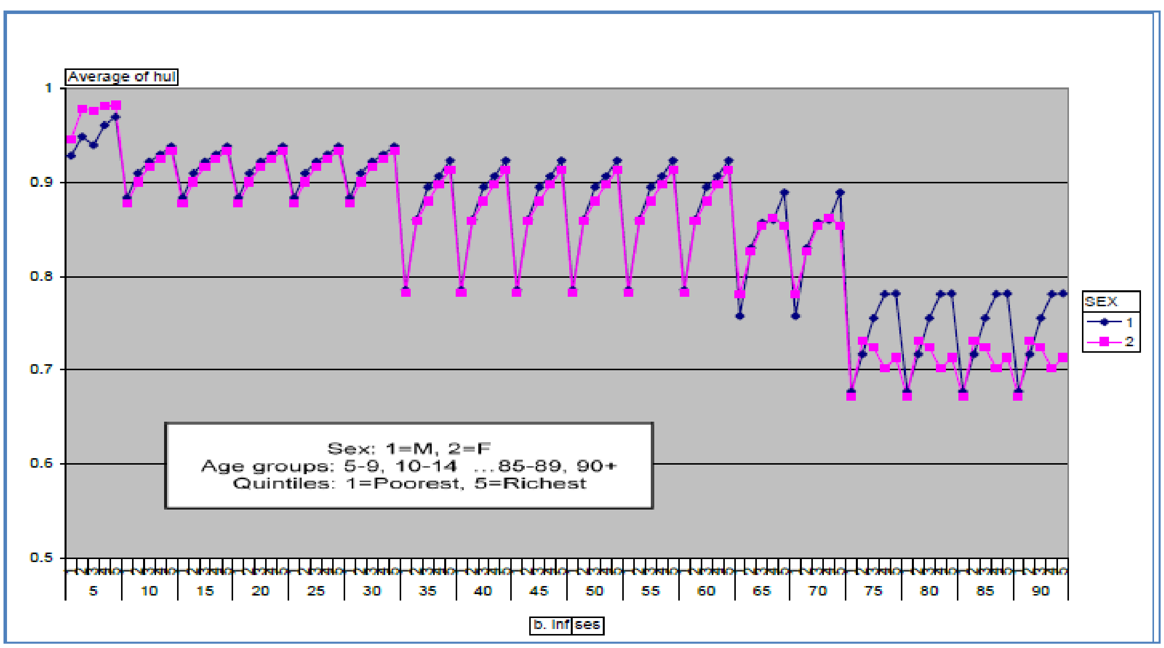
Supplemental Analysis

As a supplemental analysis we use educational attainment tertile, rather than permanent household income quintile as a measure of socioeconomic status. This analysis is undertaken to further address the issue of endogeneity of labour-market income. As noted, labour-market income is a component of household income, whereas educational attainment is further removed from it. These regression models have permanent household income quintile as an explanatory variable rather than educational attainment bracket. In this supplemental analysis, we also estimate separate regression models for women and men within each educational tertile, therefore gender is not a variable in the regression models. Results for this analysis are provided in Appendix 2.

Part 2 Analysis Component 1

The valuation of reductions in morbidity in terms of QALYs gained includes all ages (i.e., not just those 25-54 as in Part 1). It draws on analyses undertaken by Statistics Canada on socioeconomic inequalities in morbidity by income quintile.

Figure 5: HUI by income quintile and age (5 year groups), males and females, Canada*



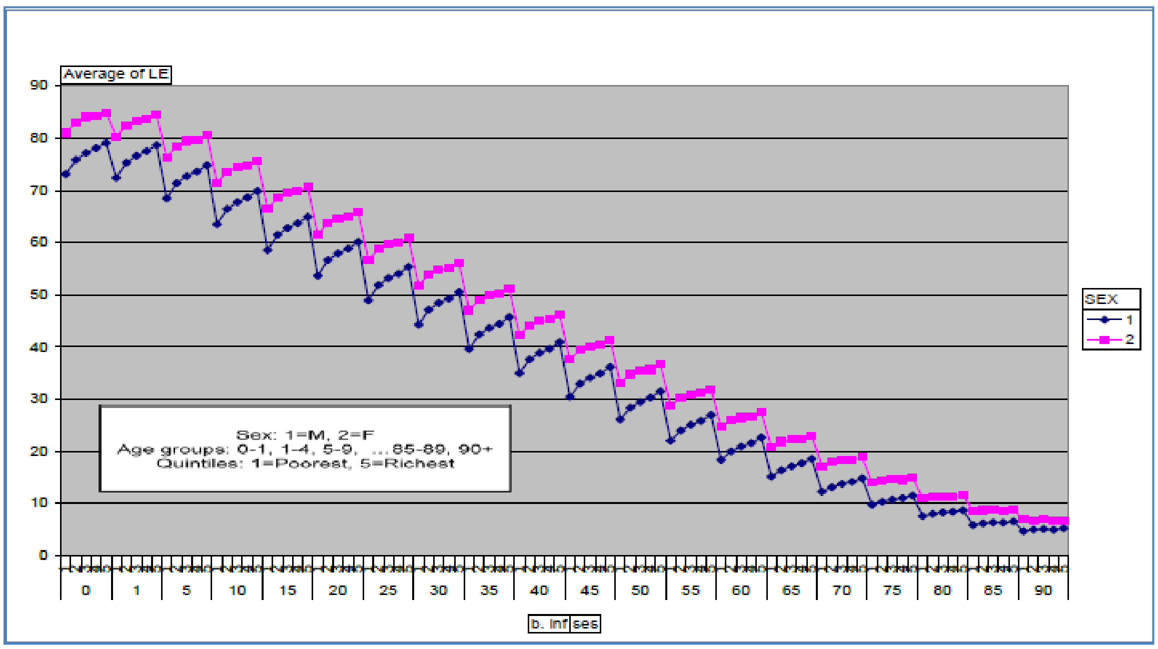
*Statistics Canada (2010).

We use Statistic Canada's calculations of HUI values for five-year age bracket by gender (see Figure 5 for details), which has 18 sets of five groups for each gender. Quintiles 1 through 4 are leveled up to the HUI level of quintile 5 for all 18 groups. Gains in health from leveling up are based on the difference between the HUI values of quintile 5 and the current HUI values of each of the lower quintiles. HUI units, which represents years of perfect health, are converted to monetary units by multiplying them by some monetary value of a QALY/HUI.

Part 2 Analysis Component 2

The valuation of gains in life expectancy in terms of QALYs gained due to reduced mortality also includes all age groups. It draws on analyses undertaken by Statistics Canada on socioeconomic inequalities in mortality/life expectancy by income quintile (see Figure 6 for details).

Figure 6: Life expectancy by income quintile and age (5 yr groups), males and females*



*Statistics Canada (2010)

In this counterfactual analysis we assume that all of the lower quintiles have the mortality rate of the highest quintile. Therefore, we estimate the number of lives lost due to premature mortality. The years of life lost from each premature death in that age bracket is estimated by using the life expectancy value for the highest quintile from that age bracket. The years of life lost would likely not be years of full health, so they need to be adjusted for quality (i.e., converted into QALYs). We use the HUI scores for this purpose. The value of each year of lost life is taken from the morbidity tables developed by Statistics Canada, as found in Figure 5. In keeping with the notion that health inequalities associated with socioeconomic status are eliminated in the counterfactual scenario, we use the HUI scores associated with the highest quintile. Since the years of life gained in the counterfactual scenario are in the future, they need to be discounted to the present. HUI scores are converted to monetary units by multiplying them by some monetary value of a QALY/HUI.

The Value of a QALY

Through counterfactual analysis we identified the gains in QALYs based health-related improvements in role functioning across all social roles, as well as the intrinsic value of health. These gains are associated with the elimination of adverse health exposures associated with socioeconomic inequalities. In order to facilitate development of a summary measure, QALYs need to be converted to monetary units. To determine the value of a QALY we can turn to several sources such as, 1) the health policy arena and health institutions where funding decision or guidelines are made for investment in health technologies, 2) the academic literature on health technology assessment, 3) contingent valuations studies where a sample of individuals from the general population have been asked to state their preferences through willingness-to-pay or willingness-to-receive questionnaire, and 4) revealed preference studies where analysts have extracted the statistical value of health based on risk-return tradeoffs made by individuals in the marketplace.

Health Policy Arena and Health Institutions

One source for monetary threshold values for a QALY are guidelines used in the policy arena or proposed by health institutions. A good example is the Canadian Agency for Drugs and Technologies in Health (CADTH), which uses a value of $50,000 per QALY (QALYs: The Canadian Experience, 2007). This is the base value we use in our analysis.

Another source is the Dutch National Council for Public Health and Health Care, which proposed an upper limit of Euro 80,000 for a QALY (Mackenback et al., 2007). The United Kingdom’s National Institute for Health and Clinical Excellence (NICE) uses a range of £20,000 (€29,500; US$40,000) to £30,000 per QALY (Appleby et al., 2007). No calendar year is identified for the currency, but the NICE guidelines updated in 2009 retain the same values (NICE, 2009). As a more general guideline, the World Health Organization (WHO) proposed a value of three times the GDP per capita as an upper limit for a Disability Adjusted Life-Year (Commission 2001). These ranges of values can serve as a sensitivity analysis.

Health Technology Assessment (HTA) Studies

An influential article by Laupacis et al. (1992) that provides guidelines for HTA, suggests a lower bound incremental cost per QALY of CAN$20,000 (1990 dollars) and an upper bound of CAN$100,000 (1990 dollars) for assessing the desirability for adoption of new technologies. Specifically, they suggest that a cost per QALY of less than $20,000 provides strong evidence for adoption, and more than $100,000 provides weak evidence for adoption. A systematic review of monetary thresholds used in HTA (Khor et al., 2010) found that $50,000 was the most common single value used in studies (63 of 188 studies identified that used single values). Other common values used were $20,000 (61 of 188 studies) and $100,000 (51 of 188 studies). Of studies that used a range of values, the most commonly used range was $20,000-$100,000 (142 of 202 studies). We use this range in our sensitivity analysis. Kohr et al. (2010) suggests that the $20,000 value used by Laupacis et al. (1992) was justified by commonly funded intervention in

Ontario at the time and may require updating. Furthermore, the monetary thresholds were provided as guidelines rather than edicts. They are not official guidelines. In general, economic evaluation guidelines proposed by Gold et al. (1996), Drummond et al. (2005) and others emphasize the need to incorporate ethical and political considerations into technology adoption decisions in health care rather than relying solely on a specific monetary threshold for all purposes.

Contingent Valuations Studies

The contingent valuation or stated preference approach to valuing health (i.e., willingness-to-pay (WTP) and willingness-to-accept (WTA)) uses survey methods to collect data on respondents' preferences, specifically their maximum WTP for health gains, or their WTA money and forego desirable health outcomes. The main difference between WTP and WTA is in the initial level of utility, higher for WTA than WTP. As a result of this difference it is expected that WTA values will be greater than WTP, though generally by a small amount if total utility is large relative to the health benefits under consideration. Values derived from contingent valuation methods are sensitive to the questions used to elicit values. Depending on how questions are worded, valuations may capture more than just the value of health outcomes. A more restricted willingness-to-pay approach that exclusively values health consequences would be the preferred approach (Tompa et al., 2008). As a result of the sensitivity to methods, the variance in values found across studies is quite wide. A systematic review of contingent valuation studies (Hirth et al., 2000) identified an average value of US$161,305 (1997 dollars). We use this value as the high end value for our analysis.

Revealed Preference Studies

This is a particular application of utility-based risk analysis that relies on labour market data to identify the statistical value of a human life. It is based on the assumption that providing safe work conditions is costly. Firms have a choice of either reducing risks and make lower profits or paying workers a risk premium to bear the risk. In the labour market, different employers offer different combinations of safety and risk premiums based on the costliness of reducing risk versus paying risk premiums. The assumption is that there is variability in risk-premium offerings because the cost of risk reduction varies across sectors and also firms within a sector. Since workers have the choice of bearing risk in return for higher pay they can select into jobs that reflect their risk preferences. In equilibrium, the wage-risk trade-off between employers and workers is the same. Based on this logic, economists have used data on job risks and wage rates to extract the risk premiums through econometric analysis. The concept is known as "revealed preferences" because workers reveal their preference for monetary compensation for health risks through their behaviour in the labour market (i.e., the choice of jobs they make). Most revealed preferences studies have investigated risks of mortality and have used the results to identify the statistical value of a human life. A few studies have investigated morbidity risks. A similar approach is also used to identify the statistical value of human life with data from non-labour market sources such as road and vehicle safety.

A review by Cookson and Dorman (2008) summarizes the findings from other literature reviews and comments on the concerns with this methodological approach to valuing health. A key concern is the broad range of values identified by studies. A review by de Blaeij et al. (2003) which focussed on road safety found estimates of the value of a statistical life ranged from approximately $3.0 million to $9.6 million (one outlier at each end was excluded in the range), with most concentrated at the low end. A review by Blomquist (2004) that included a few studies not found in de Blaeij et al. (2003) identified values of $5.6 million to $14.4 million, with no particular concentration at either end of the spectrum. Labour-market studies on the statistical value of human life have been comprehensively summarized in Viscusi and Aldy (2003). They found the range of values for US studies to be US$1.4 to US$41.6 million, while the range for non US studies was even wider, US$0.4 to US$148.2 million. Hirth et al. (2000) identified values of US$93,000 for a QALY from non-labour market studies and US$428,000 for labour-market studies (1997 dollars). These broad ranges raise some concern and make it difficult to identify an appropriate value or meaningful range to use in burden and economic evaluation studies.

Recommendations for the Selection of a Value for a QALY

Given the wide range of values for a QALY identified above, we consider a range of values in the form of a sensitivity analysis. As noted, our baseline value is $50,000. For the sensitivity analysis, we begin with the range of $20,000 to $100,000, which is the range found in other studies by Khor et al. (2010). For the high end, we use the average value found in willingness to pay studies by Hirth et al. (2000), which is $160,000 per QALY. The proposed range of $20,000 to $160,000 spans the values used in European HTA studies. The values from revealed preference studies are much higher and the range much broader. Given the concerns raised by reviewers about the revealed preference literature, we suggest not considering these values.

Aggregation of Part 1 and 2

We have identified and estimated three components of indirect losses of socioeconomic health inequalities, namely a labour-market earnings component related to improved health, a health component related to reduced mortality, and a health component related to reduced morbidity. These four components were identified with the following equations:

$$\begin{aligned}
&\mathit{Total\ labour\ market\ earnings\ gains}_{all\ quintiles} \\
&\quad = GDP_{labour} \times \mathit{Proportional\ increase\ in\ labour\ market\ earnings}_{all\ quintiles} \\
&\quad = \left[GDP_{labour\ market\ earnings} + GDP_{supplemental\ labour\ income}\right] \\
&\quad \times \mathit{Proportional\ increase\ in\ labour\ market\ earnings}_{all\ quintiles}
\end{aligned}$$

$$\begin{aligned}
&\mathit{Total\ value\ of\ morbidity\ reductions}_{all\ quintiles} \\
&\quad = \sum_{q=1}^{4}\sum_{j=1}^{18}\sum_{g=1}^{2}\left(HUI_{g,j,q} - HUI_{g,j,5}\right) \times P_{g,j,q} \times Value_{HUI}
\end{aligned}$$

$$Value\ of\ mortality\ reductions_{all\ quintiles} = \sum_{q=1}^{4}\sum_{j=1}^{18}\left(M_{j,q} - M_{j.5}\right) \times P_{j,q} \times \sum_{k=1}^{(L_{j,5}-A_{j,midpoint})} [Value_{HUI} \times HUI_{L_{j,5}-k+1}] \div [(1+i)^{(L_{j,5}-A_{j,midpoint}-k+1)}]$$

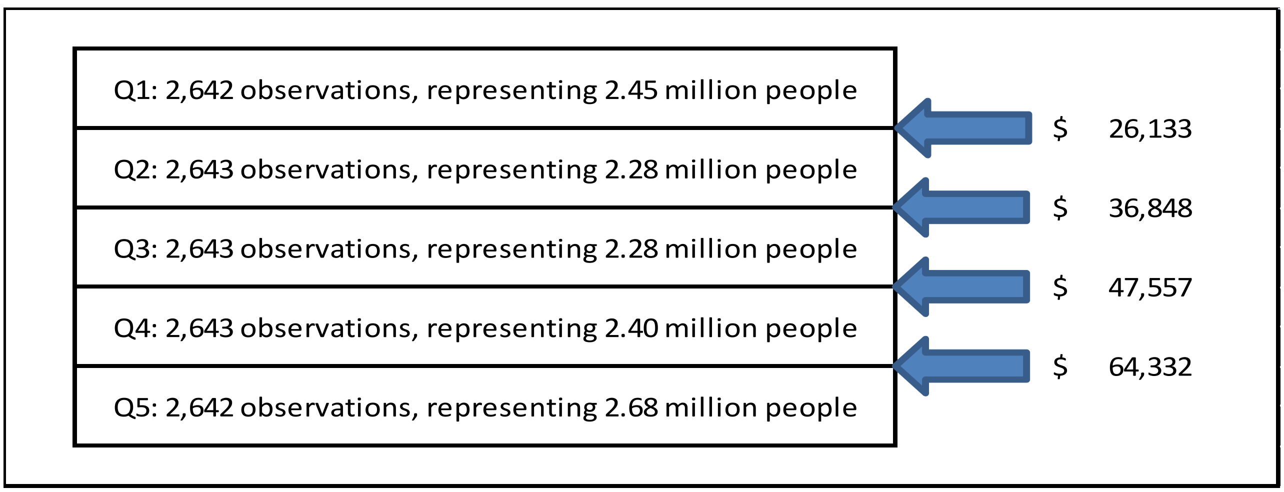
The sum of the three components represents the principal sources of gains associated with the elimination of socioeconomic health inequalities. We caution that there may be much overlap between Part 1 and Part 2, so the values might best be considered independently. Overlaps exist because the construction of QALYs assumes that the value of health in terms of social role functioning and the intrinsic value of health can be measured independently from the impact of health on labour-market engagement and earnings. In reality, the two parts are very much related.

Results

Sample Descriptives

The most recently completed panel of the Survey of Labour and Income Dynamics (2002-2007) serves as the data source for our sample. We selected individuals who were between the ages of 25-54 and not full-time students in 2006. We included individuals who were self-employed in the sample. The sample consists of 13,213 observations on individuals. The family income quintile ranges, as identified through the permanent household income measure, are as follows: 1) ≤ $26,133; 2) $6,133-$36,848; 3) $36,848-$47,557; 4) $47,557-$64,332; and 5) ≥ $64,332 (values are in 2007 Canadian dollars). There are approximately 2,640 observations in each quintile. Each observation in the sample represents multiple people at the population level and weights are provided to inflate the sample to that level. Because the survey uses stratified cluster sampling methods, the weights for observations can differ. Consequently the population level numbers for each quintile are not exactly the same. Table 4 presents the above information in visual form.

Table 4: Family Income Quintile Cut Points*



*monetary values are 2007 Canadian dollars

Descriptive statistics

The key explanatory variable used in the modeling is self-reported health status. As noted in the methods section, this variable is measured on a five point Likert scale, consisting of poor, fair, good, very good, and excellent. The proportion of individuals reporting each level across socioeconomic quintile reflects the typical health gradient identified in the literature. A greater proportion of individuals in lower quintiles report poor, fair or good health compared to higher quintiles. In contrast, a lower proportion report very good or excellent health. Chart 2 and 3 provide details.

Chart 2: Distribution of Poor, Fair, Good, Very Good and Excellent Health

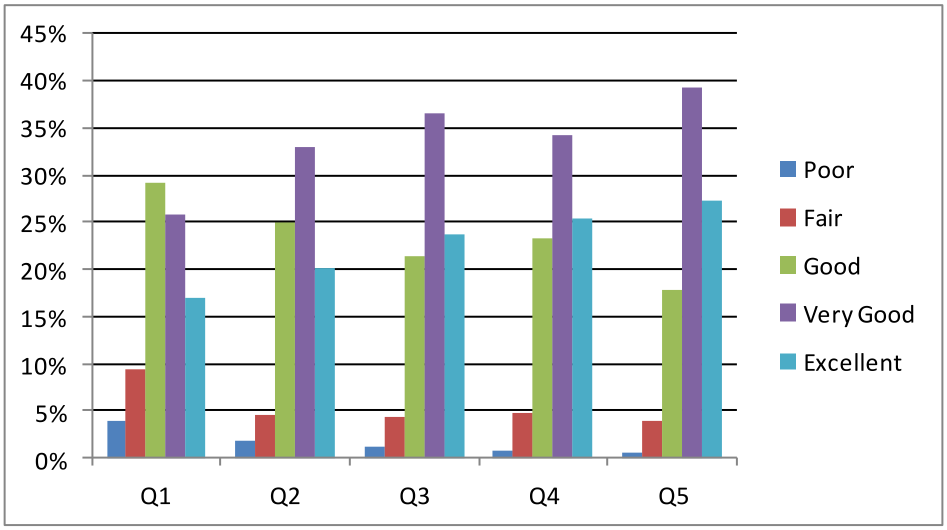
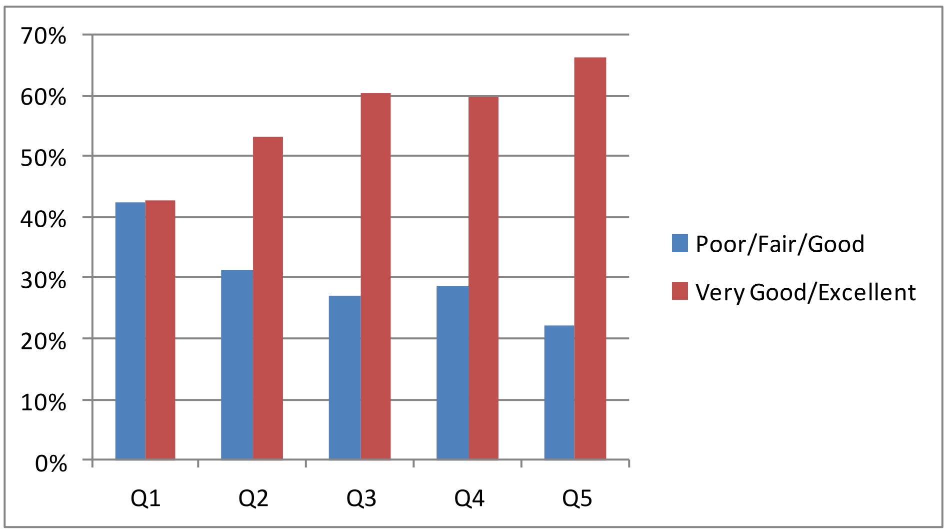


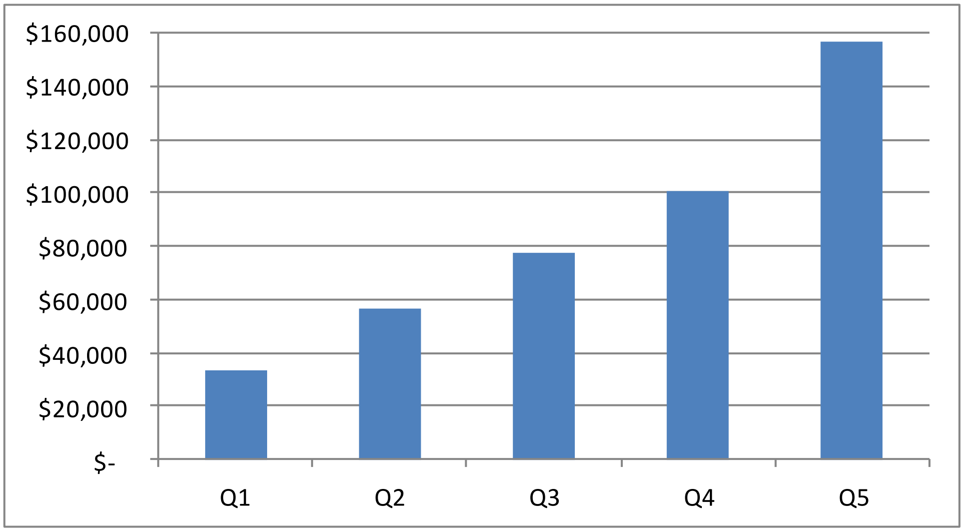
Chart 3 collapses the five levels of health into two—poor/fair/good versus very good/excellent. The gradient in health is much more apparent this way.

Chart 3: Distribution of Poor/Fair/Good Health versus Very Good/Excellent Health



Individual-level yearly labour-market earnings from all sources is the primary outcome variable of interest for the regression models. This is the indirect loss that we model in our statistical analysis. As might be expected, average quintile income increases with higher quintiles. The averages are as follows: 1) $33,320; 2) $56,825; 3) $77,353; 4) $100,639 and 5) $156,523 (2007 Canadian dollars). These values include 14% for social contributions that are part of the value of labour inputs but are paid by employers. [3] The values are presented in Chart 4.

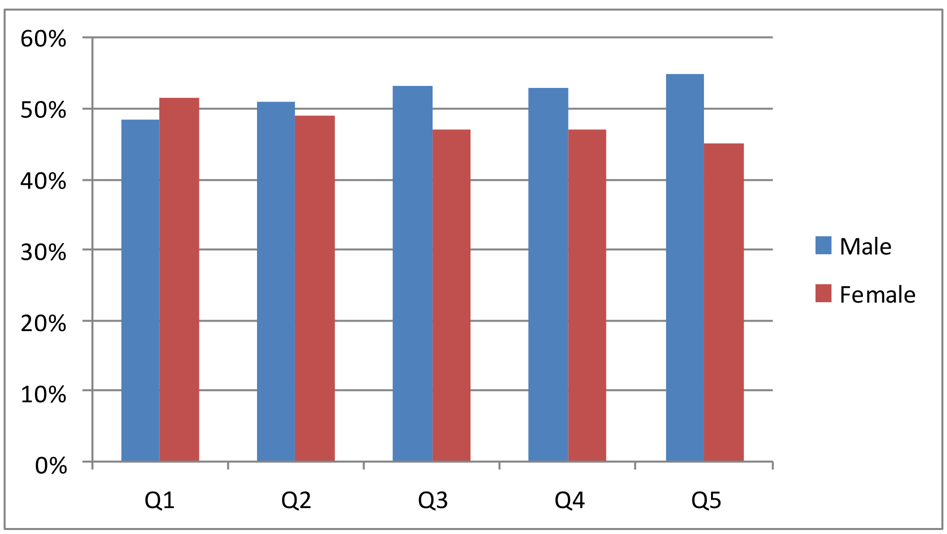
Chart 4: Average Labour-market Income by Quintile*



*monetary values are 2007 Canadian dollars

Other key explanatory characteristics to be used in the modeling include sex, educational attainment, age category, marital status, province of residence, and urban/rural residence. Descriptive statistics by quintile are provided for these characteristics in Chart 5 though 10.

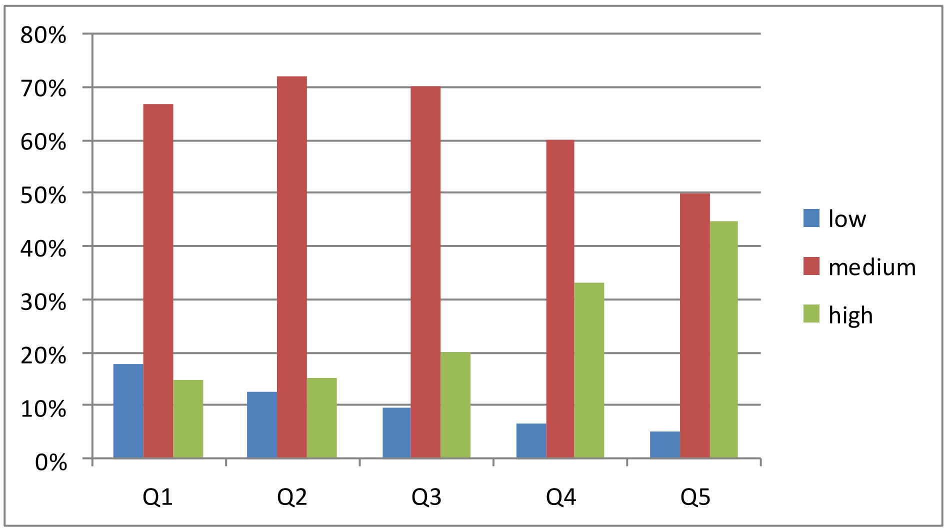
Chart 5: Gender Distribution



[3] The estimate of 14% is based on data from Statistics Canada catalogue number 13-021-X found on the following website: http://www.statcan.gc.ca/pub/13-021-x/2012002/t/tab0201-eng.htm.

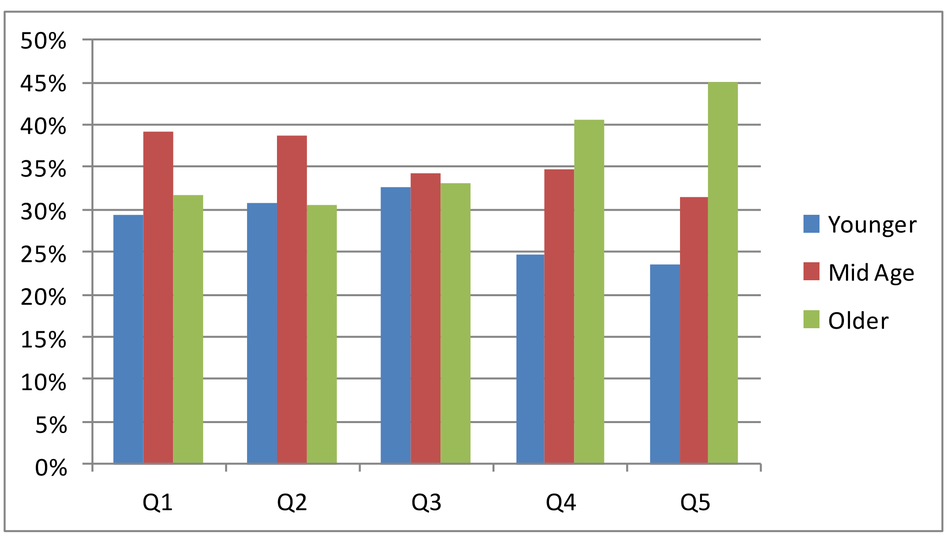
Chart 5 presents the distribution by gender. A larger fraction of the lowest quintile is composed of women, and conversely, a larger fraction of the highest quintile is composed of men. A sex gradient is apparent across the quintiles. Table 6 presents the distribution by educational attainment. Three categories are used—less than high school (low), high school or some post-secondary education (medium), and post-secondary degree or certificate (high). Lower quintiles have a higher proportion of individuals with lower levels of educational attainment. There is a clear gradient across the quintiles, particularly noteworthy with the lowest and highest levels of educational attainment.

Chart 6: Distribution of Educational Attainment*



* low (less than high school), medium (high school or some post-secondary education), high (post-secondary degree or certificate)

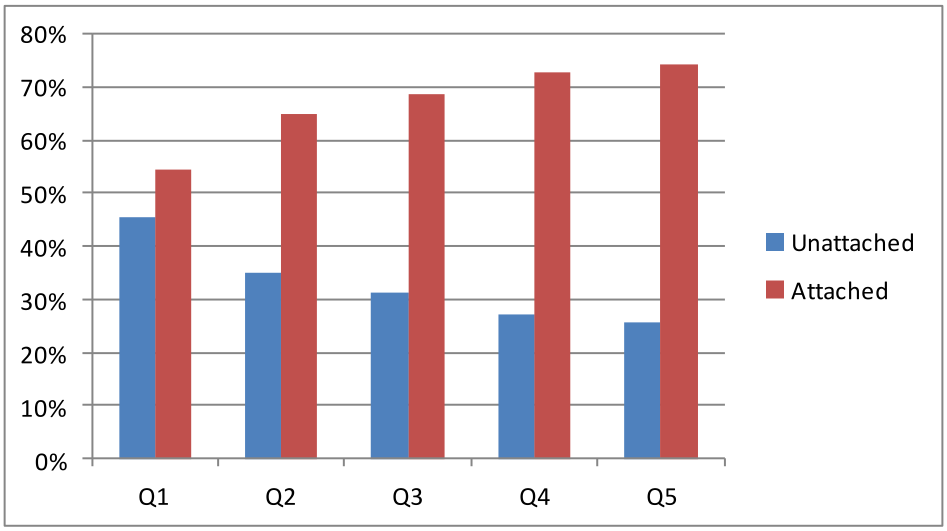
Chart 7: Distribution of Age Category*



* younger (25-34), mid age (35-44), older (45-54)

Chart 7 presents the distribution by age category. Three categories are used for this stratification—younger (25-34), mid age (35-44) and older (45-54). The higher quintiles have a larger proportion of individuals in the oldest category, whereas lower quintiles have a larger proportion of individuals in the younger and middle age category. Chart 8 provides data on marital status. Two categories are used—single, divorced or widowed, which we label unattached; and married or common law, which we label attached. It shows that a slightly larger proportion of individuals are attached in the higher quintiles. The lowest quintile has a particularly larger proportion of unattached individuals compared to the other four.

Chart 8: Distribution of Marital Status*



* unattached (single, divorced, separated or widowed), attached (married or common law)

Table 5: Distribution by Province of Residence

	Q1	Q2	Q3	Q4	Q5
Newfoundland and Labrador	2%	2%	1%	2%	1%
Prince Edward Island	1%	1%	1%	0%	0%
Nova Scotia	4%	3%	3%	2%	2%
New Brunswick	3%	3%	2%	2%	1%
Quebec	27%	27%	22%	22%	19%
Ontario	30%	35%	38%	41%	44%
Manitoba	4%	4%	5%	3%	2%
Saskatchewan	4%	3%	3%	3%	2%
Alberta	6%	9%	11%	12%	15%
British Columbia	17%	13%	13%	11%	12%
Missing	2%	1%	1%	1%	2%
	100%	100%	100%	100%	100%

Table 5 provides data on the distribution by province of residence. A disproportionately larger number of individuals in higher quintiles reside in Ontario and Alberta. One can see in Table 5 how the proportion of individuals in these two provinces increases with higher quintile levels. Conversely, a disproportionately large number of individuals in lower quintiles reside in Quebec and British Columbia.

Chart 9: Distribution of Rural/Urban Residence

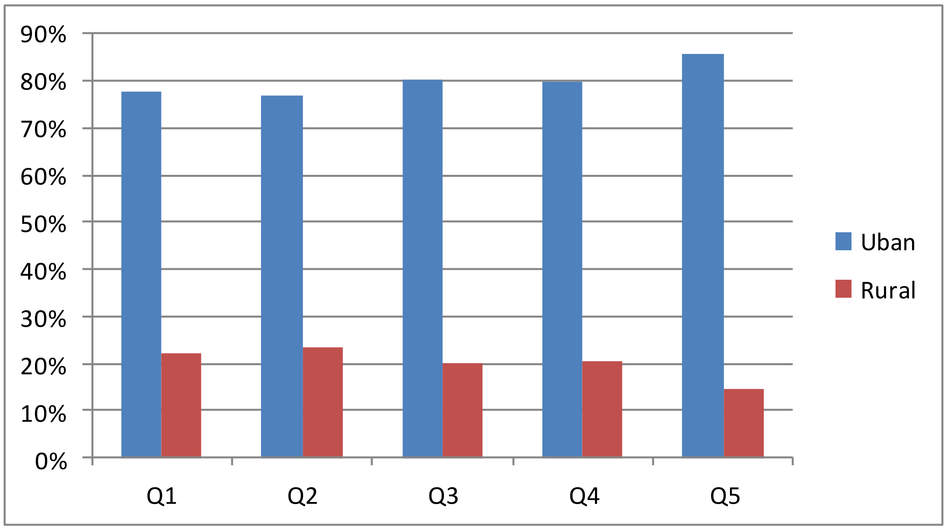


Chart 9 presents the distribution by rural versus urban residence. There is a slight gradient here, in that a larger proportion of individuals in higher gradients reside in urban areas.

Part 1 Analysis Results

For Part 1 Analysis we ran log-linear regression models in which the log of labour-market earnings was the dependent variable and health status (five categories) was the key explanatory variable. These models were then used to estimate average predicted earnings for each health status level in each quintile based on the characteristics of the observations within each quintile.

Table 6 presents the results of the statistical modeling. As might be expected, there is a reasonably patterned gradient in terms of the magnitude of coefficients for the health status level, i.e., lower health status levels have a larger negative magnitude compared to excellent health. Lower educational attainment also has a patterned gradient in terms of the magnitude of coefficients, i.e., negative compared to the highest level of post-secondary degree or certificate. Being married (including common law) and having children under 16 has a consistently positive and significant impact on earnings relative to single (including divorced, separated, widowed) and no children under 16. Overall the models are consistent with expectations, though some variables are not statistically significant, possibly due to the small sample sizes of the quintiles and the large number of covariates.

Table 6: Quintile Regression Models

Explanatory Variable	Q1 Estimate		Q2 Estimate		Q3 Estimate		Q4 Estimate		Q5 Estimate	
Intercept	12.46	***	10.52	***	10.23	***	11.15	***	12.26	***
Poor Health	-0.62	***	-0.29	***	-0.26	**	0.02		-0.88	***
Fair Health	-0.23	***	-0.11	*	-0.12	*	-0.08		-0.24	***
Good Health	0.05		0.00		-0.08	**	-0.10	***	-0.05	
Very Good Health	-0.03	**	-0.04		0.03		-0.08	***	-0.07	**
Excellent Health	---		---		---		---		---	
Female	0.0652		0.0129		-0.0637	**	0.0149		-0.0034	
Less than High School	-0.23	***	-0.05		-0.15	***	-0.18	***	-0.25	***
High School	-0.25	***	0.03		-0.09	***	-0.06	**	-0.19	***
Post-secondary Degree	---		---		---		---		---	
Age	-0.12	***	-0.01		0.04	**	0.00		-0.03	*
Age Squared	0.00	***	0.00		0.00	**	0.00		0.00	*
Married	0.50	***	0.37	***	0.22	***	0.30	***	0.31	***
Kids	0.24	***	0.26	***	0.19	***	0.20	***	0.23	***
Newfoundland	-0.39	**	-0.20	*	-0.26	**	-0.18	**	-0.01	
British Columbia	0.04		0.05		-0.23	***	-0.13	***	-0.17	***
Prince Edward Island	-0.24		-0.09		-0.25		-0.21		-0.28	
Nova Scotia	-0.04		-0.12		-0.38	***	-0.09		-0.44	***
New Brunswick	-0.21		-0.04		-0.28	***	-0.18	**	-0.18	
Quebec	-0.22	**	-0.12	**	-0.28	***	-0.18	***	-0.20	***
Ontario	-0.17		-0.07		-0.21	***	-0.11	**	-0.13	***
Manitoba	-0.29	*	0.01		-0.20	***	-0.21	***	-0.44	***
Saskatchewan	-0.34	**	0.08		-0.08		-0.05		-0.10	
Alberta	---		---		---		---		---	
Rural	-0.04		-0.05		-0.03		-0.04		-0.09	**
Scale	32.22		19.45		18.42		16.56		21.07	
Observations Used	1,500		1,707		1,749		1,839		1,900	

*** 1% significance, ** 5% significance, *10% significance

Table 7: Predicted Labour-market Earnings by Quintile and Health Status*

Quintile Health Status	Predicted Labour-market Earnings	Quintile Health Status	Predicted Labour-market Earnings
Q1H1	$ 13,107	Q3H1	$ 49,875
Q1H2	$ 18,021	Q3H2	$ 58,298
Q1H3	$ 25,666	Q3H3	$ 61,936
Q1H4	$ 24,842	Q3H4	$ 70,775
Q1H5	$ 25,613	Q3H5	$ 67,527
Q2H1	$ 37,644	Q4H1	$ 88,856
Q2H2	$ 39,900	Q4H2	$ 86,912
Q2H3	$ 49,648	Q4H3	$ 85,660
Q2H4	$ 47,802	Q4H4	$ 89,158
Q2H5	$ 48,713	Q4H5	$ 96,607

*monetary values are 2007 Canadian dollars

Table 7 provides estimates of the predicted labour-market earnings by quintile for each health status level. These values include 14% for employer social contributions added to the raw predicted values from the regression estimates. Generally, predicted earnings are larger with higher health status levels within a quintile. Higher quintiles also have larger earnings, as would be expected. Confidence intervals are also reasonably narrow around the predicted values. These predicted values are used to estimate the counterfactual scenario in which the lower quintiles are assumed to have the health status distribution of the highest quintile.

Table 8 provides details on the calculation of the gains in labour-market earnings by quintile from leveling up health status to that of the highest quintile. For this leveling up calculation, we use quintile population size estimates based on the SLID data sample used for Part 1 Analysis.

The net change in labour-market earnings is largest for the lowest quintile group, and smallest for the highest quintile group. Oddly, the change is smaller for quintile 2 than quintile 3.[4] The overall net change is $5.1 billion (including employer social contributions), which is approximately 0.34% of GDP in 2007.[5]

Table 8: Estimate of Net Change in Labour-market Earnings in the Counterfactual Scenario*

Quintile Health Status Level	Predicted Labour-market Earnings	Population Proportion	Population (millions)	Total Labour-market Earnings (millions)	Counterfactual Proportion (Q5)	Counterfactual Population (millions)	Counterfactual Total Labour-market Earnings (millions)	Net Change in Total Labour-market Earnings (millions)
Q1H1	$ 13,107	4.66%	0.11	$ 1,496	0.57%	0.01	$ 183	-$ 1,313
Q1H2	$ 18,021	11.00%	0.27	$ 4,851	4.45%	0.11	$ 1,963	-$ 2,888
Q1H3	$ 25,666	34.15%	0.84	$ 21,454	20.05%	0.49	$ 12,595	-$ 8,859
Q1H4	$ 24,842	30.39%	0.74	$ 18,481	44.19%	1.08	$ 26,872	$ 8,391
Q1H5	$ 25,613	19.81%	0.48	$ 12,420	30.75%	0.75	$ 19,278	$ 6,859
Q1 Total			**2.45**	**$ 58,701**		**2.45**	**$ 60,891**	**$ 2,191**
Q2H1	$ 37,644	2.18%	0.05	$ 1,869	0.57%	0.01	$ 490	-$ 1,379
Q2H2	$ 39,900	5.29%	0.12	$ 4,815	4.45%	0.10	$ 4,048	-$ 768
Q2H3	$ 49,648	29.55%	0.67	$ 33,450	20.05%	0.46	$ 22,692	-$ 10,758
Q2H4	$ 47,802	39.10%	0.89	$ 42,616	44.19%	1.01	$ 48,159	$ 5,544
Q2H5	$ 48,713	23.88%	0.54	$ 26,522	30.75%	0.70	$ 34,149	$ 7,628
Q2 Total			**2.28**	**$ 109,271**		**2.28**	**$ 109,538**	**$ 267**
Q3H1	$ 49,875	1.25%	0.03	$ 1,423	0.57%	0.01	$ 650	-$ 773
Q3H2	$ 58,298	4.96%	0.11	$ 6,596	4.45%	0.10	$ 5,917	-$ 679
Q3H3	$ 61,936	24.62%	0.56	$ 34,784	20.05%	0.46	$ 28,324	-$ 6,460
Q3H4	$ 70,775	41.91%	0.96	$ 67,670	44.19%	1.01	$ 71,342	$ 3,673
Q3H5	$ 67,527	27.26%	0.62	$ 41,991	30.75%	0.70	$ 47,364	$ 5,372
Q3 Total			**2.28**	**$ 152,464**		**2.28**	**$ 153,597**	**$ 1,133**
Q4H1	$ 88,856	0.83%	0.02	$ 1,763	0.57%	0.01	$ 1,219	-$ 544
Q4H2	$ 86,912	5.30%	0.13	$ 11,071	4.45%	0.11	$ 9,292	-$ 1,779
Q4H3	$ 85,660	26.37%	0.63	$ 54,282	20.05%	0.48	$ 41,262	-$ 13,020
Q4H4	$ 89,158	38.69%	0.93	$ 82,880	44.19%	1.06	$ 94,666	$ 11,787
Q4H5	$ 96,607	28.82%	0.69	$ 66,892	30.75%	0.74	$ 71,374	$ 4,482
Q4 Total			**2.40**	**$ 216,889**		**2.40**	**$ 217,814**	**$ 925**
Overall Total				**$ 537,324**			**$ 541,840**	**$ 4,515**

*monetary values are 2007 Canadian dollars

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[4] The statistical model for quintile 2 had noticeably fewer significant explanatory variables, so there may be some outlier observations that are driving these results.

[5] In 2007 GDP of Canada was $1.53 trillion.

The quintile and overall population counts identified through the SLID for the 25-54 age bracket are smaller than those identified in the data from Statistics Canada for the HUI estimates. Specifically, the SLID count for the 25-54 population is 10.31 million, whereas it is 18.4 million in the Statistics Canada data for HUI estimates. In contrast, the 2006 Census data provides an estimate of 13.8 million. The SLID estimates are the lowest, likely because they reflect the panel composition that entered the sample in 2002. In contrast, Statistics Canada's estimates for the HUI data are for 2007. If we used the population values from either of the other two sources, the estimate of the burden from socioeconomic health inequalities would be higher. This can be undertaken as a sensitivity analysis, with the underlying assumption that the relationships identified in the statistical models are constant over time and for more recent populations. We undertook this approach, details of which are found in Table 8A.

Table 8A: Sensitivity Analysis Based on Three Sources of the 25-54 Population Counts*

Quintile Health Status Level	Net Change Based on SLID Pop Counts (millions)	Net Change Based on 2006 Census Pop Counts (millions)	Net Change Based on StatsCan Estimated Pop Counts (millions)
Q1H1	-$ 1,313	-$ 1,480	-$ 1,973
Q1H2	-$ 2,888	-$ 3,257	-$ 4,341
Q1H3	-$ 8,859	-$ 9,990	-$ 13,316
Q1H4	$ 8,391	$ 9,463	$ 12,613
Q1H5	$ 6,859	$ 7,734	$ 10,310
Q1 Total	**$ 2,191**	**$ 2,470**	**$ 3,293**
Q2H1	-$ 1,379	-$ 1,669	-$ 2,225
Q2H2	-$ 768	-$ 930	-$ 1,239
Q2H3	-$ 10,758	-$ 13,025	-$ 17,361
Q2H4	$ 5,544	$ 6,712	$ 8,947
Q2H5	$ 7,628	$ 9,235	$ 12,310
Q2 Total	**$ 267**	**$ 323**	**$ 431**
Q3H1	-$ 773	-$ 936	-$ 1,247
Q3H2	-$ 679	-$ 822	-$ 1,095
Q3H3	-$ 6,460	-$ 7,817	-$ 10,420
Q3H4	$ 3,673	$ 4,444	$ 5,924
Q3H5	$ 5,372	$ 6,501	$ 8,666
Q3 Total	**$ 1,133**	**$ 1,371**	**$ 1,827**
Q4H1	-$ 544	-$ 625	-$ 833
Q4H2	-$ 1,779	-$ 2,044	-$ 2,725
Q4H3	-$ 13,020	-$ 14,957	-$ 19,938
Q4H4	$ 11,787	$ 13,540	$ 18,049
Q4H5	$ 4,482	$ 5,149	$ 6,863
Q4 Total	**$ 925**	**$ 1,063**	**$ 1,417**
Overall Total	**$ 4,515**	**$ 5,227**	**$ 6,967**
Total with Social Contributions	**$ 5,148**	**$ 5,959**	**$ 7,943**
%of 2007 GDP	**0.34%**	**0.39%**	**0.52%**

*monetary values are 2007 Canadian dollars

As can be seen in Table 8A, the values found through the sensitivity analysis do not change dramatically. Using the 2007 census population counts we found an overall net change is $6.0 billion (including employer social contributions), which is approximately 0.39% of GDP in 2007. Using the population counts estimated by Statistics Canada for the direct health care cost burden study, we found corresponding values of $7.9 billion, which is 0.52% of GDP.

Part 2 Component 1 Analysis Results: The Valuation of Reductions in Morbidity

The valuation of health gains due to reduced morbidity includes all age brackets. If we use the gender and age bracket calculations for HUI, we have five quintiles sets with 18 age brackets for each gender. We represent the set as $HUI_{g,1,q}$-$HUI_{g,,18,q}$, using the same subscript notation as previously. Each item in the set is assumed to contain the HUI score for a specific gender, age bracket and quintile.

As might be expected, lower quintiles have lower HUI scores for most gender and age brackets. Figures 7 and 8 present the differences between each of the four lower quintiles compared to the fifth quintile for women and men, respectively. Most values are negative, with a few exceptions for women in older age brackets.

Figure 7: Differences in HUI Scores for Women

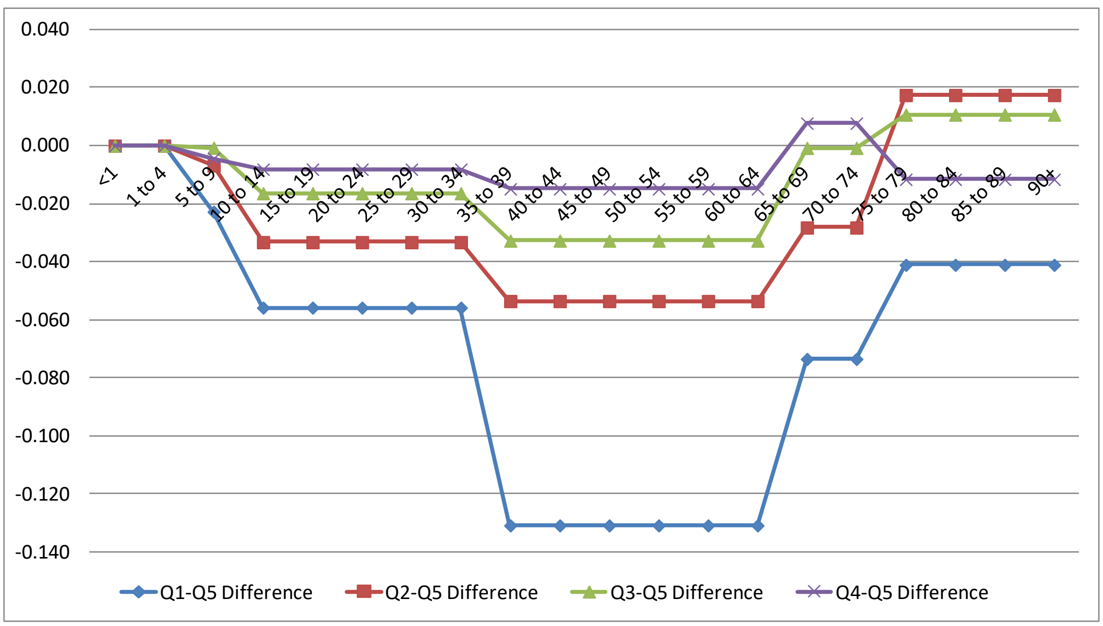

Figure 8: Differences in HUI Scores for Men

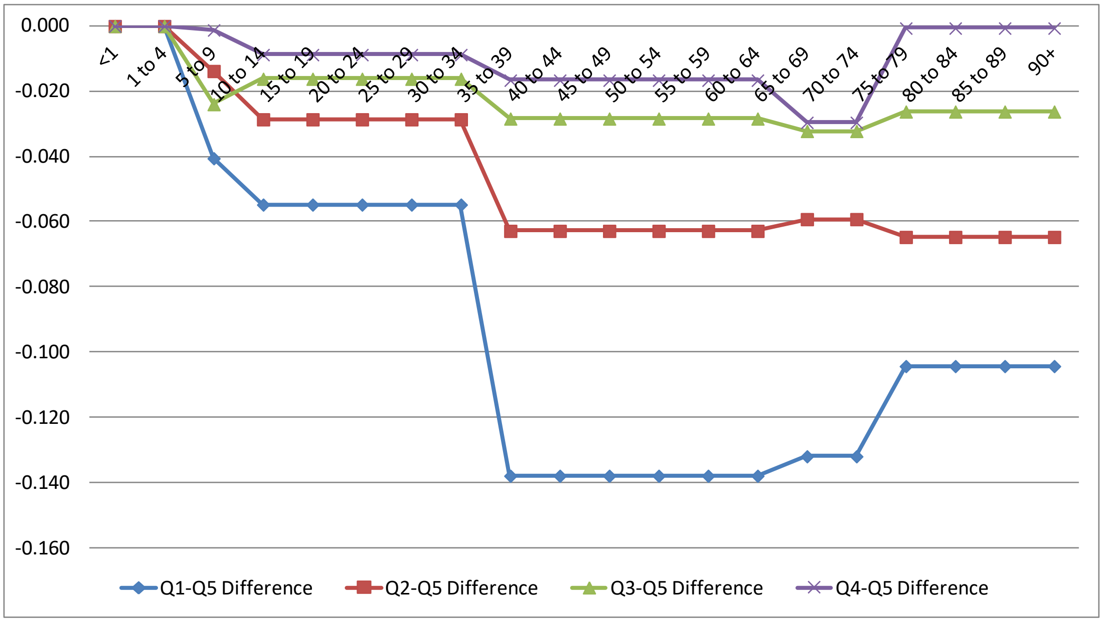

Table 9 provides details of the values identified. As might be expected, the largest value is realized by the first quintile. The amount is $31.1 billion, or 2.03% of GDP. The higher quintiles have progressively lower gains. In total, gains from leveling up morbidity amount to $57.7 billion, or 3.77% of GDP.

Table 9: Monetary value of Morbidity Reductions by Quintile and Gender*

Qintile	Category	Women	Men	Total	% of GDP
1	HUIs Gained	316,819	304,908	621,727	
	Monetary Value of HUIs	$ 15,840,957,489	$ 15,245,384,354	$ 31,086,341,843	2.03%
2	HUIs Gained	125,155	165,759	290,914	
	Monetary Value of HUIs	$ 6,257,745,570	$ 8,287,932,533	$ 14,545,678,103	0.95%
3	HUIs Gained	73,244	83,936	157,179	
	Monetary Value of HUIs	$ 3,662,175,933	$ 4,196,783,602	$ 7,858,959,535	0.51%
4	HUIs Gained	35,149	49,408	84,557	
	Monetary Value of HUIs	$ 1,757,454,469	$ 2,470,418,757	$ 4,227,873,226	0.28%
Total	HUIs Gained	550,367	604,010	1,154,377	
	Monetary Value of HUIs	$ 27,518,333,461	$ 30,200,519,247	$ 57,718,852,708	3.77%

*monetary values are 2007 Canadian dollars

Part 2 Component 2 Analysis Results: The Valuation of Reductions in Mortality

The valuation of health-related quality of life gains from reductions in mortality includes all age groups. It draws on analyses undertaken by Statistics Canada on socioeconomic inequalities in mortality/life expectancy by income quintile and related analyses on morbidity level by income quintile. In this counterfactual analysis, we assume that all of the lower quintiles (i.e., quintiles 1 through 4) have the mortality rate of the highest quintile (i.e., quintile 5).

Though each quintile, by definition, is the same size, the distribution across age brackets and gender vary within quintiles. Figure 9, which is not stratified by gender, provides details on the quintile age bracket distribution. As is apparent in this table, the higher quintiles have a larger proportion of individuals in the older age brackets. This is expected, given that higher income quintiles have longer life expectancies.

Figure 9: Age Distribution by Quintile Age

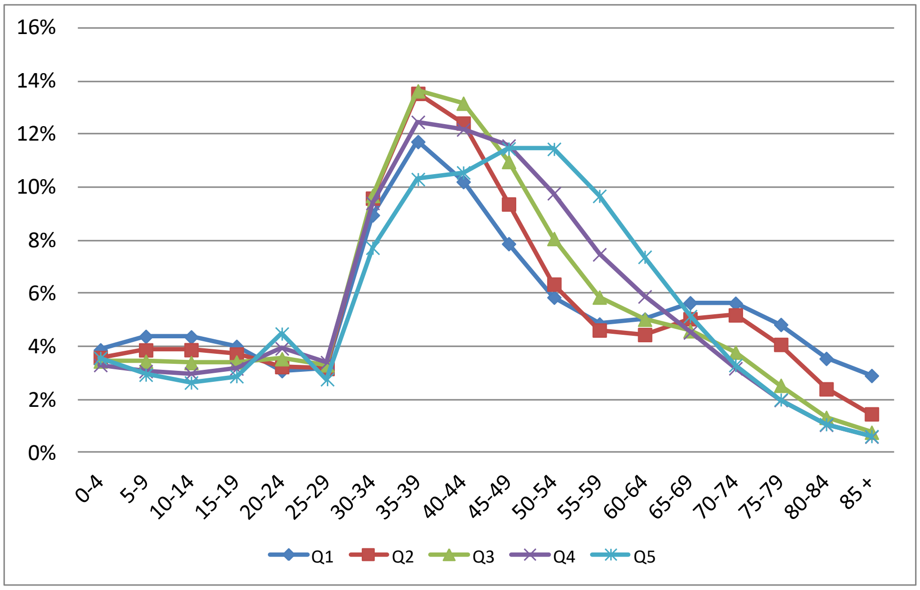

Figure 10 and Figure 11, provide details on conditional life expectancy by age bracket and quintile. As is apparent, differences in remaining life expectancy between quintiles are greatest in younger age brackets, and become less distinct with older age brackets.

We estimated years of life lost from premature death in an age bracket (for a particular gender and quintile) based on the counterfactual assumption that individuals would have the conditional life expectancy values of quintile five for that age bracket. In total we used 18 age brackets, which are identified in the horizontal axis of Table 10.

As mentioned earlier, the years of life lost would likely not be years in full health, so they had to be adjusted (weighted) for different morbidity levels. In keeping with the notion that health inequalities (including morbidity differences) associated with socioeconomic status are eliminated in the counterfactual scenario, we use the gender and age bracket specific HUI scores associated with the fifth quintile as weights. Since the years of life gained in the counterfactual scenario are in the future, the HUI weighted years gained were discounted to the present. For this study we use a 3% discount rate, which is a value commonly used for public sector investments. We denote the weighted and discounted years of life gained by an individual of a particular gender, quintile and age bracket as $Discounted\ HUI_{g,j,q}$, where g is for gender, j is for age bracket, and q is for quintile. As might be expected, the number of years of life gained for each gender age bracket (based on values from the fifth quintile) is substantially larger than the HUI weighted and discounted value. Table 11 provides details. The rows labeled *conditional life expectancy* are the years gained without morbidity weighting or discounting.

Figure 10: Conditional Life Expectancy by Age Bracket and Quintile for Women

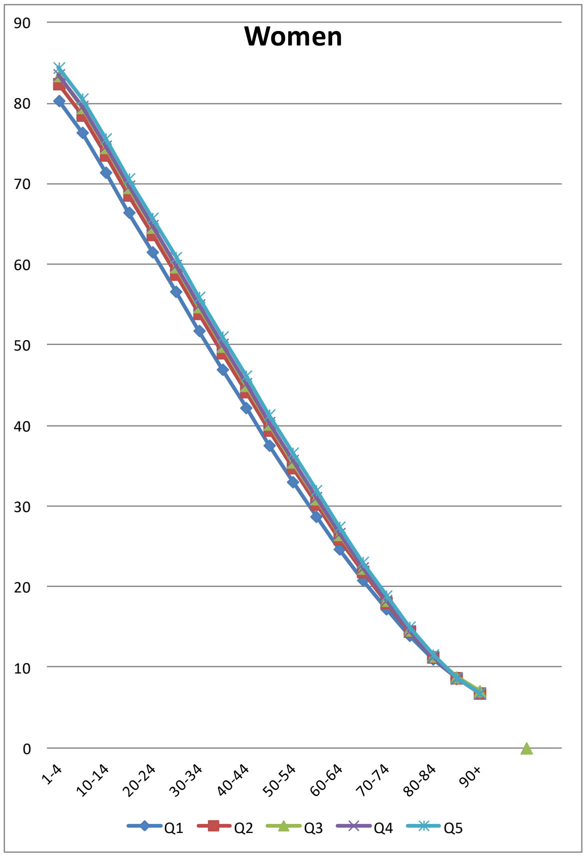

Figure 11: Conditional Life Expectancy by Age Bracket and Quintile for Men

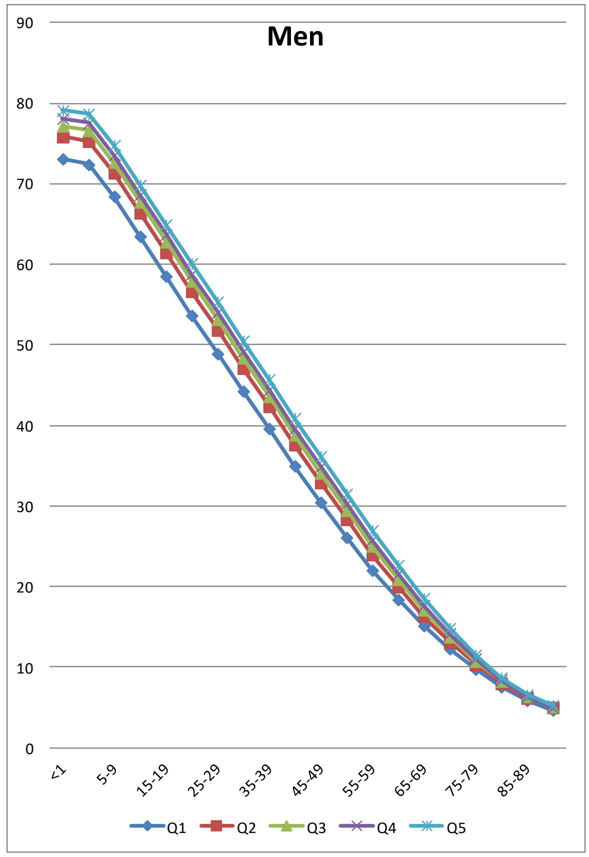

Table 10: Conditional Life Expectancy by Gender and Age Bracket

	Age Bracket	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Women	Conditional Life Expectancy	85	81	76	71	66	61	56	51	46	41	37	32	27	23	19	15	12	8
	HUI weighted and discounted	29	29	28	27	26	26	24	23	22	21	23	20	15	13	11	7	7	3
Men	Conditional Life Expectancy	79	75	70	65	60	55	51	46	41	36	31	27	23	19	15	12	9	6
	HUI weighted and discounted	29	28	27	27	26	25	24	22	21	19	20	16	13	11	9	7	5	3

HUI values need to be converted into monetary values by multiplying them by a dollar value for an HUI. We represent this monetary value by *Monetary Value*$_{HUI}$. In this report we use the value of $50,000, which is a value commonly used in Canadian health technology assessment studies.

Based on the approach described above, we estimated the total value of years of life gained by leveling up life expectancy and related morbidity levels for years gained to that of quintile five. Table 11 provides details on the values identified.

Table 11: Monetary Gains from Mortality Reductions by Quintile and Gender*

Qintile	Category	Women	Men	Total	% of GDP
1	Averted Fatalities	23,832	31,092	54,924	
	Discounted HUIs Gained	426,580	531,777	958,357	
	Monetary Value of HUIs	$ 21,328,989,825	$ 26,588,870,099	$ 47,917,859,924	3.13%
2	Averted Fatalities	11,504	20,007	31,511	
	Discounted HUIs Gained	188,005	292,971	480,976	
	Monetary Value of HUIs	$ 9,400,259,244	$ 14,648,546,517	$ 24,048,805,760	1.57%
3	Averted Fatalities	6,953	13,865	20,819	
	Discounted HUIs Gained	104,190	196,187	300,377	
	Monetary Value of HUIs	$ 5,209,519,968	$ 9,809,352,229	$ 15,018,872,197	0.98%
4	Averted Fatalities	4,805	9,382	14,187	
	Discounted HUIs Gained	72,306	134,769	207,075	
	Monetary Value of HUIs	$ 3,615,316,052	$ 6,738,450,318	$ 10,353,766,371	0.68%
Total	Averted Fatalities	47,095	74,346	121,441	
	Discounted HUIs Gained	791,082	1,155,704	1,946,786	
	Monetary Value of HUIs	$ 39,554,085,089	$ 57,785,219,164	$ 97,339,304,252	6.36%

*monetary values are 2007 Canadian dollars

As might be expected, the largest value is realized by the first quintile. The amount is $47.9 billion, or 3.13% of GDP. The higher quintiles have progressively lower gains. In total, gains from leveling up of mortality amount to $97.3 billion, or 6.36% of GDP.

The value of mortality reductions is somewhat larger than morbidity reductions. The total value from leveling up health-related quality of life (from both reduced morbidity and mortality) is $155B, or 10.14% of GDP. This value is similar to that identified by Mackenbach et al. (2011) for Europe. That study identified a value of 9.4% of GDP from health-related quality of life gains realized from leveling up the lower half of socioeconomic status individuals to that of the upper half. The Mackenbach study used education as a measure of socioeconomic status rather than permanent family income. We used the latter in this study.

Sensitivity Analysis

In the analysis undertaken above, we used $50,000 for the value of an HUI and a discount rate of 3%. In Mackenbach et al. (2011), a value of $100,000 and 1.5% were used. The $100,000 value is taken from Nordhaus (2002) who draws on willingness-to-pays studies. In subsequent sensitivity analyses, we will evaluate the impact of using different values for an HUI and different discount rates. Other sensitivity analyses will also be performed around key assumptions.

Discussion

Our estimate of the total indirect loss associated with socioeconomic health inequalities consists of $5.1 billion in output losses and $155.0 billion in health-related quality of life losses for a total of $160.4 billion (10.47% of GDP). Caution should be taken in adding the two parts together as there is likely some overlap in the measurement of constructs within them. Specifically, the measure of health-related quality of life may capture some utility/value associated with labour-market engagement and earnings. This is the case even though the instruments developed to measure health-related quality of life attempt to distinguish between its direct impacts on utility from its impact through earnings (Donaldson et al., 2002). Essentially, good health is so fundamental to all aspects of life that it is difficult to disentangle the multiple ways in which it is valued into mutually exclusive measurement exercises.

The total amount identified in our study is comparable to a recent study by Mackenbach et al. (2011) that estimated similar indirect loss for Europe. In that study, educational attainment was used as the key measure of socioeconomic status, rather than permanent family income quintile. The Mackenbach et al. (2011) study identified a total gains of 10.73% of GDP, comprised of 1.35% in gains from labour-market earnings and related social contributions, and 9.38% in gains from improvements in health-related quality of life. Our findings for the first component, gains from labour-market earnings and related social contributions, is somewhat lower, possibly due to the use of permanent family income as a measure of socioeconomic status. In a supplemental analysis (found in the Appendix) we use educational attainment and find the gains to be larger. Another difference with the Mackenbach et al. (2011) is that they consider individuals 16-64, whereas we only consider individuals 25-54 in the labour-market analysis component (we consider all ages in the health-related quality of life component). Though their sample frame is more inclusive of the population, including the very young and older individuals may bias estimates due to different labour-market engagement patterns of these individuals compared to the core working age population.

Many other potential gains are not captured in this study. For example, we have not included the impact on premature mortality on paid labour-force output. The approach likely underestimates the true impact of health on output for other reasons. Some fraction of organizational profits may be attributable to labour-market activity of individuals, but we do not attempt to account for this. Another aspect not captured is the effect of health on aggregate level productivity at the organizational level (e.g., team-based and time sensitive production processes). Other phenomena not considered are the impact of health on educational attainment, savings and capital accumulation. Also not considered is the impact of health on other individuals in the family and community (i.e., on their earnings and time use).

In the counterfactual scenario it is assumed that increases in labour supply arising from improvements in health will be matched with equally gainful employment opportunities. In reality, if there are dramatic increases in labour supply there are likely to be numerous adjustments in the economy over the short- and medium-term that eventually take the economy to a new general equilibrium in the long run. One concern raised by some economists (Rodriguez and Lopez-Valcarcel, 2011) is that if there are dramatic increases in labour supply over a short period of time, it may result in lower wages and higher levels of unemployment. Essentially, a larger labour supply may not be offset by an increase in labour demand. If this is the case, the proposed methods may overestimate the indirect losses. There is a flaw in this logic in that no specific interventions are being proposed, and therefore the rate of change in health and related labour supply is not being specified. Indeed, with a dramatic change in health, multiple aspects of society will change such as labour-supply, output, saving, educational investment, capital accumulation, family formation, in addition to labour demand. Ultimately, population size and the economic base may be substantially larger and relative prices may be different, including the wage rates. But estimating all the prices and other characteristics of the new equilibrium would require a macro model of the entire economy. In our study we use a reduced form estimation approach that focuses on the supply of labour to assessing the impact of health on productivity and output. It is only a first-order approximation from the vantage point of relative prices as they exist today.

There are a number of strengths in the methods we employ. We have attempted to address the issue of reverse causality by using panel data and appropriate temporal sequencing. Additionally, we use permanent income to identify socioeconomic position. Nonetheless, our methods may not fully address endogeneity. Future work might consider using instrumental variables, structural equation modeling and/or simulation models to disentangle the complex relationship between health and economic outcomes. Despite the possibility of endogeneity, the proposed methods likely provide very conservative estimates given the possibility of underestimation for a number of reasons which we described above.

The health measures we use are broadly inclusive. The use of self-reported health status as the key health measure in labour-force output estimates is a more comprehensive approach than that used in EBIC studies in which specific diagnostic categories were considered separately. The downside of using a subjective measure of health is that it may result in more noise than objective measures and the possibility of reporting biases (e.g., reporting lower levels of health because of non-participation in the paid labour force). The use of HUI as the key health measure in estimating health-related quality of life is also more comprehensive for the same reason. Our broader approach addresses concerns noted in the EBIC studies about missing the impact of co-morbidities. Furthermore, the proposed multivariate regression modeling approach for estimating paid labour-force output accounts for multiple factors contributing to output, thus avoiding the risk of inadvertently attributing all earnings differences to health.

One aspect of our conceptualization of the sources of indirect burden reductions may have implications for direct burdens. Specifically, reductions in mortality would result in a larger number of individuals reaching retirement age. This in turn may increase health care and social security expenditures. These increased expenditures offset gains from the indirect categories at issue in this study, but have not been taken into consideration. In a system where health accounts are neutral over the life course (i.e., payment to them through taxes are balanced by use of resources funded through them), increased used of health care at an elderly age may be less of a concern.

The estimation of indirect losses associated with labour-force output is based on the assumption that earnings are a reasonable estimate of the value of individual output in the paid labour force. Furthermore, our use of the human capital approach assumes that health-related output losses are enduring. We noted that the friction costs approach has been proposed in the economic evaluation literature. Our sense is that the friction cost approach is relevant only under specific conditions, most notably if unemployment rates are above the frictional level, and in cases of small scale initiatives that affect population health only at the margins. As noted, the health changes we investigate are substantial, not marginal, so the friction cost approach is not appropriate for the issue being investigated.

Overall, this study substantially advances the measurement of gains to be realized from eliminating socioeconomic health inequalities. The findings dovetail well with previous work undertaken in Canada and elsewhere, in particular recent efforts by Statistics Canada to estimate the health care cost burden of socioeconomic health inequalities. Many studies have focussed on the impact of socioeconomic status on health (e.g., Brekke et al., 1999; Brown et al., 2004; Link and Phelan 1995; Marmot 2005; Marmot and Wilkinson, 2006; Raphael, 2004), but have not taken the next step of considering their health care cost burden and indirect values associated with market output and health-related quality of life. Most studies related to this topic focus on productivity and output losses of poor health rather than socioeconomic health inequalities. Some of these studies are aggregate-level studies (e .g., Acemoglu and Johnson, 2007; Barro and Sali-i-Martin, 1995; Bhargava et al., 2001; Bloom et al., 2001; Knowles and Owen, 1995, 1997; Rivera and Currais, 1999a, 1999b), whereas others use micro-data (i.e., studies using individual data) such as EBIC (1986, 1993, 1998). Though important, these studies overlook the values associated with socioeconomic status related health inequalities within populations. Socioeconomic health inequalities are a major challenge to policy makers and legislators in developed countries, but offer the potential for substantial improvements in population health as well as economic performance (McKee, 2011).

It is important to emphasize that this study is a burden study and not an evaluation of an intervention or a prescription for particular policy interventions. Health burden studies are meant to highlight the financial costs of adverse health so that policy makers can be better informed about potential gains to be realized by implementing appropriate interventions. In some cases there may not be sufficient evidence-based interventions to fully realize all potential gains. In such cases, the call to action for policy makers may be to invest in research and development. It is also important to emphasize policy options directed at reducing socioeconomic status related health inequalities are not necessarily about income transfers from higher to lower socioeconomic groups. The intent is not to eliminate socioeconomic status inequalities, but rather health inequalities associated with socioeconomic status. This can be achieved through a range of programs. They key message is that there is a potential for substantial gains in addressing socioeconomic status related health inequalities.

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Appendix 1: Methods Details

In this appendix we provide the methods section in its entirety, i.e., including all mathematical calculations and statistical formulations used in the analyses.

Part 1 Analysis

Health and Labour-force Participation

There is a large literature on the effects of health on economic outcomes at the macro and micro level (Sharpe and Murray, 2010). Health is similar to education in that it is a form of human capital that bears on participation in the paid labour force and on labour-market earnings. Health capital can impact conventional measures of productivity through presenteeism, i.e., productivity while at work, and absenteeism. Health capital can also impact social productivity measures through unemployment and labour-force participation. The literature also identifies other pathways. Specifically, four broad pathways have been described (Bloom and Canning, 2000). The above noted impacts on conventional measures of productivity identified by Sharpe and Murray (2010) fall under the category of the direct impact on labour quality. A second category is the impact of health on educational investment. A third category is the impact on savings and capital accumulation. A fourth category is demographic effects, which is primarily about survival rates of children, the size of the working age population, fertility and female participation in the paid labour force. The social productivity measures identified by Sharpe and Murray (2010) might be placed under category one or four.

In the modeling for *Part 1 Analysis*, we are estimating the impact of health on paid labour-force participation and productivity, not educational investment, savings/capital accumulation. In this modeling, we are assuming that an individual's labour-market earnings reflect the value of an individual‘s productivity and out. In turn, the aggregate of individual output across the entire paid labour force is assumed to reflect the value of market activity. We are considering only the value of output in the paid labour force to estimate market activity. The value of participation in social roles, including work, is taken into consideration in Part 2.

In our approach to valuation in *Part 1 Analysis* we are considering only supply side factors, whereas a number of demand-sided factors also bear on paid labour-market earnings. For example, with more people in the labour due to better health profiles, the wage rate might decrease due to increased competition for jobs. Over the long run, the better health profiles within a population would give rise to multiple changes in society as described above, ultimately a new general equilibrium. The proposed models might be thought of as reduced form models, since we are not modeling supply and demand side factors through a structural equations modeling approach.

The objective of the modeling is to estimate the effects of health on labour-market outcomes. We build into the analysis the role of socioeconomic status by estimating separate models for different levels of socioeconomic status. We also attempt to estimate separate models for women and men, where possible. In the modeling we need to minimize the possibility of reverse causality (i.e., the effects of earnings on health). This is addressed through temporal sequencing in which explanatory variables, particularly health, are taken from a time period prior to the outcome variable of interest. This requires longitudinal/panel data at the individual level. The basic functional form for the income equation will be as follows:

$$y_{t,i} = f\ (\textit{health status}_{t-1,i}, \textit{other demographic characteristics}_{t-1,i}, \textit{contextual factors}_{t-1,i})$$

where $y_{t,i}$ is the outcome of interest, labour-market earnings, in time t by individual i.

The regression model parameters are used to estimate a counterfactual scenario in which the impact of health inequalities associated with socioeconomic status are eliminated. This counterfactual analysis relies on individual data, but ultimately is estimated at the aggregate (i.e., national) level. It should be noted that eliminating socioeconomic health inequalities is different from eliminating socioeconomic status or eliminating health inequalities. In the counterfactual scenario socioeconomic status differences continue to exist, and health inequalities also continue to exist. Only health inequalities due to socioeconomic status are eliminated.

Primary Data Source

Data for the study is drawn from the Canadian Survey of Labour and Income Dynamics (SLID), a nationally representative longitudinal labour-market survey based on a stratified, multi-stage design that uses probability sampling. The sample frame for the SLID is individuals aged 16 and older who reside in one of the ten Canadian provinces. The SLID excludes residents of the Yukon, the Northwest Territories and Nunavut, residents of institutions, and persons living on Indian reserves. Overall, these exclusions amount to less than three percent of the population (Statistics Canada, 1997). The SLID is composed of six-year overlapping panels. The first panel began in 1993, a second in 1996, a third in 1999, and a fourth in 2002. The response rate for SLID is considered within the good to very good range. For the present study, we use the fourth panel which spans the period from 2002 to 2007. For the fourth panel, the response rate was approximately 80% in the first year, decreasing slightly by the final wave. Each panel comprises approximately 15,000 households. Information is collected annually from all household members with one individual selected for a more in-depth labour and income interviews. For this individual, detailed information is collected on the characteristics of up to six jobs annually. One of the jobs is identified as the individual's main job, based on the greatest number of hours, or highest earnings in the reference year. Individuals are also asked about socio-demographic characteristics, income sources and amounts at the individual and family level, and information on their general health at the time of the survey.

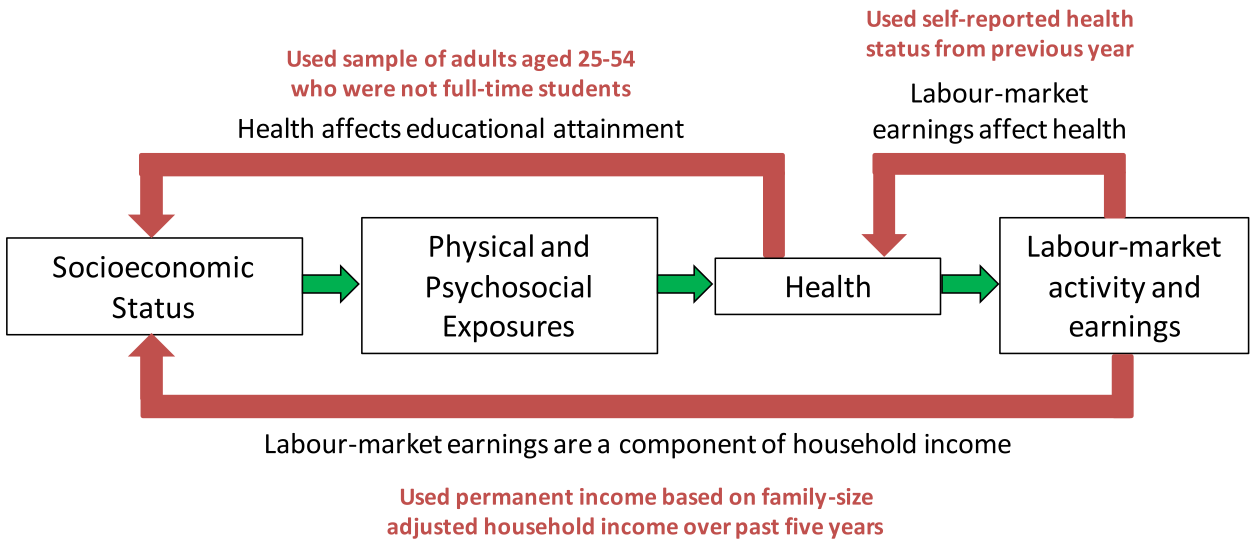
Sample Selection

Given that the objective of *Part 1 Analysis* is to identify the total impact of better health of working age adults on output in a calendar year, the subsample of individuals to be selected for analysis should be prime-age working adults (i.e., 25 to 54), excluding full-time students and unpaid family workers. A starting age of 25 is suggested in order to capture individuals at a point when they have completed most of their formal education. This sample includes individuals with zero labour-market earnings. In the first iteration of the analysis we include only those individuals who have labour-market income. The inclusion of individuals with zero labour-market earnings result in lower estimates of average labour-market earnings for the sample.

Measures

The primary indicator of socioeconomic status for the proposed study is pre-tax household income adjusted for family size.[6] Income quintiles are created based on the distribution of family income, with the category 1 representing the lowest socioeconomic status and 5 the highest. We note that the use of this variable introduces the possibility of endogeneity due to the fact that household income is determined in part by total labour-market earnings, the primary outcome measure of interest. In other words, while the focus of our analysis is the impact of health on labour-market earnings, we risk capturing the reverse relationship—namely, the impact of socioeconomic status (measured by household income quintile) on health. This is because household income is determined, in part, by labour-market income. Unlike education, which is reasonably unchanged for most individuals after a certain age, household income can change dramatically over time for working age adults. The concern is that if health changes income, it may also change socioeconomic status, which in turn bears on health. To address the issue of endogeneity of income we use average household income over a period of years prior to the year of the outcome variable. This might be thought of as a measure of permanent household income. Figure 4 provides a summary of the various ways we attempt to address endogeneity/selection effects.

Figure 4: Methods used to Minimize Selection Effects



Drawing on data from panel four of the SLID, we use average household income, adjusted for household size and composition[7], over the years 2002 to 2006 to identify socioeconomic status in

[6] The family definition used in the SLID is the economic family. An economic family is composed of two or more persons living together related by blood, marriage, adoption or common-law.
[7] We use an adjustment for family size derived from Statistics Canada's calculation of the Low Income Measure. Adjusted family size is determined as follows: the first adult is counted as one (1.0) person with each additional adult counted as 0.4 of a person and each child (under 16 years of age) as 0.3 of a person. If the family is comprised

a model with the outcome (labour-market earnings) taken from 2007. The specification for average household income is as follows:

$$Permanent\ Household\ Income_i = \sum_{t=2002}^{2006} Family\ Size\ Adjusted\ Household\ Income_{t,i} \ / \ 5$$

where *i* represents an individual in the sample and *t* the calendar year.[8] Individuals are then allocated to a socioeconomic status quintile based on the range of permanent household income values identified in the SLID. For each quintile, separate labour-market earnings regression models are estimated.

The outcome variable for this analysis is total annual labour-market earnings from all sources, which constitutes a widely used measure of productivity based on the notion that individuals are paid at the rate of their marginal product of labour. Labour-market earnings are comprised of gross employment and net self-employment earnings from all sources. The log transformation of labour-market earnings is undertaken prior to use in the models in order to improve the symmetry of the overall distribution of this variable within the sample.

The key explanatory variable in the modeling is self-reported health status. This self-report of general health is collected annually in the SLID. It consists of a single-item taken from a question that reads as follows:

> *In general, how would you describe your state of health? Would you say it is excellent, very good, good, fair or poor?*

Responses are scored on a five-point Likert scale ranging from excellent to poor (1 to 5, respectively). The measure is used as a categorical variable (i.e., with five distinct categories of self-reported health).

Self-reported health is considered a valid measure of acute and chronic conditions, physical functioning, and to a lesser extent health behaviours and mental health problems (Cott et al., 1999; Krause and Jay, 1994). Self-reported general health is also a strong independent predictor of subsequent illness and premature death (Idler and Benyamini, 1997; McCallum et al., 1994).

As is the case with socioeconomic status, health may also be endogenous. To minimize the possibility of endogeneity, self-reported health status from the prior year is used in the modeling.

Other explanatory variables included in the analysis are level of education (three categories), age, age squared, gender, marital status, children under 16, province of residence, and rural/urban residence. For educational bracket we use less than high school, high school and

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of only one adult, the first child is counted as 0.4 of a person (Statistics Canada, 1999).

[8] All dollar amounts are standardized to calendar year 2007, prior to aggregation, using the Canadian consumer price index (CPI) for all goods and services. The CPI series relevant to the SLID panel are as follows: (2002=1.12, 2003=1.08, 2004=1.06, 2005=1.04, 2006=1.02 and 2007=1.00).

some post-secondary, post-secondary degree/diploma. Table 3 provides details on the explanatory variables used in the analysis.

Table 3: Explanatory Variables Used in the Modeling

Variable (SLID variable name)	***Specification***	***Details***
Health Status (crhlt26)	*health status (poor, fair, good, very good, excellent)*$_{t-1,i}$	Set of dummy variables indicating the level of self-reported health status—one level serves as the comparator
Educational attainment (hleved18)	*education (less than high school, high school or some post-secondary, post-secondary degree/certificate)*$_{t-1,i}$	Set of dummy variables indicating educational attainment category—one category serves as the comparator
Age (age26)	$age_{t-1,i}$ $age^2_{t-1,i}$	Age Age squared
Gender (sex99)	$gender_i$	Dummy variable indicating sex
Marital Status (state4)	$married_{t-1,i}$	Dummy variable indicating individual is married or living common law as opposed to single/divorced, widowed
Children (nbsa26)	$children_{t-1,i}$	Dummy variable indicating the individual has children under 16 in the family unit
Province of Residence (pvreg25)	*province (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland)*$_{t-1,i}$	Set of dummy variables indicating province of residence—one province serves as a comparator
Urban/Rural Residence (urbrur25)	$rural_{t-1,i}$	Dummy variable indicating rural as opposed to urban residence

Regression Modeling Analysis

Following is a generic specification of the model:

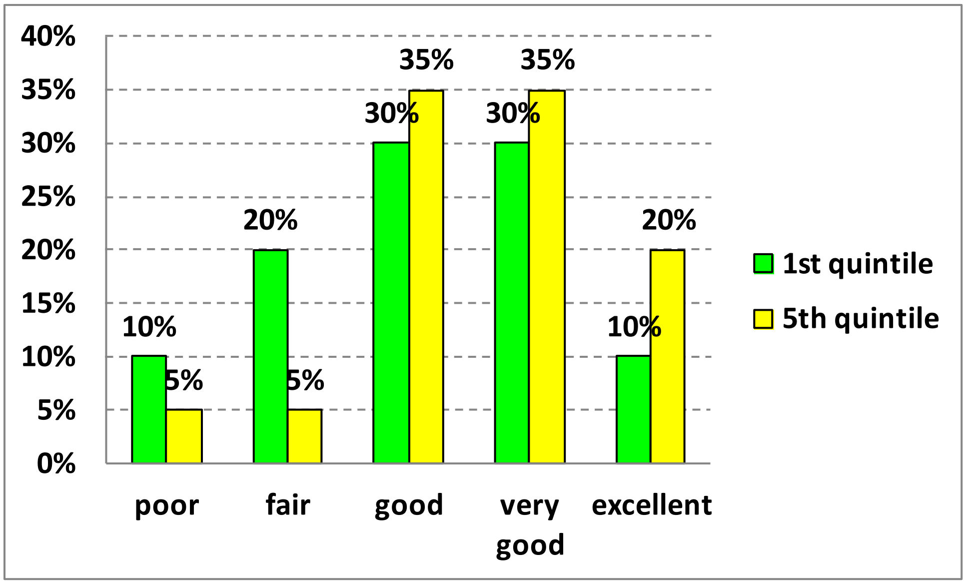
$$y_{t,i} = f\{\ \textit{health status (five categories)}_{t-1,i},\ \textit{education (three categories)}_{t-1,i},\ age_{t-1,i},\ age^2_{t-1,i},\ gender_i,\ married_{t-1,i},\ children_{t-1,i},\ \textit{province (ten categories)}_{t-1,i},\ rural_{t-1,i}\}.$$

where t is time period/calendar year, and i is individual.

Counterfactual Analysis

Counterfactual analysis is based on the assumption that if socioeconomic health inequalities are eliminated, then the distribution of health will be the same in each of the lower four quintiles as in the highest quintile. In Chart 1 we depict a hypothetical example comparing the health profiles of the 1st and 5th quintiles for a particular gender and age bracket.

Chart 1: Example of Health Profiles for the 1st and 5th Quintiles



Let us assume that average labour-market earnings for the 1st quintile for poor, fair, good, very good, and excellent health are $1,000, $9,000, $12,000, $15,000, and $19,000 respectively. In the counterfactual analysis, the 1st quintile would have the health profile of the 5th quintile, therefore the proportion of individuals with poor, fair, good, very good and excellent health would be 5%, 5%, 35%, 35% and 20% respectively. Labour-market earnings for the 1st quintile in the counter factual analysis would be determined by multiplying the mean labour-market earnings in each health status level (as estimated in the original scenario) times the number of individuals in that health status level as determined by the new proportions. If there are 1,000 individuals in the 1st quintile, the calculation would be as follows:

$$Total\ labour\ market\ earnings\ gains\ from\ improved\ health_{first\ quintile} = 1{,}000\ \times\ (\$1{,}000\ \times\ 5\% + \$9{,}000\ \times 5\% + \$12{,}000\ \times 35\% + \$15{,}000\ \times 35\% + \$19{,}000\ \times 20\%)$$

This approach to estimating the counterfactual scenario preserves the correlation matrix of the explanatory variables, and hence the model parameters for each of the regression models also remain the same. Furthermore, the socioeconomic status of individuals should remain unchanged, even though labour-market earnings may increase for some, because we are using earnings specific to the quintiles. Essentially the relative ranking of individuals in socioeconomic quintiles remains unchanged.

For the counterfactual analysis we begin with the estimation of total labour-market earnings based on current health profiles and demographic characteristics. If we group individuals with others in the same socioeconomic quintile and health status level, we can estimate the mean fitted value of labour-market earnings for each quintile and health status level. We represent these means as $\bar{Y}_{q,h}$, where q denotes the quintile and h the health status category. We used the fitted values of labour-market earnings rather than actual earnings to ensure we account for only those aspects of earnings associated with the explanatory variables in our regression models Actual earnings may vary from fitted or predicted earnings for a number of reasons, and we do not want to include this 'noise' in our estimates. With 5 quintiles and 5 health levels (i.e., poor, fair, good, very good and excellent), the set of mean labour-market earnings values can be denoted as $\bar{Y}_{1,1}, \bar{Y}_{1,2}, \bar{Y}_{1,3}, \bar{Y}_{1,4}, \bar{Y}_{1,5}, \ldots \bar{Y}_{5,1}, \bar{Y}_{5,2}, \bar{Y}_{5,3}, \bar{Y}_{5,4}, \bar{Y}_{5,5}$. The proportion of individuals within a quintile that have a specific health status level (i.e., the proportion of that quintile) can be estimated using counts based on the population weights. These proportions are represented as $Prop_{q,h}$ and the set includes 25 items that are counterparts to the set of mean labour-market earnings values. The number of individuals in a quintile is represented by n_q.[9] Using the mean values, proportions and numbers of individuals, the total labour-market earnings across all socioeconomic quintiles can then be estimated in a different way as follows:

$$Total\ labour\ market\ earnings_{baseline} = \sum_{q=1}^{5} n_q \sum_{h=1}^{5} Prop_{q,h} \times \bar{Y}_{q,h}$$

Total labour-market earnings under the counterfactual scenario ($Total_{counterfactual}$) would be:

$$Total\ labour\ market\ earnings_{counterfactual} = \sum_{q=1}^{5} n_q \sum_{h=1}^{5} Prop_{5,h} \times \bar{Y}_{q,h}$$

The above information is used to estimate the proportionate increase in labour-market earnings from improved health that would be achieved by eliminating health inequalities due to socioeconomic status ($Proportion\ increase\ in\ labour\ market\ earnings_{all\ quintiles}$). This amount is simply the total earnings in the counterfactual scenario over total earnings in the baseline scenario:

$$\begin{aligned} &Proportion\ increase\ in\ labour\ market\ earnings_{all\ quintiles} \\ &\quad = \left(Total\ labour\ market\ earnings_{countefactual} \right. \\ &\quad \left. \div\ Total\ labour\ market\ earnings_{baseline}\right) - 1 \end{aligned}$$

By subtracting one from the proportion, the equation estimates the incremental amount of increase over baseline.

In this counterfactual scenario, we are assuming that the distribution of health in all quintiles is the same as the highest quintile while at the same time preserving the covariate structure of the

[9] The values for $\bar{Y}_{q,h}$ and n_q are estimated using the population weights provided by the SLID and the fitted values for individual level labour-market income. The latter is estimated based on the regression model coefficients for each quintile group, and the characteristics of individuals in the sample.

contextual factors included in each of the quintile labour-market earnings models (i.e., each of the quintile model specifications remain the same). As a result, the counterfactual scenario will likely have a higher proportion of individuals in the lower quintiles that have demographic characteristics of individuals in the higher health status categories of their respective quintiles than at baseline.

Estimation of Aggregate Earnings Gains

The total labour-market earnings increase attributable to the elimination of socioeconomic health inequalities can be estimated directly from the numbers identified above. There are several reasons why this total may underestimate the true value. First, the survey which is being used for this analysis, the SLID, does not include individuals in institutions, on reserves, in the military or living in the territories. Second, it does not include labour earnings elements paid for by employers such as payroll taxes, also known as employer social contributions. To accommodate this factor, we use the proportionate increase in labour-market earnings ($Proportional\ increase_{labour\ market\ earnings}$) and multiplying it by the labour income component of gross domestic product (GDP), which we denote as GDP_{labour}. The labour income component of GDP is comprised of two broad items: 1) labour-market earnings, and 2) supplementary labour income. The latter is employers' social contributions (either compulsory or voluntary). We denote the two items as $GDP_{labour\ market\ earnings}$ and $GDP_{supplementary\ labour\ income}$, respectively. Following is the specification:

$$\begin{aligned} &Total\ labour\ market\ earnings\ gains_{all\ quintiles} \\ &\quad = GDP_{labour} \times\ Proportional\ increase\ in\ labour\ market\ earnings_{all\ quintiles} \\ &\quad = \left[GDP_{labour\ market\ earnings} +\ GDP_{supplemental\ labour\ income}\right] \\ &\quad \times Proportional\ increase\ in\ labour\ market\ earnings_{\ all\ quintiles} \end{aligned}$$

Data for the above equation is comes from Statistics Canada's CANSIM database (Table 382-0006). See Statistics Canada (2010) for details.

Supplemental Analysis

As a supplemental analysis we used educational attainment tertile, rather than permanent household income quintile as a measure of socioeconomic status. This analysis was undertaken to further address the issue of endogeneity of labour-market income. As noted, labour-market income is a component of household income, whereas educational attainment is further removed from it. These regression models had permanent household income quintile as an explanatory variable rather than educational attainment bracket. The model specifications were as follows:

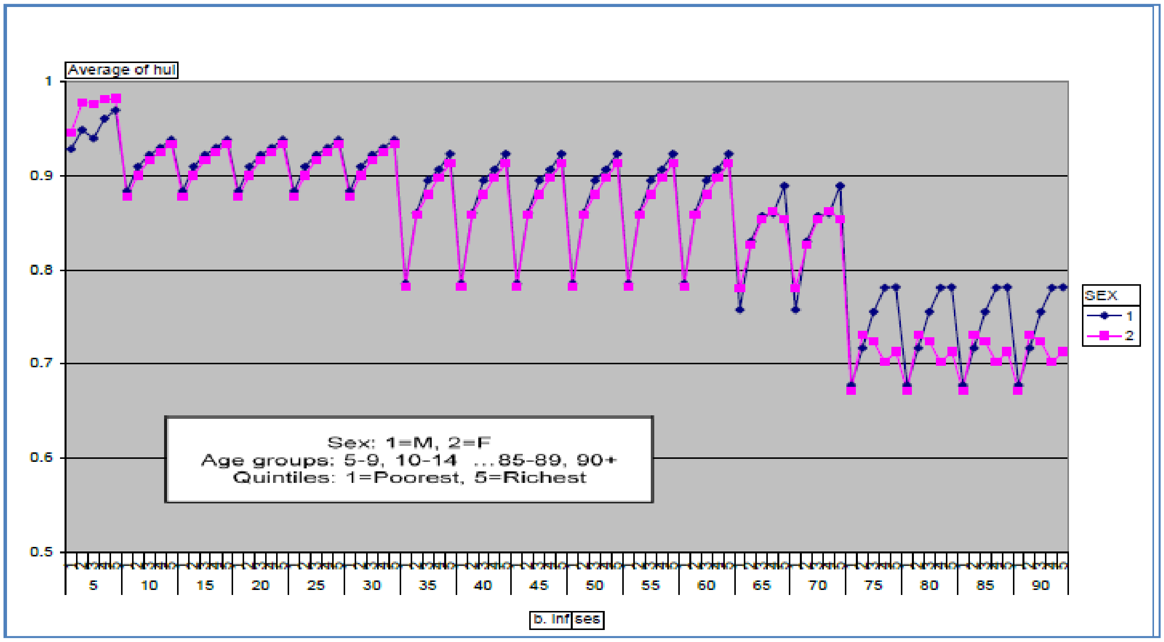
$y_{t,i} = f\{$ *health status (five categories)*$_{t-1,i}$, *permanent household income quintile (five categories)*$_{t-1,i}$, $age_{t-1,i}$, $age^2_{t-1,i}$, $married_{t-1,i}$, $children_{t-1,i}$, *province (ten categories)*$_{t-1,i}$, $rural_{t-1,i}\}$.

In this supplemental analysis, we also estimated separate regression models for women and men within each educational tertile, therefore gender was not a variable in the regression models.

Part 2 Analysis Component 1

The valuation of reductions in morbidity in terms of QALYs gained will include all ages (i.e., not just those 25-54 as in Part 1). It will draw on analyses undertaken by Statistics Canada on socioeconomic inequalities in morbidity by income quintile.

Figure 5: HUI by income quintile and age (5 year groups), males and females, Canada*



*Statistics Canada (2010).

If we use Statistic Canada's calculations of HUI values for five-year age bracket by gender (see Figure 5 for details), we have 18 sets of five groups for each gender. If we represent the set for a gender as $HUI_{1,1}$-$HUI_{18,5}$, and use the first subscript to identify the age bracket and the second subscript to identify the income quintile, the first set consists of $HUI_{1,1}$, $HUI_{1,2}$, $HUI_{1,3}$, $HUI_{1,4}$, and $HUI_{1,5}$. Each item in the set is assumed to contain the HUI scores for that age bracket and quintile. For example, for the first age bracket of <1 in the fifth quintile is represented by $HUI_{1,5}$ and contains the HUI scores for that group. We represent the population of a particular age bracket and quintile using the letter P. If we represent the monetary value of a QALY by $Value_{HUI}$, then the monetary value of the gains in morbidity for the first age bracket would be represented as follows:

$$Value\ of\ morbidity\ reductions_{fist\ age\ bracket} = \sum_{q=1}^{4} \left(HUI_{1,q} - HUI_{1,5}\right) \times P_{1,q} \times Value_{HUI}$$

Where $P_{1,q}$ represents the population in the 1st age bracket of a particular quintile. As before, q represents the quintiles. No discounting is required for this component of the valuation, since we are only considering reductions in morbidity for the one calendar year. Based on the above, the total value of gains for all age brackets would be as follows:

$$Total\ value\ of\ morbidity\ reductions_{all\ age\ brackets} = \sum_{j=1}^{18}\sum_{q=1}^{4}(HUI_{j,q} - HUI_{j,5}) \times P_{j,q} \times Value_{HUI}$$

where *j* represents the age bracket. If we modify the formula to include separate tabulations for men and women, since the morbidity levels are different across the life course for each, the specification would be as follows:

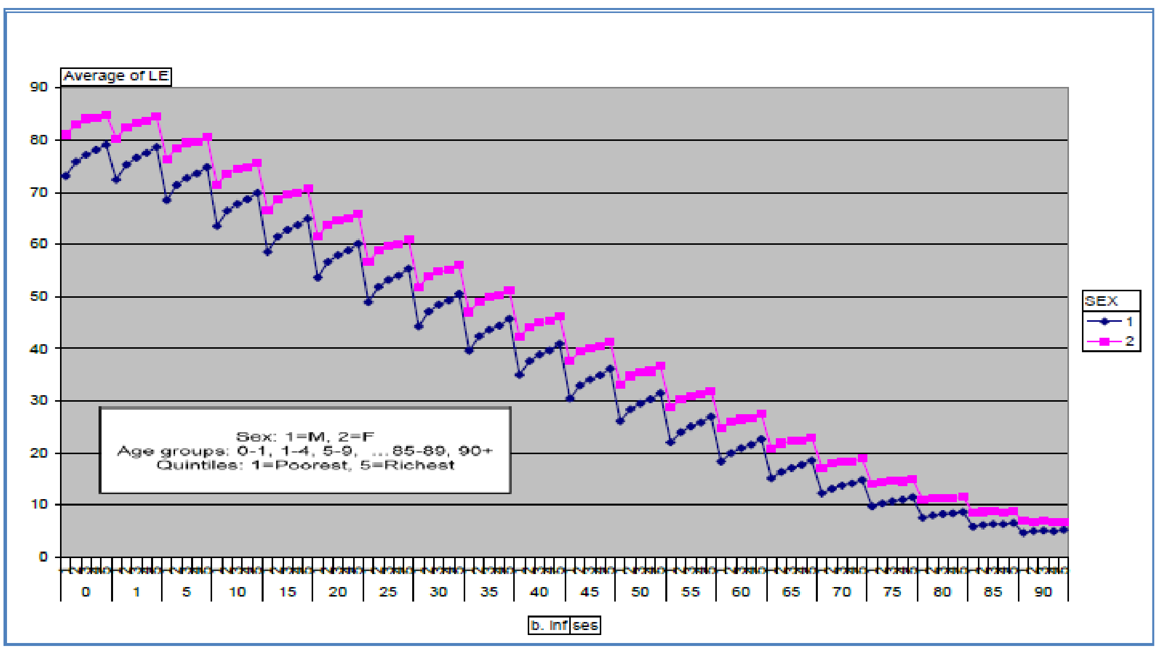
$$Total\ value\ of\ morbidity\ reductions_{all\ quintiles} = \sum_{q=1}^{4}\sum_{j=1}^{18}\sum_{g=1}^{2}(HUI_{g,j,q} - HUI_{g,j,5}) \times P_{g,j,q} \times Value_{HUI}$$

where *g* represents gender.

Part 2 Analysis Component 2

The valuation of gains in life expectancy in terms of QALYs gained due to reduced mortality will also include all age groups. It draws on analyses undertaken by Statistics Canada on socioeconomic inequalities in mortality/life expectancy by income quintile (see Figure 6 for details).

Figure 6: Life expectancy by income quintile and age (5 yr groups), males and females*



*Statistics Canada (2010)

In this counterfactual analysis we assume that all of the lower quintiles have the mortality rate of the highest quintile. Therefore, we estimate the number of lives lost due to premature mortality.

The formulation for the first quintile in the first age bracket is:

$$lives\ lost_{1,1} = (M_{1,1} - M_{1,5}) \times P_{1,1}$$

where $M_{1,1}$ represent to probability of death/mortality for the first age bracket of the first quintile, and $M_{1,5}$ for the first age bracket of the fifth quintile.

The years of life lost from each premature death in that age bracket could be estimated by using the life expectancy value for the highest quintile from that age bracket. We can represent the life expectancy values for each of the age brackets with the symbol *L*. Using this notation, the set of life expectancy values for the highest quintile of the 20 age brackets would is $L_{1,5}$ ... $L_{20,5}$.

The years of life lost would likely not be years of full health, so they need to be adjusted for quality (i.e., converted into QALYs). We use the HUI scores for this purpose. The value of each year of lost life can be taken from the morbidity tables developed by Statistics Canada, as found in Figure 5. In keeping with the notion that health inequalities associated with socioeconomic status are eliminated in the counterfactual scenario, we use the HUI scores associated with the highest quintile. We represent the set of HUI scores for the highest quintile with the symbol *HUIg,* where *g* represents a particular age.

Since the years of life gained in the counterfactual scenario are in the future, they need to be discounted to the present. Furthermore, the HUI scores need to be converted to monetary values by multiplying them by some monetary value of a QALY/HUI. We represent this monetary value by $Value_{HUI}$, as before, and the discount rate by *i*. Using these notions, the monetary value of years of life gained by the first quintile of the first age bracket can be represented as follows:

$$Value\ of\ mortality\ reductions_{1,1} = (M_{1,1} - M_{1.5}) \times P_{1,1} \times \sum_{k=1}^{(L_{1,5}-A_{1,midpoint})} [Value_{HUI} \times HUI_{L_{1,5}-k+1}] \div [(1+i)^{(L_{1,5}-A_{1,midpoint}-k+1)}]$$

The exponent $(L_{1,5} - A_{1,midpoint} - k + 1)$ is the discounting of the QALY (represented by $HUI_{L_{1,5}-k+1}$) to the present. We are assuming that the average age is in the midpoint of the age bracket, represented by $A_{1,midpoint}$, and therefore we are discounting the QALYs gained to that midpoint age. The notation identifies the HUI scores for a year of life at a particular point in time, starting at the life expectancy age of the highest quintile (approximately 79 for men and 85 for women at birth) for the first age bracket (we use the conditional remaining life expectancy for each age bracket for these calculations). After the last year of life is discounted to the present (i.e., $A_{1,\ midpoint}$), the year prior to the last year needs to be discounted. Hence the need for the subscript notation $L_{1,5-k+1}$, which identifies successively earlier years of HUI scores. If we expand the formula to include all of the four lower quintiles, it would be as follows:

$$
\begin{aligned}
&Value\ of\ mortality\ reductions_{first\ age\ bracket} \\
&\qquad = \sum_{q=1}^{4} \left(M_{1,q} - M_{1.5}\right) \times P_{1,q} \\
&\qquad \times \sum_{k=1}^{(L_{1,5}-A_{1,midpoint})} \left[Value_{HUI} \times HUI_{L_{1,5}-k+1}\right] \div \left[(1+i)^{\left(L_{1,5}-A_{1,midpoint}-k+1\right)}\right]
\end{aligned}
$$

where *q* represents the quintile. If we further expand the formula to include all 18 age brackets, it would be as follows:

$$
\begin{aligned}
&Value\ of\ mortality\ reductions_{all\ quintiles} \\
&\qquad = \sum_{q=1}^{4} \sum_{j=1}^{18} \left(M_{j,q} - M_{j.5}\right) \times P_{j,q} \\
&\qquad \times \sum_{k=1}^{(L_{j,5}-A_{j,midpoint})} \left[Value_{HUI} \times HUI_{L_{j,5}-k+1}\right] \div \left[(1+i)^{\left(L_{j,5}-A_{j,midpoint}-k+1\right)}\right]
\end{aligned}
$$

where *j* represent the age bracket.

Lastly, we expand the formula to include separate tabulations for men and women, since the morbidity levels are different across the life course for the each. In general, morbidity levels for women are higher than for men in older age brackets. This finding is consistent with that found in other studies (Kaplan et al., 2001).Introducing separate tabulations for men and women requires introducing another subscript into the formula, which would be as follows:

$$
\begin{aligned}
&Value\ of\ mortality\ reductions_{all\ quintiles} \\
&\qquad = \sum_{q=1}^{4} \sum_{j=1}^{18} \sum_{g=1}^{2} \left(M_{g,j,q} - M_{g,j.5}\right) \times P_{g,j,q} \\
&\qquad \times \sum_{k=1}^{(L_{g,j,5}-A_{j,midpoint})} \left[Value_{HUI} \times HUI_{L_{g,j,5}-k+1}\right] \div \left[(1+i)^{\left(L_{g,j,5}-A_{j,midpoint}-k+1\right)}\right]
\end{aligned}
$$

where *g* represents gender (i.e., men=1 and women =2).

The Value of a QALY

Through counterfactual analysis we identified the gains in QALYs based health-related improvements in role functioning across all social roles, as well as the intrinsic value of health. These gains are associated with the elimination of adverse health exposures associated with socioeconomic inequalities. In order to facilitate development of a summary measure, QALYs need to be converted to monetary units. To determine the value of a QALY we can turn to several sources such as, 1) the health policy arena and health institutions where funding decision or guidelines are made for investment in health technologies, 2) the academic literature on health technology assessment, 3) contingent valuations studies where a sample of individuals from the general population have been asked to state their preferences through willingness-to-pay or willingness-to-receive questionnaire, and 4) revealed preference studies where analysts have extracted the statistical value of health based on risk-return tradeoffs made by individuals in the marketplace.

Health Policy Arena and Health Institutions

One source for monetary threshold values for a QALY are guidelines used in the policy arena or proposed by health institutions. A good example is the Canadian Agency for Drugs and Technologies in Health (CADTH), which uses a value of $50,000 per QALY (QALYs: The Canadian Experience, 2007). This is the base value we use in our analysis.

Another source is the Dutch National Council for Public Health and Health Care, which proposed an upper limit of Euro 80,000 for a QALY (Mackenback et al., 2007). The United Kingdom's National Institute for Health and Clinical Excellence (NICE) uses a range of £20,000 (€29,500; US$40,000) to £30,000 per QALY (Appleby et al., 2007). No calendar year is identified for the currency, but the NICE guidelines updated in 2009 retain the same values (NICE, 2009). As a more general guideline, the World Health Organization (WHO) proposed a value of three times the GDP per capita as an upper limit for a Disability Adjusted Life-Year (Commission 2001). These ranges of values can serve as a sensitivity analysis.

Health Technology Assessment (HTA) Studies

An influential article by Laupacis et al. (1992) that provides guidelines for HTA, suggests a lower bound incremental cost per QALY of CAN$20,000 (1990 dollars) and an upper bound of CAN$100,000 (1990 dollars) for assessing the desirability for adoption of new technologies. Specifically, they suggest that a cost per QALY of less than $20,000 provides strong evidence for adoption, and more than $100,000 provides weak evidence for adoption. A systematic review of monetary thresholds used in HTA (Khor et al., 2010) found that $50,000 was the most common single value used in studies (63 of 188 studies identified that used single values). Other common values used were $20,000 (61 of 188 studies) and $100,000 (51 of 188 studies). Of studies that used a range of values, the most commonly used range was $20,000-$100,000 (142 of 202 studies). We use this range in our sensitivity analysis. Kohr et al. (2010) suggests that the $20,000 value used by Laupacis et al. (1992) was justified by commonly funded intervention in Ontario at the time and may require updating. Furthermore, the monetary thresholds were provided as guidelines rather than edicts. They are not official guidelines. In general, economic evaluation guidelines proposed by Gold et al. (1996), Drummond et al. (2005) and others emphasize the need to incorporate ethical and political considerations into technology adoption decisions in health care rather than relying solely on a specific monetary threshold for all purposes.

Contingent Valuations Studies

The contingent valuation or stated preference approach to valuing health (i.e., willingness-to-pay (WTP) and willingness-to-accept (WTA)) uses survey methods to collect data on respondents' preferences, specifically their maximum WTP for health gains, or their WTA money and forego desirable health outcomes. The main difference between WTP and WTA is in the initial level of utility, higher for WTA than WTP. As a result of this difference it is expected that WTA values will be greater than WTP, though generally by a small amount if total utility is large relative to the health benefits under consideration. Values derived from contingent valuation methods are sensitive to the questions used to elicit values. Depending on how questions are worded, valuations may capture more than just the value of health outcomes. A more restricted willingness-to-pay approach that exclusively values health consequences would be the preferred approach (Tompa et al., 2008). As a result of the sensitivity to methods, the variance in values found across studies is quite wide. A systematic review of contingent valuation studies (Hirth et al., 2000) identified an average value of US$161,305 (1997 dollars). We use this value as the high end value for our analysis.

Revealed Preference Studies

This is a particular application of utility-based risk analysis that relies on labour market data to identify the statistical value of a human life. It is based on the assumption that providing safe work conditions is costly. Firms have a choice of either reducing risks and make lower profits or paying workers a risk premium to bear the risk. In the labour market, different employers offer different combinations of safety and risk premiums based on the costliness of reducing risk versus paying risk premiums. The assumption is that there is variability in risk-premium offerings because the cost of risk reduction varies across sectors and also firms within a sector. Since workers have the choice of bearing risk in return for higher pay they can select into jobs that reflect their risk preferences. In equilibrium, the wage-risk trade-off between employers and workers is the same. Based on this logic, economists have used data on job risks and wage rates to extract the risk premiums through econometric analysis. The concept is known as “revealed preferences” because workers reveal their preference for monetary compensation for health risks through their behaviour in the labour market (i.e., the choice of jobs they make). Most revealed preferences studies have investigated risks of mortality and have used the results to identify the statistical value of a human life. A few studies have investigated morbidity risks. A similar approach is also used to identify the statistical value of human life with data from non-labour market sources such as road and vehicle safety.

A review by Cookson and Dorman (2008) summarizes the findings from other literature reviews and comments on the concerns with this methodological approach to valuing health. A key concern is the broad range of values identified by studies. A review by de Blaeij et al. (2003) which focussed on road safety found estimates of the value of a statistical life ranged from approximately $3.0 million to $9.6 million (one outlier at each end was excluded in the range), with most concentrated at the low end. A review by Blomquist (2004) that included a few studies not found in de Blaeij et al. (2003) identified values of $5.6 million to $14.4 million, with no particular concentration at either end of the spectrum. Labour-market studies on the statistical value of human life have been comprehensively summarized in Viscusi and Aldy (2003). They found the range of values for US studies to be US$1.4 to US$41.6 million, while the range for non US studies was even wider, US$0.4 to US$148.2 million. Hirth et al. (2000) identified values of US$93,000 for a QALY from non-labour market studies and US$428,000 for labour-market studies (1997 dollars). These broad ranges raise some concern and make it difficult to identify an appropriate value or meaningful range to use in burden and economic evaluation studies.

Recommendations for the Selection of a Value for a QALY

Given the wide range of values for a QALY identified above, we consider a range of values in the form of a sensitivity analysis. As noted, our baseline value is $50,000. For the sensitivity analysis, we begin with the range of $20,000 to $100,000, which is the range found in other studies by Khor et al. (2010). For the high end, we use the average value found in willingness to pay studies by Hirth et al. (2000), which is $160,000 per QALY. The proposed range of $20,000 to $160,000 spans the values used in European HTA studies. The values from revealed preference studies are much higher and the range much broader. Given the concerns raised by reviewers about the revealed preference literature, we suggest not considering these values.

Aggregation of Part 1 and 2

We have identified and estimated three components of indirect losses associated with socioeconomic health inequalities, namely a labour-market earnings component related to improved health, a health component related to reduced mortality, and a health component related to reduced morbidity. These four components were identified with the following equations:

$$
\begin{aligned}
&Total\ labour\ market\ earnings\ gains_{all\ quintiles} \\
&\quad = GDP_{labour} \times\ Proportional\ increase\ in\ labour\ market\ earnings_{all\ quintiles} \\
&\quad = \left[GDP_{labour\ market\ earnings} +\ GDP_{supplemental\ labour\ income}\right] \\
&\quad \times Proportional\ increase\ in\ labour\ market\ earnings_{\ all\ quintiles}
\end{aligned}
$$

$$
\begin{aligned}
&Total\ value\ of\ morbidity\ reductions_{all\ quintiles} \\
&\quad = \sum_{q=1}^{4}\sum_{j=1}^{18}\sum_{g=1}^{2}\left(HUI_{g,j,q} - HUI_{g,j,5}\right) \times P_{g,j,q} \times Value_{HUI}
\end{aligned}
$$

$$
\begin{aligned}
&Value\ of\ mortality\ reductions_{all\ quintiles} \\
&\quad = \sum_{q=1}^{4}\sum_{j=1}^{18}\left(M_{j,q} - M_{j.5}\right) \times P_{j,q} \\
&\quad \times \sum_{k=1}^{(L_{j,5}-A_{j,midpoint})} \left[Value_{HUI} \times HUI_{L_{j,5}-k+1}\right] \div \left[(1+i)^{(L_{j,5}-A_{j,midpoint}-k+1)}\right]
\end{aligned}
$$

The sum of the three components represents the principal sources of gains associated with the elimination of socioeconomic health inequalities. We caution that there may be much overlap between Part 1 and Part 2, so the values might best be considered independently. Overlaps exist because the construction of QALYs assumes that the value of health in terms of social role functioning and the intrinsic value of health can be measured independently from the impact of health on labour-market engagement and earnings. In reality, the two parts are very much related.

Appendix 2 Results for Education Tertiles

Below we present the results for Part 1 Analysis where we use education as a measure of socioeconomic status rather than permanent family income. In this analysis, education is categorized into tertiles, consisting of less than high school, high school or some post-secondary education, and post-secondary degree or certificate. We number the tables and charts similarly to that found in the main report in order to facilitate comparison with their quintile counterparts.

Sample Descriptives

Table A4: Education Tertile Cut Points*

E1 Females: 512 observations, representing 0.47 million people	
E1 Males: 738 observations, representing 0.70 million people	
E2 Females: 3,797 observations, representing 3.50 million people	← High school
E2 Males: 3,622 observations, representing 3.75 million people	
E3 Females: 1,404 observations, representing 1.45 million people	← Post-secondary degree/certificate
E3 Males: 1,089 observations, representing 1.36 million people	

*monetary values are 2007 Canadian dollars

Chart A2: Distribution of Poor, Fair, Good, Very Good and Excellent Health

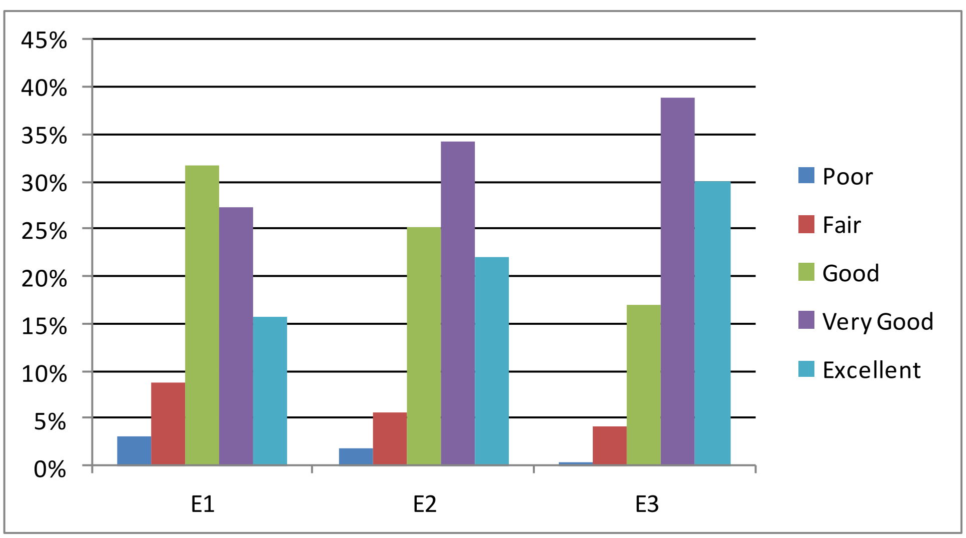


Chart A3: Distribution of Poor/Fair/Good Health versus Very Good/Excellent Health

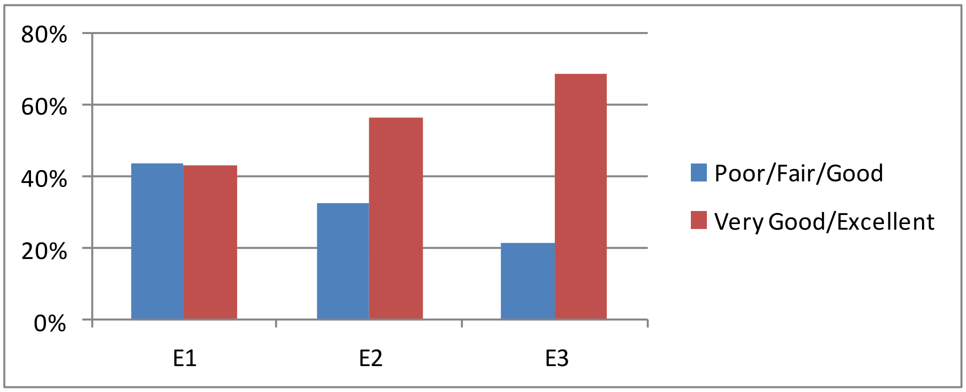


Chart A4: Average Labour-market Income by Tertile*

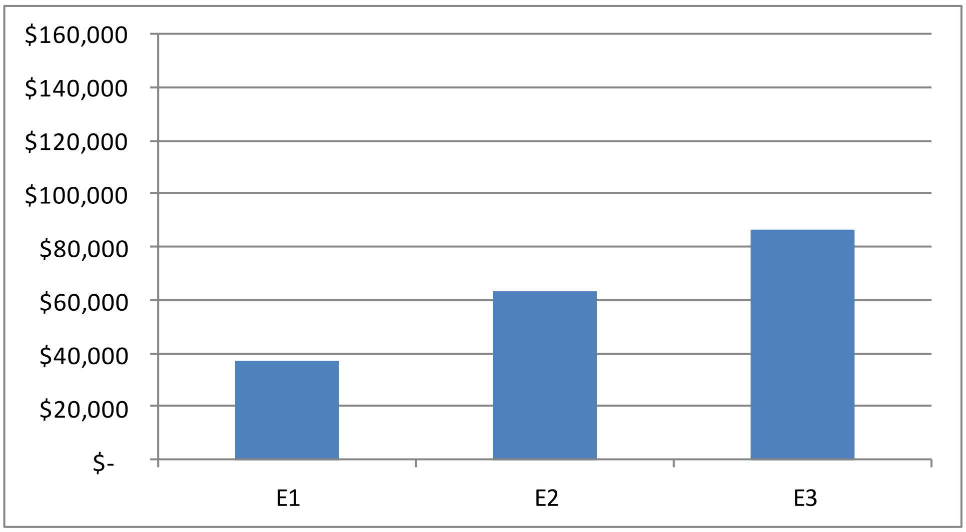


Chart A5: Gender Distribution

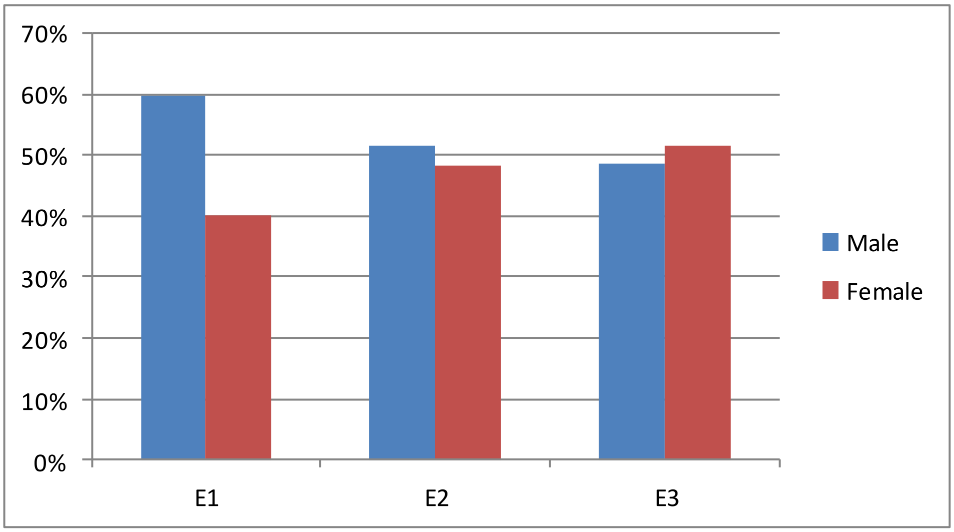
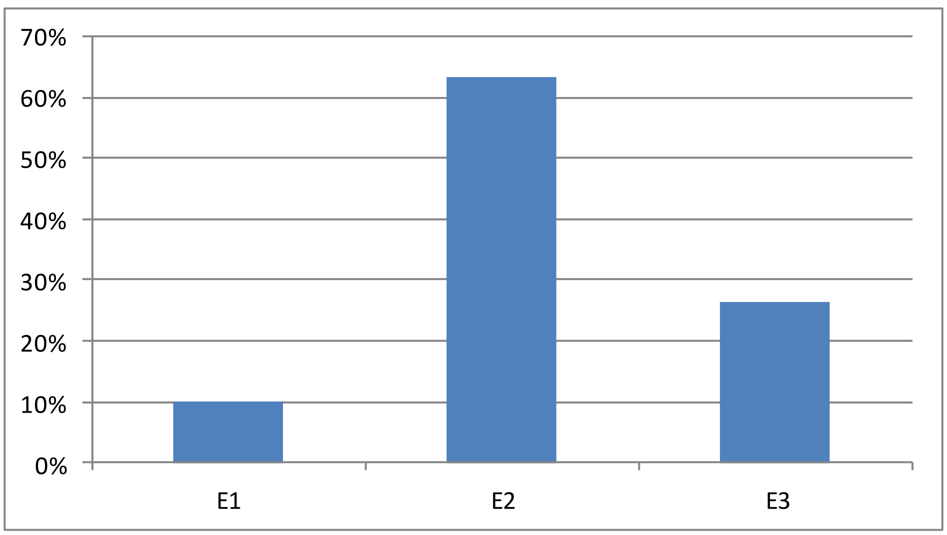
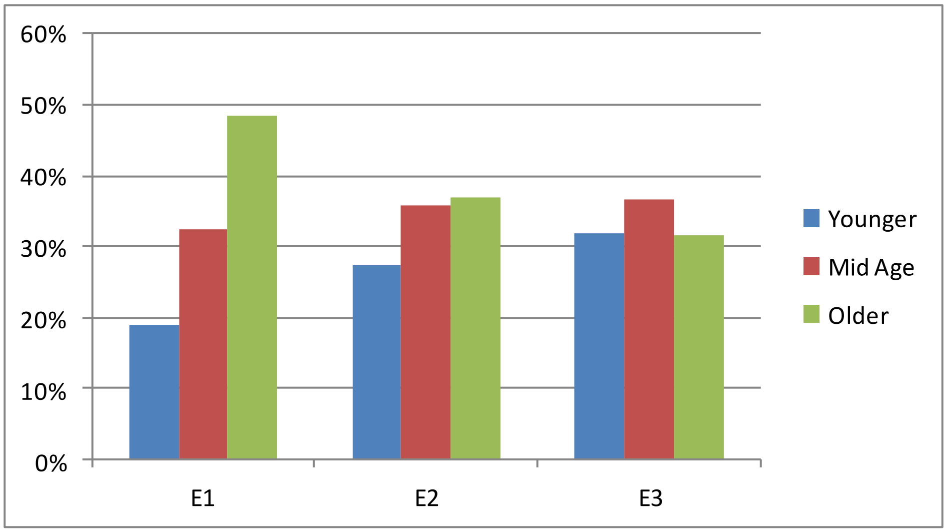


Chart A6: Distribution of Educational Attainment*



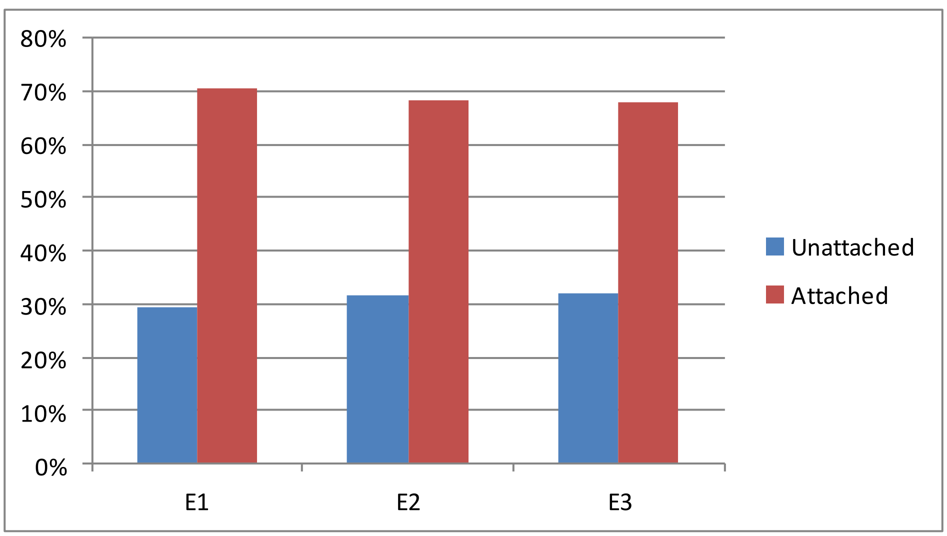
* low (less than high school), medium (high school or some post-secondary education), high (post-secondary degree or certificate)

Chart A7: Distribution of Age Category*



* younger (25-34), mid age (35-44), older (45-54)

Chart A8: Distribution of Marital Status*

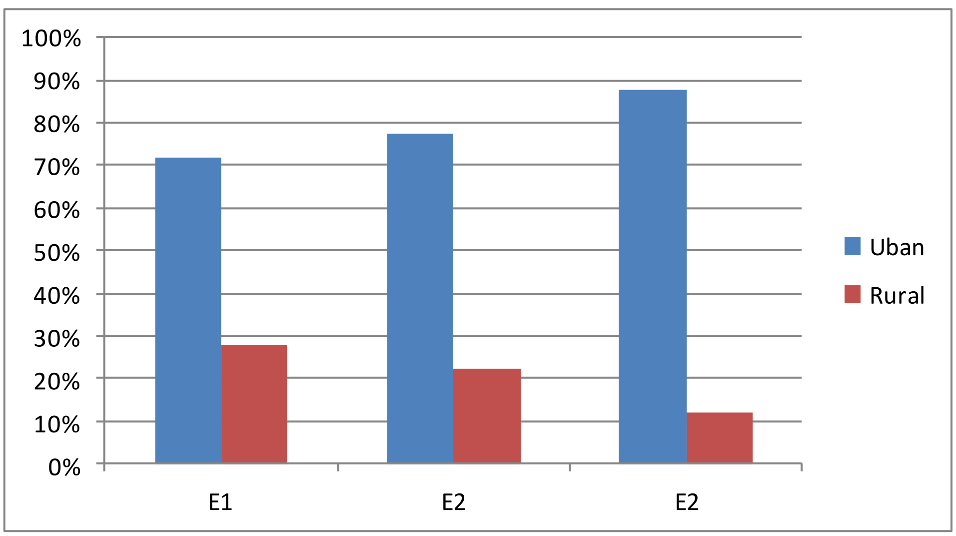


* unattached (single, divorced, separated or widowed), attached (married or common law)

Table A5: Distribution by Province of Residence

	E1	E2	E3
Newfoundland and Labrador	3%	2%	1%
Prince Edward Island	1%	0%	0%
Nova Scotia	3%	3%	3%
New Brunswick	3%	3%	2%
Quebec	34%	22%	26%
Ontario	32%	38%	40%
Manitoba	4%	4%	3%
Saskatchewan	3%	3%	2%
Alberta	9%	12%	10%
British Columbia	9%	14%	13%
	100%	100%	100%

Chart A9: Distribution of Rural/Urban Residence



Part 1 Analysis Results

Table A6: Tertile Regression Models

Explanatory Variable	E1 Females		E1 Males		E2 Females		E2 Males		E3 Females		E3 Males	
Intercept	12.26	***	10.66	***	10.61	***	12.39	***	13.06	***	12.39	***
Poor Health	-0.30		-0.38	*	-0.64	***	-0.39	***	-0.80	**	-0.39	***
Fair Health	-0.26	*	-0.49	***	-0.15	***	-0.17	***	-0.04		-0.17	***
Good Health	-0.03		0.08		-0.05		-0.01		-0.07		-0.01	
Very Good Health	-0.15		0.02		-0.06	*	0.02		-0.06		0.02	
Excellent Health	---		---		---		---		---		---	
Family Income Q1	-1.42	***	-1.46	***	-1.4522	***	-1.6261	***	-1.52	***	-1.63	***
Family Income Q2	-0.86	***	-0.86	***	-0.81	***	-0.95	***	-1.14	***	-0.95	***
Family Income Q3	-0.60	***	-0.47	***	-0.60	***	-0.58	***	-0.64	***	-0.58	***
Family Income Q4	-0.55	***	-0.18		-0.21	***	-0.36	***	-0.46	***	-0.36	***
Family Income Q5	---		---		---		---		---		---	
Age	-0.04		0.03		0.05	***	-0.05	***	-0.07	***	-0.05	***
Age Squared	0.00		0.00		0.00	***	0.00	***	0.00	***	0.00	***
Married	0.43	***	0.37	***	0.36	***	0.27	***	0.35	***	0.27	***
Kids	0.21	**	0.28	***	0.11	***	0.28	***	0.18	***	0.28	***
Newfoundland	-0.54	**	-0.40	*	-0.32	***	-0.16	*	-0.04	***	-0.16	*
British Columbia	-0.11		0.12		-0.07		-0.16	***	-0.01		-0.16	***
Prince Edward Island	-0.47		-0.57		-0.23		-0.13		-0.03		-0.13	
Nova Scotia	-0.58	**	-0.27		-0.19	**	-0.18	**	-0.06		-0.18	**
New Brunswick	-0.39		-0.26		-0.19	**	-0.18	**	-0.12		-0.18	**
Quebec	-0.26		-0.33	***	-0.25	***	-0.18	***	-0.20	***	-0.18	***
Ontario	-0.10		-0.32	***	-0.12	***	-0.17	***	-0.09		-0.17	***
Manitoba	-0.25		-0.33	*	-0.34	***	-0.14	**	-0.01		-0.14	**
Saskatchewan	-0.23		-0.02		-0.20	***	-0.11		-0.02		-0.11	
Alberta	---		---		---		---		---		---	
Rural	-0.12		-0.22		0.0041		-0.032		-0.14	***	-0.03	
Scale	22.56		22.75		22.52		21.39		18.85		21.39	
Observations Used	390		524		2,964		2,748		1,162		901	

*Table A7: Predicted Labour-market Earnings by Tertile and Health Status**

Tertile Health Status Level	Predicted Labour-market Earnings	Tertile Health Status Level	Predicted Labour-market Earnings
Females E1H1	$ 30,860	Females E2H1	$ 25,938
Females E1H2	$ 31,249	Females E2H2	$ 45,595
Females E1H3	$ 40,847	Females E2H3	$ 54,672
Females E1H4	$ 37,626	Females E2H4	$ 58,846
Females E1H5	$ 43,995	Females E2H5	$ 64,730
Males E1H1	$ 34,850	Males E2H1	$ 38,536
Males E1H2	$ 23,311	Males E2H2	$ 44,214
Males E1H3	$ 55,655	Males E2H3	$ 60,496
Males E1H4	$ 50,869	Males E2H4	$ 67,636
Males E1H5	$ 41,449	Males E2H5	$ 65,489

*monetary values are 2007 Canadian dollars

*Table A8: Estimate of Net Change in Labour-market Earnings in the Counterfactual Scenario**

Quintile Health Status Level	Predicted Labour-market Earnings	Population Proportion	Population (millions)	Total Labour-market Earnings (millions)	Counterfactual Proportion (E3)	Counterfactual Population (millions)	Counterfactual Total Labour-market Earnings (millions)	Net Change in Total Labour-market Earnings (millions)
Females E1H1	$ 30,860	4.15%	0.02	$ 595	0.16%	0.00	$ 23	-$ 572
Females E1H2	$ 31,249	11.12%	0.05	$ 1,616	3.92%	0.02	$ 569	-$ 1,047
Females E1H3	$ 40,847	38.47%	0.18	$ 7,306	20.60%	0.10	$ 3,912	-$ 3,394
Females E1H4	$ 37,626	27.37%	0.13	$ 4,789	43.30%	0.20	$ 7,576	$ 2,787
Females E1H5	$ 43,995	18.90%	0.09	$ 3,866	32.03%	0.15	$ 6,552	$ 2,686
Females Q1 Total			**0.47**	**$ 18,172**		**0.47**	**$ 18,632**	**$ 460**
Males E1H1	$ 34,850	3.21%	0.02	$ 777	0.82%	0.01	$ 199	-$ 579
Males E1H2	$ 23,311	9.59%	0.07	$ 1,553	5.08%	0.04	$ 822	-$ 731
Males E1H3	$ 55,655	35.33%	0.25	$ 13,663	16.98%	0.12	$ 6,568	-$ 7,095
Males E1H4	$ 50,869	34.12%	0.24	$ 12,062	42.69%	0.30	$ 15,092	$ 3,029
Males E1H5	$ 41,449	17.76%	0.12	$ 5,115	34.43%	0.24	$ 9,918	$ 4,803
Males Q1 Total			**0.69**	**$ 33,171**		**0.69**	**$ 32,599**	**-$ 572**
Females E2H1	$ 25,938	2.34%	0.08	$ 2,127	0.16%	0.01	$ 149	-$ 1,978
Females E2H2	$ 45,595	7.04%	0.25	$ 11,246	3.92%	0.14	$ 6,254	-$ 4,992
Females E2H3	$ 54,672	27.69%	0.97	$ 53,037	20.60%	0.72	$ 39,450	-$ 13,588
Females E2H4	$ 58,846	38.68%	1.35	$ 79,732	43.30%	1.52	$ 89,255	$ 9,523
Females E2H5	$ 64,730	24.25%	0.85	$ 54,988	32.03%	1.12	$ 72,624	$ 17,636
Females Q2 Total			**3.50**	**$ 201,130**		**3.50**	**$ 207,732**	**$ 6,601**
Males E2H1	$ 38,536	1.53%	0.06	$ 2,207	0.82%	0.03	$ 1,187	-$ 1,020
Males E2H2	$ 44,214	5.42%	0.20	$ 9,002	5.08%	0.19	$ 8,425	-$ 577
Males E2H3	$ 60,496	28.99%	1.09	$ 65,848	16.98%	0.64	$ 38,567	-$ 27,281
Males E2H4	$ 67,636	38.69%	1.45	$ 98,233	42.69%	1.60	$ 108,396	$ 10,163
Males E2H5	$ 65,489	25.37%	0.95	$ 62,368	34.43%	1.29	$ 84,648	$ 22,280
Males Q2 Total			**3.75**	**$ 237,657**		**3.75**	**$ 241,223**	**$ 3,565**
Overall Total				**$ 490,131**			**$ 500,186**	**$ 10,055**

*monetary values are 2007 Canadian dollars

Table A8A: Sensitivity Analysis Based on Three Sources of the 25-54 Population Counts*

Quintile Health Status Level	Net Change Based on SLID Pop Counts (millions)	Net Change Based on 2006 Census Pop Counts (millions)	Net Change Based on StatsCan Estimated Pop Counts (millions)
Females E1H1	-$ 572	-$ 691	-$ 921
Females E1H2	-$ 1,047	-$ 1,265	-$ 1,686
Females E1H3	-$ 3,394	-$ 4,102	-$ 5,467
Females E1H4	$ 2,787	$ 3,367	$ 4,489
Females E1H5	$ 2,686	$ 3,246	$ 4,327
Females Q1 Total	**$ 460**	**$ 556**	**$ 741**
Males E1H1	-$ 579	-$ 699	-$ 932
Males E1H2	-$ 731	-$ 883	-$ 1,177
Males E1H3	-$ 7,095	-$ 8,574	-$ 11,428
Males E1H4	$ 3,029	$ 3,661	$ 4,880
Males E1H5	$ 4,803	$ 5,804	$ 7,736
Males Q1 Total	**-$ 572**	**-$ 691**	**-$ 921**
Females E2H1	-$ 1,978	-$ 2,391	-$ 3,187
Females E2H2	-$ 4,992	-$ 6,032	-$ 8,041
Females E2H3	-$ 13,588	-$ 16,420	-$ 21,887
Females E2H4	$ 9,523	$ 11,508	$ 15,340
Females E2H5	$ 17,636	$ 21,312	$ 28,409
Females Q2 Total	**$ 6,601**	**$ 7,977**	**$ 10,634**
Males E2H1	-$ 1,020	-$ 1,232	-$ 1,643
Males E2H2	-$ 577	-$ 697	-$ 929
Males E2H3	-$ 27,281	-$ 32,967	-$ 43,945
Males E2H4	$ 10,163	$ 12,281	$ 16,370
Males E2H5	$ 22,280	$ 26,924	$ 35,890
Males Q2 Total	**$ 3,565**	**$ 4,309**	**$ 5,743**
Overall Total	**$ 10,055**	**$ 12,151**	**$ 16,197**
Total with Social Contributions	**$ 11,463**	**$ 13,852**	**$ 18,464**
%of 2007 GDP	**0.75%**	**0.91%**	**1.21%**

*monetary values are 2007 Canadian dollars

Glossary

Absenteeism: workers' unscheduled absences from the workplace.

Burden of disease: a measure of the total morbidity from a particular disease or disease in general, or its impact in terms of unfavourable consequences, or the cost of treating the victims. The burden of disease does not measure the probable success of treatment options, or the opportunity cost of measures that might be taken to reduce it.

Confounding: this occurs when the effect of an intervention is attributed to an independent variable when in fact it is due to a different but omitted variable (the confounding), which is correlated with both the independent and the dependent variable of interest.

Contingent valuation: same as stated preference.

Dependent variable: a variable that is postulated to be determined by one or more independent variables.

Direct cost: the cost of an activity or decision in terms of the resources used to execute the decision in question. It may include the cost of labour, other goods and services, capital (usually considered as a rental value) and consumables.

Disability Adjusted Life Year: often abbreviated to DALY, this is a measure of the burden of disability-causing disease and injury. Age-specific expected life-years are adjusted for expected loss of healthy life during those years, yielding states of health measures. When two streams of DALYs are compared, potential health gain or loss is identified as between different scenarios or as a consequence of different decisions.

Discount rate: the rate of interest used when discounting to calculate a present value.

Discounting: a procedure for reducing costs or benefits occurring at different times to a common point in time, usually the present, by use of an appropriate discount rate (q.v.). Thus, with an annual discount rate r (expressed as a decimal fraction) the present value (PV) of a cost (C) in one year's time is $PV = C/(l + r)$. In two year's time, it is $PV = C/(1 + r)2$.

Endogeneity: a variable is endogenous if it is a function of other parameters or variables in the model.

Exogeneity: a variable is exogenous if it is not a function of other parameters or variables in the model.

Health capital: (health as a capital good)

Health-related quality of life: a class of measures of states of health or changes in such states used to measure the effectiveness of health care programs. The Quality-Adjusted Life-Year is such a measure.

Health as a consumption good: this concept of health comes from Grossman (1972) who theorized that health was of value to individuals for two reasons, for its consumption value and its investment value. In the model, the direct value/utility of health to individuals is described as the *consumption value of health*, or *health as a consumption good*. People get utility directly from health. See also *health as an investment good*.

Health as an investment good: this concept of health comes from Grossman (1972) who theorized that health was of value to individuals for two reasons, for its consumption value and its investment value. In the model, individuals invest in health capital because it allows them to participate in the labour force and earn an income. This indirect value/utility of health to individuals is described as the *investment value of health*, or *health as an investment/capital good*. See also *health as a consumption good*.

Health maintenance: a systematic approach to preventing illness, maintaining function, and promoting health.

Health-related quality of life: a class of measures of states of health or changes in such states used to measure the effectiveness of health care programs. The Quality-Adjusted Life-Year (QALY) is such a measure.

Health technology assessment: the application of methods of economic evaluation, epidemiology and decision theory to support evidence-informed decision making. Often referred to by its acronym, HTA.

Health Utility Index (HUI): HUI is a family of generic health profiles and preference-based systems for measuring health-related quality of life that produces a summary utility score. Health-related quality of life measures combine morbidity and time in a health state into an equivalent time in perfect health. These measures include Quality-Adjusted Life-Years (QALYs) and variants such as Healthy Year Equivalents (HYEs), Disability-Adjusted Life Years (DALYs), and preference-based multi-attribute health status classifications systems, such as Quality of Well-Being, and Health Utility Index (HUI). The term QALYs is often used generically to refer to any or all these measures.

Human capital: in its most general sense, this refers to the present value of the flow over time of human services, whether marketed or un-marketed. In a narrower sense, it refers to a method for evaluating the benefits of an OHS program solely in terms of the present value of the future production that it enables.

Independent variable: a variable that affects other variables but is not affected by them.

Indirect loss (or cost): usually refers to the productivity effects that may be the consequence of a particular intervention. It is also sometimes used to refer to the costs of future medical care that an intervention may bring about (or avert) by virtue of increasing a person’s length of life.

Labour income: the sum of wages and salaries plus supplementary labour income.

Marginal benefit: the (maximum) additional benefit to be had when the rate of an activity is increased.

Marginal cost: the (minimum) additional cost entailed when the output rate is increased.

Marginal value: the maximum value attached to a small increment of an input, a good or a service.

Morbidity: a synonym for illness, often proxied by a patient's contact with a physician and the resultant diagnosis. Morbidity rates are calculated in a manner similar to that for mortality rates - especially cause- (or disease-) specific mortality rates.

Mortality rate: the crude mortality rate is the total number of deaths per year divided by the population at mid-year times 1,000. The age-specific mortality rate is the mortality rate for a specific age group (e.g. 65 years and older). The sex-specific mortality rate is the mortality rate for males or females. The age- and sex-adjusted rates are weighted according to the proportion of each group in the population. The disease- or cause- specific mortality rate is the annual number of deaths from the particular disease divided by the mid-year population times 1,000.

Multivariate analysis: an analysis in which there is more than one independent variable though it is sometimes used for analyses that have many dependent variables with "multivariable" used in the case of multiple independent variables.

Outcome: a general term applied to the consequences of an intervention. It is often preferred to "output" so as to avoid the impression that only goods and services constitute desired consequences. The treatment of cost-reducing effects varies. It is never counted as an output, sometimes counted as an outcome, sometimes counted as neither, and is deducted from costs. The most common sense of outcome in health economics is "change in health status" (which may be positive, negative or zero).

Output: an amount manufactured or produced over a period time, often measured in monetary terms.

Presenteeism: being on the job but not fully functioning due to some health-related limitation. For example, a worker who suffers from depression may be less able to work effectively.

Productivity: the amount of output per unit of input. In economics it often refers to labour productivity, i.e., the amount of output per unit of labour input.

Quality-Adjusted Life-Year: a measure of health which incorporates the effects of interventions on both mortality, through changes in survival duration, and morbidity, through effects on health-related quality of life (q.v.). Usually abbreviated as QALY. When two streams of QALYs are compared, potential health gain or loss is identified as between different scenarios or as a consequence of different decisions.

Revealed preference: willingness to pay for something as revealed by (e.g.) market transactions or controlled experiments. The emphasis is on the preference being revealed through behaviour in the form of a real act of choice or a hypothetical one rather than through mere introspection. There is a vast theoretical literature on the subject.

Reverse causality: see *endogeneity*.

Selection effects: related to endogeneity/reverse causality. Some individuals may become part of (i.e., select into) a group as a result of a trait or characteristics. For example, some people might become part of a lower socioeconomic status group because they have poor health. This may be due to lower educational attainment and/or inability to actively engage in the paid labour market due to their health. In this case, poor health is the cause of lower socioeconomic status rather than the reverse.

Socioeconomic status: an individual's position within a social hierarchy.

Stated preference: the preference to pay for a non-marketed entity like health as derived from questionnaires or experiments. It is stated verbally (i.e. orally or in writing) rather than revealed by actual behaviour in experiments or in real life. Another term for it is "contingent valuation."

Supplementary labour income: employers' social contributions, either compulsory or voluntary. Includes retirement allowances and contributions to employment insurance, the Canada and Quebec Pension Plans, other pension plans, workers' compensation, Medicare, dental plans, short- and long-term disability insurance, etc.

Systematic review: a form of literature review that seeks to minimise bias by being very explicit in its selection and evaluative procedures. Usual attributes include: explicit identification and scoping of research questions, use of explicit methods for searching the literature, explicit criteria for including or excluding material, explicit criteria for appraising quality and reliability and a systematic analysis/synthesis of research findings.

Time preference: the phenomenon that future benefits are less preferred by an individual than those closer in date – and more distant costs are regarded as less burdensome than those in immediate prospect.

Utility: an abstract way of ordering a person's preferences by assigning numbers to bundles of goods and services or to characteristics of goods or services. Higher numbers indicate greater utility or satisfaction. Utility can be measured ordinally, indicating no more than the ranking, or cardinally on linear scale in the way temperature is measured or (again cardinally but more strongly) on a ratio scale in the way that distance and weight are measured.

Wages and salaries: total remuneration, in cash or in kind, paid to employees in return for work done. It is recorded on a gross basis, before any deduction for income taxes, pensions, unemployment insurance and other social insurance schemes. Also includes other forms of compensation, namely commissions, tips, bonuses, directors' fees and allowances such as those for holidays and sick leave, as well as military pay and allowances. Excludes employers' social contributions, which are treated as supplementary labour income. See *supplemental labour income* for details.

Willingness to accept: the minimum someone requires in order to voluntarily relinquish a good or service.

Willingness to pay: the maximum someone will pay to acquire a good or service.