Indirect Health Costs by Income Level in Canada:

A Methodological Framework for the Estimation of the Indirect Cost of Socioeconomic Health Inequalities

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Executive Summary

This report has been prepared on behalf of the Public Health Agency of Canada in response to a request for proposal to synthesize current research evidence relating to the indirect costs (such as productivity losses) resulting in the additional burden of morbidity and premature mortality by income level. The review in this report includes an analysis of methods and data used in other studies with the intention of identifying the best approach to estimating the indirect cost for Canada, given available data sources. A conceptual framework, methods, and data sources are presented, followed by a discussion that presents the strength and limitations of the proposed methods and data sources. The methods have been elaborated in detail in order to facilitate execution by a third party. They have also been designed to complement efforts by the Health Determinants and Global Initiative division and Statistics Canada to develop comprehensive and current estimates of Canadian socioeconomic disparities in mortality and morbidity by income quintile and the corresponding health differences and health cost differences for Canada.

Previous efforts to document the direct and indirect costs of injury, illness and premature death have been undertaken by Health Canada (Economic Burden of Illness in Canada, 1986, 1993, and 1998). These studies did not consider the burden from socioeconomic health inequality, but rather the burden identified with standard reporting units, specifically the disease category, province, age bracket and gender.

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). In turn, these 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).

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.

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. In this study we use household income quintile as the measure of socioeconomic position.

The proposed framing question for this study is: *How much of a reduction in indirect health costs might be achieved 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 quintile groups would have the health status distribution of the highest quintile, which would affect the groups' labour-market earnings, role functioning outside of the paid labour force, and health-related quality of life.

The impact of health on paid labour-force output is an important component of the indirect cost estimates of socioeconomic health inequalities. Also important is the impact of health on participation in roles outside of work and health-related quality of life. The impact of health on the time use of other individuals in the family and community would also be a relevant, but would likely be of a smaller magnitude and more difficult to quantify. Therefore, we recommend a focus on three components: 1) the impact health on paid labour-force output; and 2) the impact of health on participation in roles outside of work; and 3) health-related quality of life. Components two and three are often collapsed into one measurement exercise. Each of these components requires estimation of socioeconomic morbidity and mortality inequalities. Hence four measurement protocols are developed within this study, as follows: 1) the impact of better health on output in a calendar year; 2) the impact on output of reduced mortality; 3) the value of reduced mortality in terms of roles outside of the paid labour force and the intrinsic value of health; and 4) the value of reduced morbidity in a calendar year in terms of roles outside of the paid labour force and the intrinsic value of health. Each of these four components entails a counterfactual analysis to estimate the monetary value of gains to be realized from eliminating socioeconomic health inequalities.

The primary data source used to estimate the indirect costs of socioeconomic health inequalities associated with paid labour-force activity (component 1 and 2) is the Survey of Labour and Income Dynamic. This is supplemented with data from the Labour Force Survey, data on mortality/life expectancy by age group and gender prepared by Statistics Canada, and national accounts data. Regression modeling analysis is proposed to estimate the impact of health on labour-market earnings. The primary data source used to estimate the indirect costs associated with social roles outside of the paid labour force and the intrinsic value of health (components 3 and 4) is data on mortality/life expectancy and Health Utility Index values by age group and gender prepared by Statistics Canada.

Some indirect costs are not captured in the proposed methods. The approach taken to estimating the impact of morbidity and mortality on paid labour-force output excludes individuals under 25 and over 64 years of age, and the self-employed. The approach likely underestimates the true impact of health on output for other reasons. Some fraction of organization 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).

Overall, the methods proposed in this study offer the potential to substantially advance the measurement of the indirect costs of socioeconomic health inequalities in Canada. The report provided detailed methods and data sources such that the methods can be easily executed. The proposed methods dovetail well with previous work undertaken in Canada and elsewhere, as well as current efforts by Statistics Canada. We believe the methods offer an approach that will provide a comprehensive though reasonably conservative estimate of the impact of health on indirect costs by income level.

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). In turn, these 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).

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, Canning and Sevilla, 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). 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 has been prepared on behalf of the Public Health Agency of Canada in response to a request for proposal to synthesize current research evidence relating to the indirect costs (such as productivity losses) resulting in the additional burden of morbidity and premature mortality by income level. The review in this report includes an analysis of methods and data used in other studies with the intention of identifying the best approach to estimating the indirect cost for Canada, given available data sources. A conceptual framework, methods, and data sources are presented, followed by a discussion that presents the strength and limitations of the proposed methods and data sources. The methods have been elaborated in detail in order to facilitate execution by a third party. They have also been designed to complement efforts by the Health Determinants and Global Initiative (HDGI) division and Statistics Canada to develop comprehensive and current estimates of Canadian socioeconomic disparities in mortality and morbidity by income quintile and the corresponding health differences and health cost differences for Canada.

Conceptual Framework

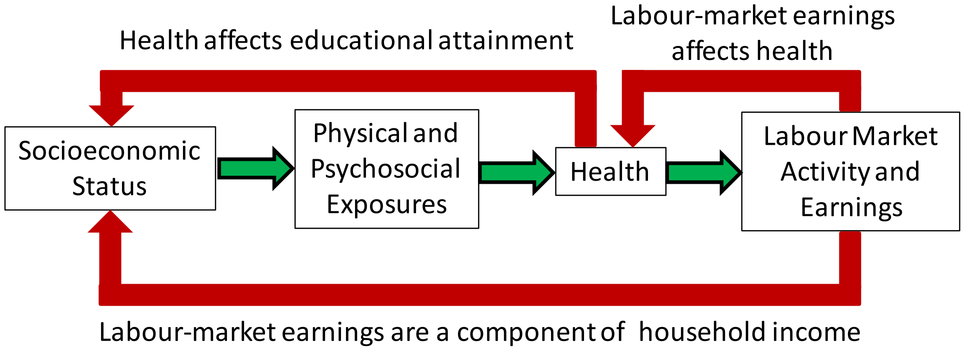
Relationship between Socioeconomic Status and Health

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; 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*).

Figure 1: Causal Pathways and Selection Effects



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 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.

There are also indirect costs for individuals and society associated with health inequalities. Some indirect costs 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 costs 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 unemployment - 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 the life course
Life expectancy, savings and capital investment	life expectancy → savings for retirement → capital investment → productivity and output
Child health and demographic effects	child health → fertility → size of the working age population → output child health → fertility → female participation in 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 around 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.

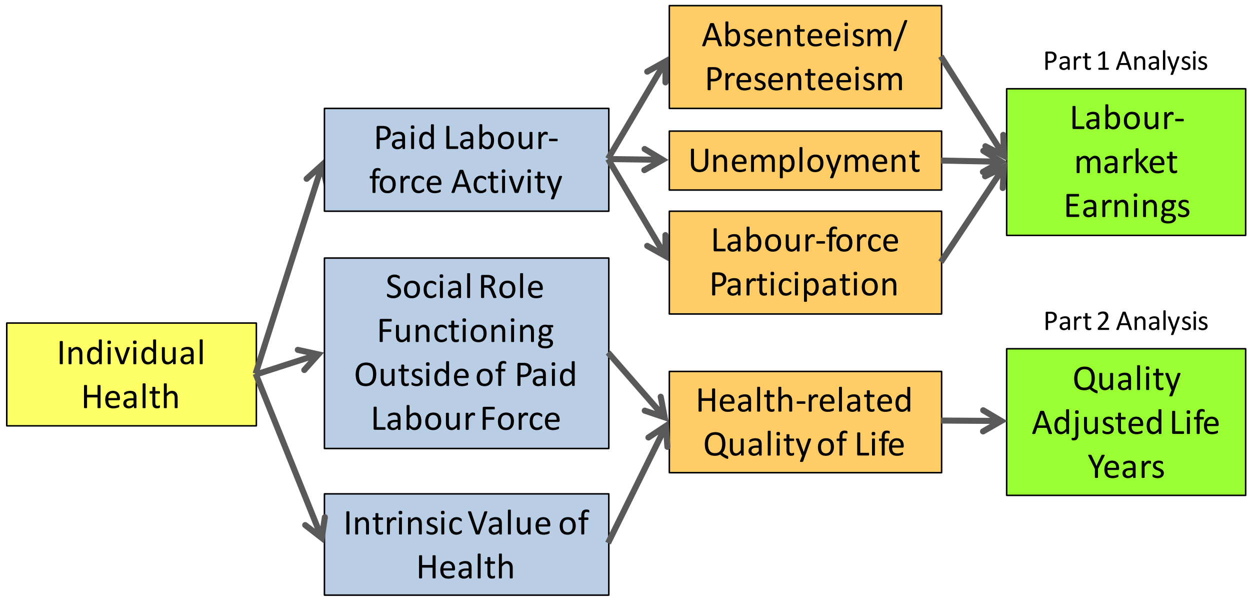
To summarize, Table 2 highlights the various aspects of indirect costs of health.

Table 2: Aspects of Indirect Costs of 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 roles outside of paid work	- parenting - home care - community involvement - religious activities - leisure activities - education
Health-related quality of life	- intrinsic value of good 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 cost 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 recommend a focus on three components: 1) individual health and its impact on paid labour-force output; 2) individual health and its impact on participation in roles outside of work; and 3) health-related quality of life. Components two and three are often 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 costs.

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



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 other 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).

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 resource 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. 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 (see 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.

Methodological Underpinnings

Proposed Framing Question

Based on the conceptual framework described above and the objective of the study as outline on the request for proposals, we have formulated the following overarching question to guide the development of our methods:

How much of a reduction in indirect health costs might be achieved 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 quintile groups would have the health status distribution of the highest quintile, which would affect the groups' labour-market earnings, role functioning outside of the paid labour force, and health-related quality of life.

The approach used to estimate indirect health costs 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 cost associated with the disease for that year in terms of direct health care costs and indirect costs such as lost productivity. 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, (i.e., poor health in general), then a comparator would need to be identified in order to assess the burden (i.e., the values gained if everyone had better health). Since indirect costs are to be assessed by household income quintile in this study, the natural comparator would be the highest income quintile group. The burden of interest would then be the value gained if everyone had the health profile of the highest income quintile.

Figure 3: Estimate of Aggregate Indirect Cost of Socioeconomic Health Inequalities

Change in yearly labour-market earnings due to reduced morbidity	+	Change in company yearly social contribution and profit due to better health	=	Total impact on output of reduced morbidity in a calendar year	Part 1 Analysis Component 1
				+	
Change in lifetime labour-force participation due to reduced mortality within a calendar year	X	Average Life-time labour-market earnings plus company social contributions and profit	=	Total impact on output of reduced mortality in a calendar year	Part 1 Analysis Component 2
				+	
Change in QALYs due to reduced morbidity in a calendar year	X	Willingness-to-pay for a QALY	=	Total value of reduced morbidity in a calendar year	Part 2 Analysis Component 1
				+	
Lifetime change in QALYs due to reduced mortality in a calendar year	X	Willingness-to-pay for a QALY	=	Total value of reduced mortality in a calendar year	Part 2 Analysis Component 2
				Aggregate indirect cost	

The broad categories of costs associated with socioeconomic inequalities include direct health care costs and indirect costs of poor health. In the latter 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 direct health 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 task has been assigned to Statistics Canada. For indirect health costs, we suggest measurement of four components: 1) the total impact of better health on output in a calendar year; 2) the total impact on output of reduced mortality; 3) the total value of reduced mortality; and 4) 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.

Indirect Health Cost Estimates for Canada

Previous efforts to document the direct and indirect costs of injury, illness and premature death have been undertaken by Health Canada (Economic Burden of Illness in Canada (EBIC), 1986, 1993, and 1998). These studies did not consider the burden from socioeconomic health inequality, but rather the burden identified with standard reporting units, specifically disease category, province, age bracket and gender. Interestingly, the 1998 study found that the direct and indirect costs were almost of equal magnitude— $83.9 billion for the direct costs and $75.5 billion for the indirect costs. For the latter, three components were considered: 1) the value of years of life lost due to premature mortality ($33.5 billion), 2) the value of activity days lost due to short-term disability ($9.8 billion), and 3) the value of activity days lost due to long-term disability ($32.2 billion). Indirect costs associated with time use of family and community members were not included.

Conceptually, the EBIC (1998) estimates include only two of the three broad categories identified in Figure 2, namely paid labour-force activity and social role functioning outside of the paid labour force. Not explicitly considered is the intrinsic value of health to individuals. The analysis was partitioned into three clusters: 1) mortality costs; 2) short-term disability costs; and 3) long-term disability costs. Under each cluster health-related losses associated with both paid labour-force activity and social role functioning outside of the paid labour force were estimated. The counterpart for Cluster 1 (mortality costs) in Figure 3 would be the combination of Part 1 Component 1 and Part 2 Component 1. The counterpart of Cluster 2 and 3 (short- and long-term disability) in Figure 3 would be the combination of Part 1 Component 2 and Part 2 Component 2. For all indirect costs EBIC used a human capital approach in which time lost in an activity (whether paid or unpaid) due to poor health/premature death was multiplied by the monetary value of output in that activity.

Underpinning of the Human Capital Approach

The human capital approach is an estimate of the counterfactual, that is, what the individual would have earned or produced had they not been absent due to injury, illness or premature death. Actual wages are used to calculate labour-market losses and assumed to be either fixed over time or adjusted for lifetime earnings growth.[1] Adjustments are generally based on data from population statistics (stratified by occupation, educational attainment and other relevant labour-market earnings characteristics depending on data availability) or collected through matching of injured individuals with a healthy cohort on socio-demographic characteristics and contextual factors that bear on earnings potential (see Weil, 2001, for a summary of methods). For non-wage work, the opportunity cost of time or replacement cost approach is often used to estimate output losses (see Drummond et al., 2005, p. 216 for details).[2]

There are three key concerns regarding the human capital approach. First, wage rates may not accurately reflect the marginal product of labour due to market imperfections. Second, it focuses exclusively on productivity/output as the only value of good health. Third, output losses are assumed to begin immediately upon absence and continue until return to work, or in the case of permanent work disability and death, until the age an individual would normally have retired if in good health. Organizations are unable to mitigate losses by hiring replacement workers even in the long run. Hence, the impact of long-term health absences on productivity and output are enduring at the organizational and societal levels. As such, the human capital approach might be thought of as a measure of potential output (Koopmanschap et al., 1995).

An alternative approach to conceptualizing the impact of health-related absences on aggregate output is known as the ‘friction cost approach’ (Koopmanschap et al., 1995). According to this approach there is a short-run friction period during which an organization may incur losses while an adjustment is made to a worker’s absence. In the long run, no losses occur because the worker either returns to work and output returns to the pre-absence level, or the organization replaces the worker with a new hire and output eventually becomes comparable to what it was before.

[1] EBIC (1998) also adjusted for productivity growth as identified from historical trends.
[2] EBIC (1998) used the replacement cost generalist method to estimate the value of unpaid work.

Underlying the friction cost approach is the assumption that there is excess unemployment (i.e., above the frictional unemployment level), such that there are many individuals in the ranks of the unemployed that are available to take the place of individuals unable to work due to poor health. Hence, poor health affects output at the margins and only in the short run, even at the population level. This is a strong assumption that is likely not borne out in all setting and time periods. Furthermore, larger health initiatives that have substantial impact on the health of populations likely have more than just a marginal impact on output. Therefore in this study, we use the human capital approach to estimating the impact of poor health on output.

Indirect Health Cost Estimates for the European Union

A recent estimate of indirect health costs in the European Union focused on the burden of socioeconomic health inequalities (Mackenbach et al., 2007). Socioeconomic status is proxied with educational attainment, stratified into three categories. The study estimates indirect costs in two categories; 1) labour-market earnings losses associated with morbidity (labelled 'health as a capital good'); and 2) the value of health burdens associated with morbidity and mortality (labelled 'health as a consumption good'). For calendar year 2004, the indirect costs estimate is €1,121 billion (10.9% of GDP), consisting of €141 billion for category 1 and €980 billion (9.5% of GDP) for component 2. These values are not directly comparable to EBIC (1998) due to the difference in clustering of components. In Table 3 we have attempted to compare the two studies by reclustering the EBIC (1998) estimates into the two categories used by Mackenbach et al. (2007). For the value of gains from health as a capital good, the estimates for the European Union and Canada are comparable in terms of percentage of GDP—1.35% for the European Union and 1.9% for Canada. For the value of gains from health as a consumption good, the estimates diverge substantially—9.38% for the European Union and 2.81% for Canada. One reason for this divergence may be attributable to the fact that the intrinsic value of health has not been included in the Canadian estimate.

Table 3: Comparison of Canada and European Union

	European Union 2004 (Mackenbach et al., 2007)	% of GDP	Canada 1998 (EBIC, 1998)	% of GDP
paid work associated with morbidity	€141 billion	1.35%		
paid work associated with premature mortality			$13.5 billion	0.84%
paid work associated short-term disability			$ 3.9 billion	0.24%
paid work associated long-term disability			$13.0 billion	0.81%
total value of gains from health as a capital good	**€141 billion**	**1.35%**	**$30.4 billion**	**1.90%**
unpaid work and intrinsic value associated with mortality and morbidity	€980 billion	9.38%		
unpaid work associated with premature mortality			$20.0 billion	1.25%
unpaid work associated short-term disability			$ 5.9 billion	0.37%
unpaid work associated long-term disability			$19.2 billion	1.20%
total value of gains from health as a consumption good	**€980 billion**	**9.38%**	**$45.1 billion**	**2.81%**
overall total	**€1,121 billion**	**10.73%**	**$75.5 billion**	**4.72%**

To estimate the value of gains from health as a capital good, only socioeconomic morbidity inequalities are considered (i.e., socioeconomic mortality inequalities are not considered). Specifically, regression modeling is undertaken using data from the 5th wave (1977) of the European Community Household Panel (ECHP). The model is of labour-market earnings with health and other individual characteristic as explanatory variables. Earnings are measured in terms of gross monthly wages and salaries, and health/morbidity in terms of self-reported health status. Separate models are estimated for each of the socioeconomic categories. To assess the earnings gains realized by eliminating socioeconomic health inequalities, a population attributable risk approach is used to compare the current situation with the counterfactual scenario of no inequalities. Essentially, individuals in the lower educational attainment category are levelled up such that they have the same health profiles as individuals in the highest educational attainment category. Using the model parameters from the monthly wages and salaries equation, fitted values are estimated for the lower socioeconomic status group under two scenarios (i.e., the current situation and the counterfactual). The difference in total earnings of the group under the two scenarios represents the gains from health as a capital good.

To estimate the value of gains from health as a consumption good, both mortality and morbidity inequalities are considered. With regards to mortality, two approaches are used to estimating the value of reductions in mortality from levelling up mortality rates of lower socioeconomic status groups to that of higher status groups. One approach identifies and values lives saved, and another identifies and values discounted life-years saved. Both approaches result in values within a reasonably similar range. With regards to morbidity, the value of reductions are estimated by identifying the years of life in good health gained by levelling up the number of individual cases with fair and poor health to that of the highest socioeconomic group. Disability weights of 0.90 and 0.80 are used for fair and poor health respectively in order to translate them into years of life in good health.

The Mackenbach et al. (2007) indirect cost estimates include estimates of three of the four components identified in Figure 3. Its estimate of health as a capital good is the counterpart for Part 1 Component 1. Its estimate of health as a consumption good includes counterparts for both Part 2 Component 1 and Part 2 Component 2. The methodological underpinnings of this study serve as a good platform for the current one.

Proposed Methods Details

Part 1 Component 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 Component 1, we are estimating the impact of health on paid labour-force participation and productivity, not educational investment, savings/capital accumulation. In Part 1 Component 2 we are estimating demographic effects as they relate to the size of the working age population, in particular the impact from premature mortality.

In the modeling, we are assuming that labour-market earnings of an individual reflect that individual's labour productivity (i.e., the value of an individual's output). We are considering only the value of output in the paid labour force, and ignoring the fact that some individuals will work in non-wage activities that have social value, such as home maintenance, child care, etc. These non-wage activities are taken into consideration in Part 2. Furthermore, we are considering primarily supply side factors in our modeling, whereas a number of demand-sided factors also bear on paid labour-market earnings. 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 modeling is to estimate the effects of health on labour-market outcomes, primarily earnings, participation, and hours worked. We build into the analysis the role of socioeconomic status by estimating separate models for different levels of socioeconomic status. We also suggest estimating separate models for women and men. In the modeling we need to minimize the possibility of reverse causality (i.e., the effects of earnings on health). This can be addressed through temporal sequencing in which explanatory variables, particularly health, are taken from a time period prior to the outcome variable of interest. In fact, we suggest considering different time lags for the effect of health on economic outcomes. This requires longitudinal/panel data at the individual level. The basic functional form for the equation will be as follows:

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

where $y_{t,i}$ is the outcome of interest (earnings, participation, hours worked) in time t by individual i.

The regression model parameters developed from the micro-level panel data will be 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 will be 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 recommend use of fourth panel which spans the period from 2002 to 2007. This is the most recent panel in SLID for which all waves of data are available. 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 Component 1 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 64), excluding full-time students, individuals self-employed in their main job, 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. The sample would include many individuals with zero labour-market earnings. We note that another iteration of the analysis might use a two step process in which all working age individuals are in the first part of the analysis sample. This step would determine labour-force participation (i.e., an outcome of yes/no in the labour force). A second step would include only those individuals who are working, and would determine labour-market earnings. There is precedence in the literature to consider individuals working 8 hours or less per week as being out of the labour force (Mackenbach et al., 2007).We note, however, that inclusion of individuals with zero labour-market earnings would result in lower estimates of average labour-market earnings for the sample.

Measures

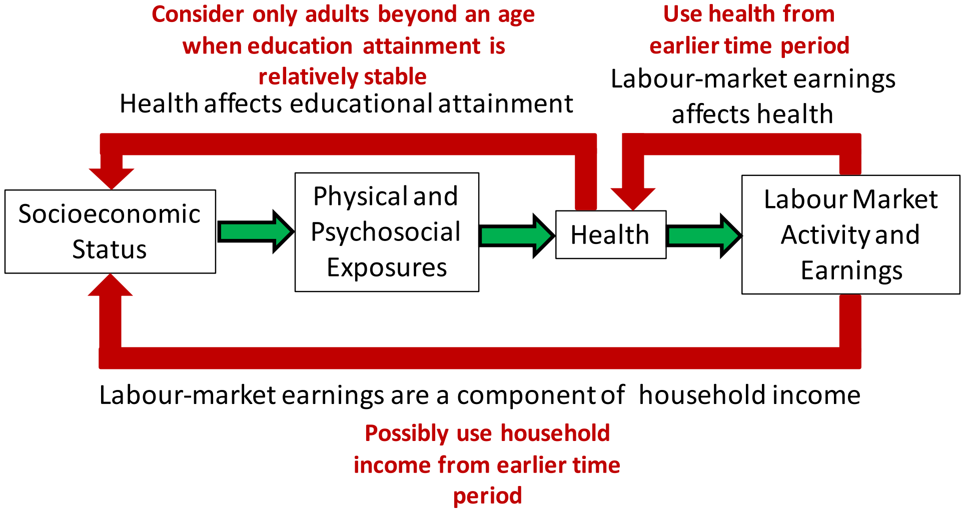
The recommended indicator of socioeconomic status for the proposed study is pre-tax household income adjusted for family size.[3] Income quintiles will be created based on the distribution of family income, with the category 1 representing the lowest socioeconomic status and 5 the highest. We note that 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

[3] 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.

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.

One method for dealing with the endogeneity issue in this analysis is to use household income from a prior year to identify income quintile. If a prior year's value is used, it is less likely to be endogenous. Another variation would be to 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 suggestions for the treatment of endogeneity/selection effects.

Figure 4: Methods for Minimizing Selection Effects



The permanent income approach to addressing endogeneity is our recommended approach. To illustrate how this would be done using panel 4 of SLID, we could use the average household income (adjusted for household size and composition[4]) over the years 2002 to 2006 to identify socioeconomic status (as proxied by household income quintile) in a model with the outcome taken from 2007. The specification would be as follows:

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

where *i* represents an individual in the sample and *t* the calendar year. Individuals would then be allocated to a socioeconomic status quintile based on *Permanent Household Income*$_i$. For each quintile, separate regression models will be estimated.

[4] We recommend 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. The latter rule holds unless the family is comprised of only one adult plus children where the first child is counted as 0.4 of a person (Statistics Canada, 1999).

The key 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 is comprised of gross employment earnings from all source—salaries, wages, and other employment income—but excludes capital returns and social security benefits. The log transformation of this variable is necessary since it improves the symmetry of the overall distribution of earnings. All dollar amounts must be standardized using annual inflation adjustments according to the Canadian consumer price index (CPI). Price indices are readily available from Statistics Canada. We suggest using the one for Canada for all goods and services.

Other outcome measures to be used in secondary analyses in order to round-out our understanding of the impact of health on labour-market engagement are hourly wages, employment/unemployment experience, and number of hours worked per month. Table 4 provides a summary of the outcome variables suggested for the study.

Table 4: Outcome Variables

Variable	**Details**
Labour-market Earnings$_{t,i}$	Total individual labour market earnings from all sources in calendar year 2007 (in log form)
Hourly Wages$_{t,i}$	Estimated hourly wage rate for an individual in the calendar year 2007 (in log form)
Employment Experience$_{t,i}$	Number of months the individual was employed in calendar year 2007
Unemployment Experience$_{t,i}$	Number of months the individual was unemployed in calendar year 2007
Hours Worked per Month$_{t,i}$	Average hours worked per month by an individual in calendar year 2007

The key explanatory variable to be used 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 could be used as a categorical variable or a continuous variable (i.e., have five distinct categories of self-reported health, or treat it as a continuous variable in which it can take the value from one to five).

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 a prior year should be used in the modeling. Furthermore, since it is possible that economic outcomes are determined by health history rather than by health at any single point in time, it is important to investigate the independent effects of health measured at different lag times. Given the six year window of each panel of SLID, different lag times from 1 to 5 years can be analysed and compared.

In addition to the subjective self-reported general health measure, the SLID also contains a more objective measure of functional limitations. The measure is identified through two items in the questionnaire, which read as follows:

> *Do you have any difficulty hearing, seeing, communicating, walking, climbing stairs, bending, learning or doing any similar activities?*
>
> *Does a physical condition or mental condition or health problem reduce the amount or kind of activity that you can do [at home/at work/at a job or business or at school]?*[5]

Respondents who answer *yes* to either question might be considered *functionally impaired* for analysis purposes. Tests of this outcome coupled with the results from the models with self-reported general health provide a method of triangulating the information on the impact of health on labour-market outcomes. In other words, findings from the models using different health measures could be compared to see whether the relationships hold across different measures of health.

Other explanatory variables to be included in the analysis due to their potential association with the outcome variable, and because they are of substantive interest in their own right, are: age bracket, gender, level of education, marital status, children under 16, province of residence, and rural/urban residence. For age, we suggest using age bracket (e.g., 25-34, 35-44, 45-54, and 55-64), and for education, educational bracket (e.g., less than high school, high school, post-secondary degree/diploma). In analyses with stratification by gender or age bracket the variables would not be included in the models, since a model would be specified for each gender or age bracket. A final variable to consider for inclusion is the provincial unemployment rate, possibly adjusted for age bracket. This variable might be an important contextual factor that determines both labour-force participation and earnings. Data for this variable can be drawn from the Labour Force Survey (LFS), which is the best source for unemployment statistics. Table 5 provides details on the explanatory variables to be considered in the analysis.

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[5] These questionnaire items are available in the SLID starting in 1999. Prior to this, the indicator of disability status consisted of a single item which read as follows: "Because of a long-term physical or mental condition or health problem, are you limited in the kind and amount of activity you can do at home, at school, at work, in other activities such as transportation to or from work or school or leisure time activities?"

Table 5: Explanatory Variables

Variable (SLID variable name)	***Specification***	**Details**
Health Status (crhlt26)	*Poor Health*$_{t-1,i}$; *Fair Health*$_{t-1,i}$; *Good Health*$_{t-1,i}$; *Very Good Health*$_{t-1,i}$; *Excellent Health*$_{t-1,i}$	Set of dummy variables indicating the level of self-reported health status—one level will serve as the comparator
Age (age26)	*Age25-34*$_{t-1,i}$, *Age35-44*$_{t-1,i}$, *Age45-54*$_{t-1,i}$, *Age55-64*$_{t-1,i}$	Set of dummy variables indicating age bracket—one bracket will serve as the comparator
Gender(sex99)	*Gender*$_{i}$	Dummy variable indicating gender—the variable is not required in models stratified by gender
Educational attainment (hleved18)	*Less than High School*$_{t-1,i}$, *High School*$_{t-1,i}$, *University/College Degree*$_{t-1,i}$	Set of dummy variables indicating educational attainment identified by three categories—one category will serve as the comparator
Marital Status (state4)	*Married*$_{t-1,i}$	Dummy variable indicating the individual is married or living common law as opposed to single
Children (nbsa26)	*Children*$_{t-1,i}$	Dummy variable indicating that the individual has children under 16 in the family unit
Province of Residence (pvreg25)	*British Columbia*$_{t-1,i}$, *Alberta*$_{t-1,i}$, *Saskatchewan*$_{t-1,i}$, *Manitoba*$_{t-1,i}$, *Ontario*$_{t-1,i}$, *Quebec*$_{t-1,i}$, *New Brunswick*$_{t-1,i}$, *Nova Scotia*$_{t-1,i}$, *Prince Edward Island*$_{t-1,i}$, *Newfoundland*$_{t-1,i}$	Set of dummy variables indicating province of residence—one province will serve as the comparator
Urban/Rural Residence(urbrur25)	*Urban Residence*$_{t-1,i}$	Dummy variable indicating urban as opposed to rural residence
*Unemployment Rate (*lfsstat)*	*Provincial Unemployment Rate*$_{t}$	Variable with provincial unemployment rate

*variable taken from the Labour Force Survey (LFS).

Regression Modeling Analysis

Following is a generic specification of the model:

$y_{t,i}$ = *f (self-reported health status*$_{t-1,i}$, *age bracket*$_{t-1,i}$, *gender*$_{i}$, *educational attainment*$_{t-1,i}$, *marital status*$_{t-1,i}$, *children*$_{t-1,i}$, *province*$_{t-1,i}$, *urban residence*$_{t-1,i}$, *provincial unemployment rate*$_{t}$*).*

where *t* is time period/calendar year, and *i* is individual. As noted, the variable for self-reported health status can be entered into the model in two ways: 1) as a set of dummy variables (e.g., poor health, fair health, good health, very good health, and excellent health); and, 2) as a continuous variable. The first method yields an estimate of the magnitude of the impact of each level of health status on labour-market earnings, whereas the second method identifies the incremental effect of a unit difference in health status on labour-market earnings.

We recommend estimating separate models for women and men as well as for the different age brackets. Given the large sample size of SLID ($N \approx 18{,}000$ individuals including only the above noted subgroups), separate analyses should be unproblematic. It is likely not large enough to stratify across three dimensions at the same time (i.e., income quintile, gender and age bracket), so we suggest having only two levels of stratification (i.e., quintile and gender or quintile and age bracket).

Key questions to be addressed through the analysis are as follows:

1) What is the magnitude of the effect of self-reported health status on total labour-market earnings?
2) How does the effect of self-reported health status on total labour-market earnings vary according to socioeconomic status?
3) Are the effects of self-reported health status on total labour-market earnings different for women compared to men?
4) Are the effects of self-reported health status on total labour-market earnings different for different age brackets?
5) How do more objective measures of health (e.g., functional limitations) compare to self-reported health status in terms of the impact on total labour market earnings?

As noted, incremental analyses should supplant total labour-market earnings as the primary outcome with other measures of productivity (e.g., hourly wages) and labour supply (e.g., yes/no working; number of hours worked per month). The use of alternative outcome measures will provide a fuller picture of the impact of health status on various labour-market outcomes.

Preliminary Assessment of Health Inequalities

Table 6 shows the results from preliminary analyses using SLID investigating the distribution of health status by income quintile in the Canadian population. We note that we have used quintile values previously derived from research undertaken by the HDGI division and Statistics Canada to develop estimates of the health and health cost differences of Canadian socioeconomic disparities in mortality and morbidity by income quintile.

Table 6: Proportion with Health Status by Income Quintile[a^]

Health Status	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
Poor	6.4	3.8	0.9	1.0	0.6
Fair	13.3	7.7	6.4	5.30	4.2
Good	29.8	29.3	28.6	27.2	23.7
Very Good	36.2	39.8	37.2	17.9	43.4
Excellent	14.4	19.4	26.9	25.1	28.2

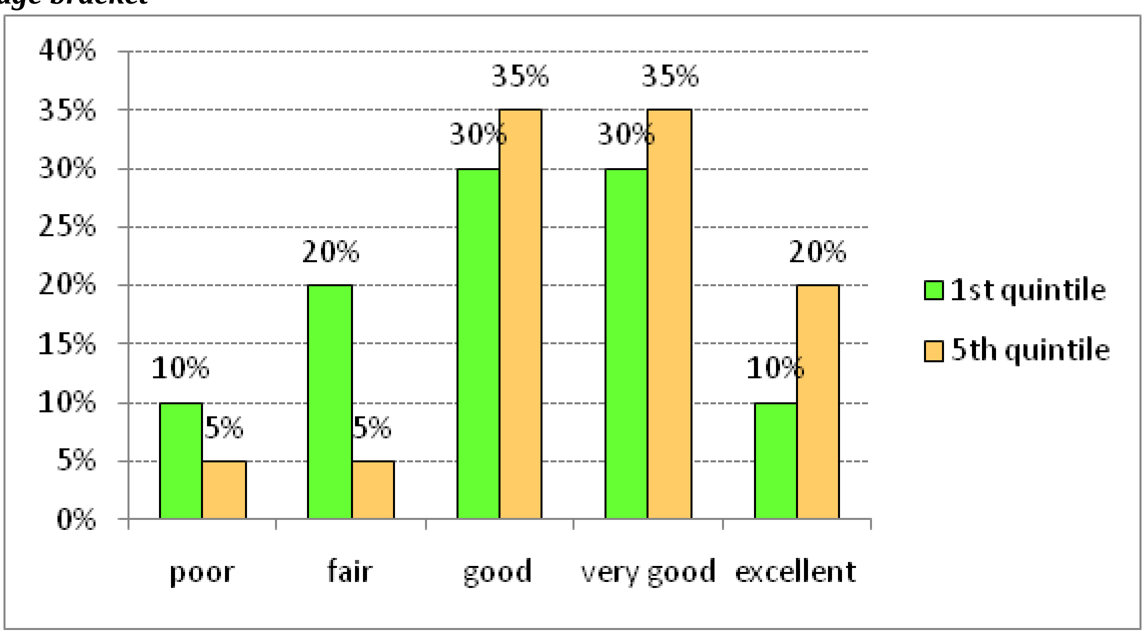
[a] Proportion based on weighted percentages (N=17,897).
[^]SLID 2007; values for the income quintiles are as follows: 1st quintile: $0-$21,000; 2nd quintile: $21,001-$34,286; 3rd quintile: 34,287-$45,059; 4th quintile: $45,060-$65,217; 5th quintile: => $65218.

The proportion of the population (weighted data) represented within each income quintile is as follows: 1st quintile, 20.1%; 2nd quintile, 21.6%; 3rd quintile 20.8%; 4th quintile 17.1%; 5th quintile, 20.3%. As expected, we find that health status is unequally distributed across income quintiles with a substantially greater proportion of individuals in the 4th and 5th income quintiles reporting very good to excellent health, while individuals in the lowest quintile are more likely to report poor health relative to their counterparts with higher levels of income.

Counterfactual Analysis

Counterfactual analysis will be 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 for a particular gender and age bracket



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:

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

where $Total\ labour\ market\ earnings\ gains\ from\ improved\ health_{first\ quintile}$ is the total labour-market earnings of the first quintile for a particular gender and age bracket in the counterfactual scenario. 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.

To begin the counterfactual analysis, we begin with the estimation of total labour-market earnings based on current socioeconomic health inequalities. 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.[6] Using the mean values, proportions and numbers of individuals, the total labour-market earnings across all socioeconomic quintiles can then be estimating estimated in a different way as follows:[7]

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[6] 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.

[7] An alternative calculation of the baseline is possible using fitted values for individual level labour-market income ($\hat{y}_i$). To scale the sample up to the population level there are population weights provided for the SLID. The formula is as follows:

$$Total\ labour\ market\ earnings_{baseline} = \sum_{i=1}^{N} w_i \times \hat{y}_i$$

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

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

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

These two equations can be expanded to include each of the four age bracket and the two genders that were included in the regression specifications. Two additional subscripts are required to denote them in the equations. With their inclusion the equations would be as follows:

$$Total\ labour\ market\ earnings_{baseline} = \sum_{b=1}^{4} \sum_{q=1}^{5} \sum_{g=1}^{2} n_{b,g,q} \sum_{h=1}^{5} Prop_{b,g,q,h} \times \bar{Y}_{b,g,q,h}$$

$$Total\ labour\ market\ earnings_{counterfactual} = \sum_{b=1}^{4} \sum_{q=1}^{5} \sum_{g=1}^{2} n_{b,g,q} \sum_{h=1}^{5} Prop_{b,g,q,h} \times \bar{Y}_{b,g,q,h}$$

where *g* represents gender (e.g., 1=men and 2=women), and *b* represents the age brackets (i.e., 25-34, 35-44, 45-54, and 55-64).

The proportionate increase in labour-market earnings that would be achieved by eliminating health inequalities due to socioeconomic status (*Proportion labour market earnings gains from improved health*) is simply total earnings in the counterfactual scenario over total earnings in the baseline scenario:

$$\begin{aligned} &Proportional\ labour\ market\ earnings\ gains\ from\ improved\ health_{all\ age\ brackets} \\ &= (Total\ labour\ market\ earnings_{counterfactual} \\ &\div\ Total\ labour\ market\ earnings_{baseline}) - 1 \end{aligned}$$

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 contextual factors included in each of the quintile labour-market earnings models (i.e., each of the quintile model specifications remain the same). For example, the counterfactual scenario will likely have a higher proportion of individuals who are in the lowest quintile with the demographic characteristics of individuals in the higher health status categories of that quintile than at baseline.

where w_i represent the population weight provided for the SLID sample, *N* represents the total number of individuals in the sample.

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. Specifically, it is $Total\ labour\ market\ earnings_{counterfactual} - Total\ labour\ market\ earning_{baseline}$.[8] 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 propose using 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) wages and salaries, and 2) supplementary labour income. The latter is employers' social contributions, either compulsory or voluntary. We denote the two items as $GDP_{wages\ and\ salaries}$ and $GDP_{supplementary\ labour\ income}$, respectively. Following is the specification:

$$\begin{aligned} &Total\ labour\ market\ earnings\ gains\ from\ improved\ health_{all\ age\ brackets} \\ &= \mathrm{GDP}_{\mathrm{labour}} \times \mathrm{Proportional\ increase}_{\mathrm{labour\ market\ earnings}} \\ &= \left[\mathrm{GDP}_{\mathrm{wages\ and\ salaries}} + \mathrm{GDP}_{\mathrm{supplementary\ labour\ income}}\right] \\ &\quad \times \mathrm{Proportional\ increase}_{\mathrm{labour\ market\ earnings}} \end{aligned}$$

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

Part 1 Component 2 Analysis

Based on the analysis described above, we can identify a set of yearly average labour-market earnings in the counterfactual scenario for each of the quintiles over the working lifetime (i.e., over the years from 25 to 64). Specifically, average fitted values of labour-market earnings for the highest quintile would be calculated for each by age bracket and gender. We identify this set with the symbol $Earnings_{q,a}$. As before, the subscript q identifies the quintile and the subscript a identifies the age (between 25-64). The set of earnings can then be used to estimate the earnings losses associated with individuals in each age bracket who die prematurely due to being in a lower socioeconomic status quintile.

The determination of the number of individuals who die prematurely will draw on analyses undertaken by Statistics Canada on socioeconomic inequalities in mortality/life expectancy by income quintile prepared for the Canada Health Agency. These analyses are based on multiple data sources and used two approaches to calculate life expectancy.

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[8] Labour-market earnings increase attributable to the elimination of socioeconomic status related health inequalities can also be estimated as follows:

$$Total\ labour\ market\ earnings\ gains_{all\ age\ brackets} = \sum_{q=1}^{4} n_q \sum_{h=1}^{5} [(P_{5,h} \times \bar{Y}_{q,h}) - (P_{q,h} \times \bar{Y}_{q,h})]$$

The highest quintile labour-market earnings remains the same, therefore the labour-market earnings of this group is not included in the above differencing.

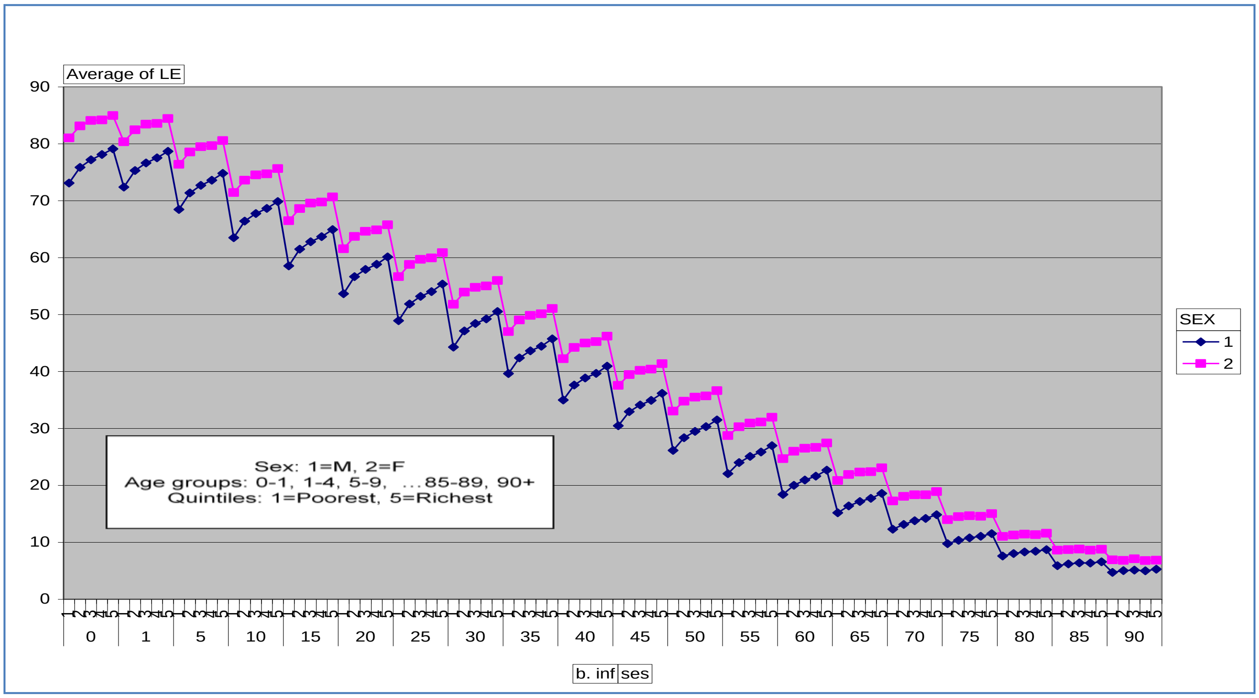
1) For age 0-24: Life expectancy was computed from sex-specific life tables that were grouped by neighbourhood income quintiles in urban Canada. Data was from 1996. Twenty five census metropolitan areas (CMAs) were considered. Specifically, census tracts within each of the 25 CMAs were sorted by the percentage of economic families whose income were lower than the Statistics Canada low-income cutoff, and then grouped into quintiles. The quintiles were pooled across CMAs to create the aggregated data.
2) For age 25+: Life expectancy was computed from linked mortality and census data with quintiles developed from provincial household income information.

Statistics Canada has prepared tables of socioeconomic gradient for life expectancy by gender and age group. Two sets of age groups were developed, the first with five age brackets consisting of 0-24, 25-44, 45-64, 65-79 and 80+; and the second with primarily five-year age brackets starting with 0-1, followed by 1-4, 5-9 though to 90+ (see Diagram 1 for details). For each of the age groups, life expectancy was calculated across household income quintile. A noticeable gradient was found for almost all age brackets, the exception being the oldest age brackets.

If we use the five-year age brackets by gender calculations, then we have 20 sets of five groups for each gender. We need to use the mortality statistics underlying this data. If we represent the set of mortality statistics for a gender as $M_{1,1}$-$M_{20,5}$, where the first subscript represents the age bracket and the second subscript the income quintiles, the first set consisting of $M_{1,1}$, $M_{1,2}$, $M_{1,3}$, $M_{1,4}$, and $M_{1,5}$.[9] Each item in the set is assumed to contain the mortality rate for that age bracket and quintile. For example, for the first age bracket of 0-1 the fifth quintile is represented by $M_{1,5}$ and contains the mortality rate for that group. We can represent the population of a particular age bracket and quintile in a similar way, using the letter P. Thus, the population of the first age bracket for each quintile would be denoted by $P_{1,1}$, $P_{1,2}$, $P_{1,3}$, $P_{1,4}$, and $P_{1,5}$, and each contains the size of that age bracket and quintile population.

[9] We use the Statistics Canada estimates for mortality rate by age bracket, gender and income quintile based on the assumption that these rates accurately reflect the risk of mortality for all individuals in the quintile. The rates do not account for all risk at the individual level, but are assumed to be reasonably generalizable.

Diagram 1: Life expectancy by income quintile and age (5 yr groups), males and females, *Canada**



*Statistics Canada (2010)

In our counterfactual analysis we assume that all of the lower quintiles will have the mortality rate as the highest quintile. We can identify the number of lives lost due to socioeconomic position in a quintile lower than the highest by subtracting the mortality rate of each of the lower quintiles from the highest. For the first quintile in the first age bracket it would be:

$$lives\ lost_{1,1} = (M_{1,1} - M_{1,5}) \times P_{1,1}/1{,}000$$

where *lives lost*$_{1,1}$ represents lives lost in the first quintile of the first age bracket. The division by 1,000 in the above expression is to account for the mortality rates reflecting deaths per 1,000 individuals. The total value of labour-market earnings gains from eliminating premature mortality associated with socioeconomic status for the first quintile in the first age bracket can be represented as follows:

$$Total\ labour\ market\ earnings\ gains\ from\ mortality\ reductions_{1,1}$$
$$= (M_{1,1} - M_{1,5}) \times P_{1,1}/1{,}000 \sum_{k=1}^{(64-A_{1,midpoint})} \frac{Earnings_{1,64-k+1}}{(1+i)^{(64-A_{1,midpoint}-k+1)}}$$

Earnings below age 25 are assumed to be zero. With this discounting, we are assuming that the average age of an age bracket is in the midpoint of the age bracket, represented by $A_{1,midpoint}$, and therefore we are discounting the earnings gained to that midpoint age. The midpoint age may be rounded to an integer for simplicity. The exponent $(64 - A_{1,midpoint} - k + 1)$ is the discounting of $Earnings_{1,64-k+1}$ to present.

If we expand the formula to include all of the four lower quintiles, it would be as follows:

$$Total\ labour\ market\ earnings\ gains\ from\ mortality\ reductions_{first\ age\ bracket} = \sum_{q=1}^{4}(M_{1,q} - M_{1,5}) \times P_{1,q}/1{,}000 \sum_{k=1}^{(64-A_{1,midpoint})} \frac{Earnings_{q,64-k+1}}{(1+i)^{(64-A_{1,midpoint}-k+1)}}$$

where q represents the quintile. If we further expand the formula to include the first 14 age brackets (i.e., the age brackets up to 64), it would be as follows:

$$Total\ labour\ market\ earnings\ gains\ from\ mortality\ reductions_{all\ age\ brackets} = \sum_{j=1}^{14}\sum_{q=1}^{4}(M_{j,q} - M_{j,5}) \times P_{j,q}/1{,}000 \sum_{k=1}^{(64-A_{j,midpoint})} \frac{Earnings_{q,64-k+1}}{(1+i)^{(64-A_{j,midpoint}-k+1)}}$$

where j represent the age bracket.

Lastly, we want to expand the formula to include separate tabulations for men and women, since earnings levels are different across the life course for each gender. Introducing separate tabulations for men and women requires introducing another subscript into the formula, which would be as follows:

$$Total\ labour\ market\ earnings\ gains\ from\ mortality\ reductions_{all\ age\ brackets} = \sum_{j=1}^{14}\sum_{q=1}^{4}\sum_{g=1}^{2}(M_{g,j,q} - M_{g,j,5}) \times P_{g,j,q}/1{,}000 \sum_{k=1}^{(64-A_{j,midpoint})} \frac{Earnings_{g,q,64-k+1}}{(1+i)^{(64-A_{j,midpoint}-k+1)}}$$

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

To add employer social contributions, the total value estimated above would be multiplied by the proportion of employer contributions as in component 1. The final specification would be as follows:

$$Total\ labour\ market\ earnings\ gains\ from\ mortality\ reductions_{all\ age\ brackets}$$
$$= \left[\sum_{j=1}^{14}\sum_{q=1}^{4}\sum_{g=1}^{2} (M_{g,j,q} - M_{g,j,5}) \times P_{g,j,q}/1{,}000 \sum_{k=1}^{(64- A_{j,midpoint})} \frac{Earnings_{g,q,64-k+1}}{(1+i)^{(64-A_{j,midpoint}-k+1)}}\right] \times \left[1 + {GDP_{supplementary\ labour\ income}}\Big/{GDP_{wages\ and\ salaries}}\right]$$

Part 2 Component 1Analysis: The Valuation of Gains in Life Expectancy

The valuation of QALYs gained due to reduced mortality will include all age groups. It too will draw on analyses undertaken by Statistics Canada on socioeconomic inequalities in mortality/life expectancy by income quintile.

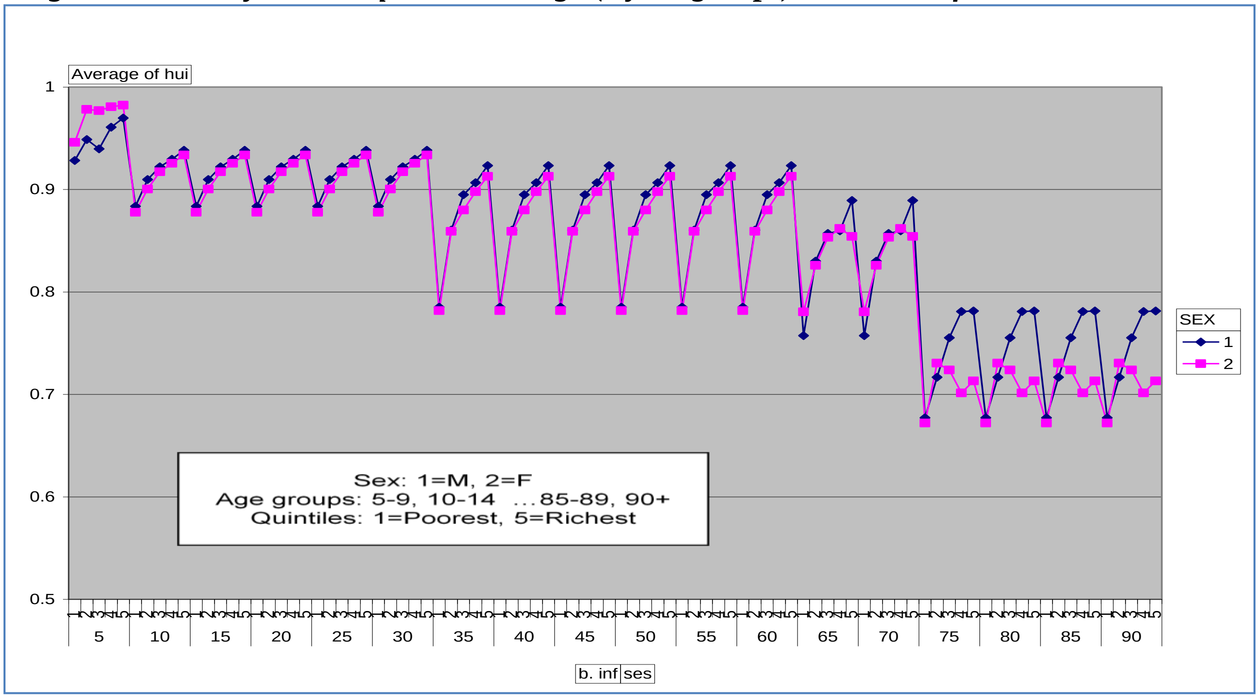
As with Part 1 Component 2, in this counterfactual analysis we assume that all of the lower quintiles will have the mortality rate as the highest quintile. Therefore, we turn to the same formulation of lives lost due to premature mortality. As before, the formulation for the first quintile in the first age bracket would be:

$$lives\ lost_{1,1} = (M_{1,1} - M_{1,5}) \times P_{1,1}/1{,}000$$

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 the same notation as with the mortality rates and population size, the set of life expectancy values for the highest quintile of the 20 age brackets would be $L_{1,5}$ ... $L_{20,5}$.

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 (see Diagram 2 for details). In keeping with the notion that health inequalities associated with socioeconomic status are eliminated in the counterfactual scenario, we suggest using the HUI scores associated with the highest quintile. We represent the set of HUI scores for the highest quintile with the symbol HUI_g, where *g* represents a particular age.

Diagram 2: HUI by income quintile and age (5 year groups), males and females, Canada*



*Statistics Canada (2010)

Since the years of life gained in the counterfactual scenario are in the future, they would need to be discounted to the present. Furthermore, the HUI scores would need to be converted to monetary values by multiplying them by some monetary value of a QALY/HUI. We represent this monetary value by $Value_{HUI}$, 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:

$$Value\ of\ mortality\ reductions_{1,1} = (M_{1,1} - M_{1,5}) \times P_{1,1}/1{,}000 \sum_{k=1}^{(L_{1,5} - A_{1,midpoint})} \frac{Value_{HUI} \times HUI_{L_{1,5}-k+1}}{(1+i)^{(L_{1,5}-A_{1,midpoint}-k+1)}}$$

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. As before, 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 $HUI_{L_{1,5}-k+1}$ 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) for the first age bracket. After this 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:

$$Value\ of\ mortality\ reductions_{first\ age\ bracket} = \sum_{q=1}^{4} (M_{1,q} - M_{1,5}) \times P_{1,q}/1{,}000 \sum_{k=1}^{(L_{1,5} - A_{1,midpoint})} \frac{Value_{HUI} \times HUI_{L_{1,5}-k+1}}{(1+i)^{(L_{1,5}-A_{1,midpoint}-k+1)}}$$

where q represents the quintile. If we further expand the formula to include all 20 age brackets, it would be as follows:

$$Total\ value\ of\ mortality\ reductions_{all\ age\ brackets} = \sum_{j=1}^{20}\sum_{q=1}^{4} (M_{j,q} - M_{j,5}) \times P_{j,q}/1{,}000 \sum_{k=1}^{(L_{j,5} - A_{j,midpoint})} \frac{Value_{HUI} \times HUI_{L_{j,5}-k+1}}{(1+i)^{(L_{j,5}-A_{j,midpoint}-k+1)}}$$

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:

$$Total\ value\ of\ mortality\ reductions_{all\ age\ brackets} = \sum_{j=1}^{20}\sum_{q=1}^{4}\sum_{g=1}^{2} (M_{g,j,q} - M_{g,j,5}) \times P_{g,j,q}/1{,}000 \sum_{k=1}^{(L_{g,j,5} - A_{j,midpoint})} \frac{Value_{HUI} \times HUI_{L_{g,j,5}-k+1}}{(1+i)^{(L_{g,j,5}-A_{j,midpoint}-k+1)}}$$

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

Part 2 Component 2: The Valuation of Reductions in Morbidity

The valuation of QALYs gained due to reduced morbidity will also include all ages. It too will draw on analyses undertaken by Statistics Canada on socioeconomic inequalities in morbidity by income quintile.

If we use the five-year age bracket by gender calculations of the HUI, we have 20 sets of five groups for each gender. If we represent the set for a gender as $HUI_{1,1}$-$HUI_{20,5}$, and use the first subscript to identify the age bracket and the second subscript to identify the income quintile, the first set consisting 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 0-5 the fifth quintile is represented by $HUI_{1,5}$ and contains the HUI scores for that group. As before, we represent the population of a particular age bracket and quintile in a similar way, using the letter P. If, as before, 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:

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

where, 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:

$$Total\ value\ of\ morbidity\ reductions_{all\ age\ brackets} = \sum_{j=1}^{20} \sum_{q=1}^{4} (HUI_{j,q} - HUI_{j,5}) \times Value_{HUI} \times P_{j,q}$$

where, as before, 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:

$$Total\ value\ of\ morbidity\ reductions_{all\ age\ brackets} = \sum_{j=1}^{20} \sum_{q=1}^{4} \sum_{g=1}^{2} (HUI_{g,j,q} - HUI_{g,j,5}) \times Value_{HUI} \times P_{g,j,q}$$

where, as before, g represents gender.

The Value of a QALY

Through counterfactual analysis we identified the gains in QALYs from improved social role functioning outside of the paid labour force as well as the intrinsic value of health to be had by eliminating 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). 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 (EURO29,500; 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).

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 recent 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). Kohr et al. (2010) emphasize that the $20,000 suggested 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 consideration into technology adoption decision 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 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).

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 finding from other literature reviews and comment 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). Clearly 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 suggest considering a range of values in the form of a sensitivity analysis. The values from the health policy arena and health institutions, as well as those from HTA studies are the smallest, with the average from willingness to pay studies being somewhat higher. These three sources of values present a range from $20,000 to approximately $160,000 per QALY. 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 four components of indirect costs of socioeconomic health inequalities, namely a labour-market earnings component related to improved health, a labour-market earnings component related to reduced mortality, a health component related to reduced mortality, and a health component related to reduced morbidity. These four components were identified with the following equations:

$$Total\ labour\ market\ earnings\ gains\ from\ improved\ health_{all\ age\ brackets} = \text{GDP}_{\text{labour}} \times \text{Proportional increase}_{\text{labour market earnings}}$$

$$Total\ labour\ market\ earnings\ gains\ from\ mortality\ reductions_{all\ age\ brackets} = \left[\sum_{j=1}^{14}\sum_{q=1}^{4}\sum_{g=1}^{2} (M_{g,j,5} - M_{g,j,q}) \times P_{g,j,q}/1{,}000 \sum_{k=1}^{(64-A_{j,midpoint})} \frac{Earnings_{g,q,64-k+1}}{(1+i)^{(64-A_{j,midpoint}-k+1)}}\right] \times \left[1 + {GDP_{supplementary\ labour\ income}}/{GDP_{wages\ and\ salaries}}\right]$$

$$Total\ value\ of\ mortality\ reductions_{all\ age\ brackets} = \sum_{j=1}^{20}\sum_{q=1}^{4}\sum_{g=1}^{2} (M_{g,j,q} - M_{g,j,5}) \times P_{g,j,q}/1{,}000 \sum_{k=1}^{(L_{g.j,5}-A_{j,midpoint})} \frac{Value_{HUI} \times HUI_{L_{g,j,5}-k+1}}{(1+i)^{(L_{g,j,5}-A_{j,midpoint}-k+1)}}$$

$$Total\ value\ of\ morbidity\ reductions_{all\ age\ brackets} = \sum_{j=1}^{20}\sum_{q=1}^{4}\sum_{g=1}^{2}\left(HUI_{g,j,q} - HUI_{g,j,5}\right) \times Value_{HUI} \times P_{g,j,q}$$

The sum of the four components represents the principal sources of indirect health costs associated with socioeconomic health inequalities.

Discussion of Issues

The proposed methods described in this report build on previous work undertaken to estimate the economic burden of injury and illness in Canada and elsewhere. Most studies of the indirect costs of health focus on productivity and output at the population level. Though important, this aggregate level approach overlooks the impact of health inequalities within populations. Indeed, a great deal of health inequalities exists within populations, a substantial amount of which is associated with socioeconomic status. These socioeconomic health inequalities are a major challenge to policy makers and legislators in developed countries, but also offer the potential for substantial improvements in population health as well as economic performance. Most micro level studies to date (i.e., studies using individual data) have focussed on the impact of socioeconomic status on health, whereas in this study we were interested in the impact of health on productivity and output.

Previous Canadian studies that estimated the indirect costs of illness in Canada considered lost production in the paid and unpaid labour force, but did not focus on socioeconomic health inequalities (EBIC, 1986, 1993, 1998). Rather they estimated the indirect costs associated with standard reporting units, specifically disease category, province, age bracket and gender. A recent European Union study is one of the first to undertake a comprehensive investigation into the indirect costs of socioeconomic health inequalities (Mackenbach et al., 2007). The methods proposed in the present study build on these previous studies and draw on existing Canadian data resources to advance the measurement of indirect health costs by income level.

In developing these methods, we were conscious of the need to ensure that they dovetail with current efforts by Statistic Canada to measure the direct costs of socioeconomic health inequalities. The proposed methods present a reasonably comprehensive consideration of three broad categories of indirect health costs: 1) paid labour-force output, 2) activities in social roles outside of the paid labour force, and 3) the intrinsic value of health. Four measurement exercises are proposed that estimate the indirect costs associated morbidity and mortality inequalities. The four components are: 1) the impact of morbidity on paid labour-force output for individuals aged 25-64; 2) the impact of premature mortality of all ages on paid labour-force output during ages 25-64; 3) the impact of premature mortality on social role functioning and intrinsic value of health for all ages; and 4) the impact of morbidity on social role functioning and intrinsic value of health for all ages.

We have attempted to address the issue of reverse causality in the methods for estimating the impact of morbidity on paid labour-force output by using panel data and appropriate temporal sequencing. Our suggestion to use permanent income to identify socioeconomic position also addresses the issue of reverse causality, as well as the possibility of misclassification due to transitory changes in income. 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. A more immediate remedy would be to undertake endogeneity tests with the currently proposed regression approach. Despite the issue of endogeneity, the proposed methods likely provide very conservative estimates given the possibility of underestimation for a number of reasons which are described below.

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 the value of activities in social roles outside of the paid labour force and the intrinsic value of health 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.

Some indirect costs are not captured in the proposed methods. The approach taken to estimating the impact of morbidity on paid labour-force output excludes individuals under 25 and over 64 years of age. It also excludes students and the self-employed. Furthermore, the primary data source for modeling of labour-market earnings does not sample all Canadians. We have attempted to correct for some of these exclusions by using national accounts data to refine the estimates. Nonetheless, our approach does not account for the self-employed and likely underestimates the true impact of health on output for other reasons. Regarding the self-employed, the adjustment we proposed does not capture their earnings because they are in a different sub-category of the national accounts than what we use in the adjustment. Specifically, self-employed earnings are in the category of 'net income of non-farm unincorporated business, including rent.' Additionally, some fraction of organization 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., with 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). Lastly, the impact of health on fertility and female labour-force participation is not considered, though this is thought to be less relevant for developed countries.

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.

The estimation of indirect costs 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.

The valuation of social role functioning outside of the paid labour force and the intrinsic value of health is sensitive to the monetary value placed on a QALY and the discount rate used in the analysis. Given this fact, we noted the need for sensitivity analysis of these two variables that considers the full range of meaningful values for them.

The focus on family income as a measure of socioeconomic status overlooks other dimensions and proxies of socioeconomic status and their relationship with health. Other possible measures include education, occupational class, and wealth. In the proposed regression modeling, the specification includes educational attainment as an explanatory variable. With regards to occupational class, it is only relevant for individuals who are working, and therefore cannot be specified for all individuals of working age. With regards to wealth, data for it is not readily available. Our choice of an income based measure of socioeconomic status is a result of the specification made in the request for proposals by the Public Health Agency of Canada and is essential for consistency with Statistics Canada's efforts to measure the direct costs of income inequalities.

Overall, the proposed methods offer the potential to substantially advance the measurement of the indirect costs of socioeconomic health inequalities in Canada. The report has provided detailed methods and data sources such that the methods can be easily executed. The proposed methods dovetail well with previous work undertaken in Canada and elsewhere, as well as current efforts by Statistics Canada. We believe the methods offer an approach that will provide a comprehensive though reasonably conservative estimate of the impact of health on indirect costs by income level.

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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 $PV = C/(1 + r)$. 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 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.