HEALTH-ADJUSTED LIFE EXPECTANCY IN CANADA:

2012 Report by the Public Health Agency of Canada

Prepared by the Public Health Agency of Canada Steering Committee on Health-Adjusted Life Expectancy

Public Health Agency of Canada   Agence de la santé publique du Canada

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MESSAGE FROM THE
CHIEF PUBLIC HEALTH OFFICER

It is well known that social, environmental, behavioural and genetic factors, along with the interactions among them, have a major impact on the health and overall life expectancy of the population.

To better describe the health of the population, it is useful to have a summary measure that includes both the quality of life as well as its length. Health-adjusted life expectancy (HALE) is the average number of years that an individual is expected to live in a healthy state. This first report on HALE from the Public Health Agency of Canada benchmarks how chronic conditions and socio-economic status influence healthy life expectancy predicted at birth, at various ages and by gender.

The report's findings indicate that chronic diseases such as diabetes, hypertension and cancer are associated with a significant loss in HALE. The findings also indicate that there is inequity in health based on income, according to HALE.

The information in this report will contribute toward the use of HALE as an important measure of the health status of populations. It will support the public health dialogue on reducing health disparities in our society.

I encourage you to use the findings of this report to support or inform your current work and to share with us your own observations on the applicability of HALE to measuring and reporting on population health.

Dr. David Butler-Jones
Chief Public Health Officer
Public Health Agency of Canada

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EXECUTIVE SUMMARY

Health-adjusted life expectancy is an indicator of the average number of years that an individual is expected to live in a healthy state. It is a summary measure that combines both quantity of life and quality of life. In other words, it combines mortality and morbidity experience into a single summary measure of population health. It can be used to measure the burden of disease and injury, risk factors in the population and the performance of public health efforts.

This report, published by the Public Health Agency of Canada, provides estimates of health-adjusted life expectancy among Canadians with and without selected chronic diseases (diabetes and cancer) and chronic conditions (hypertension), and by socio-economic status (income). Estimates are provided for females and males and for people of different ages.

Low socio-economic status is associated with a loss in health-adjusted life expectancy. In 2001, Canadian women and men in the top one-third income group had a health-adjusted life expectancy at birth of 72.3 years and 70.5 years, respectively. Compared with being in the highest income group, being in the bottom one-third income group was associated with a loss of health-adjusted life expectancy at birth of 3.2 years for women and 4.7 years for men.

Chronic diseases and conditions also are associated with a significant loss in health-adjusted life expectancy. The estimates of health-adjusted life expectancy by chronic disease status in this report were calculated based on the mortality and morbidity experience of people with and without diabetes and/or hypertension (high blood pressure) for the 2004–2006 period and of people with and without cancer for the 2002–2005 period. According to the results of this study, the diabetes cohort at age 55 had a loss in health-adjusted life expectancy of 5.8 years for women and 5.3 years for men compared to the cohort without diabetes. The cohort of people with high blood pressure at age 55 had a loss of 2.0 years and 2.7 years for females and males, respectively. The cancer cohort at age 65 had a loss in health-adjusted life expectancy of 10.3 years for women and 9.2 years for men.

This report provides information for use in public health research, policy development and practice. Future reports could extend the scope to include health-adjusted life expectancy by risk factor status (such as obesity, physical inactivity and smoking).

CHAPTER 1

Introduction

The Public Health Agency of Canada is pleased to publish its first report on health-adjusted life expectancy in Canada as part of its mission to promote and protect the health of Canadians. The main purposes of this report are to summarize the current literature and provide initial results on health-adjusted life expectancy among subpopulations of Canadians with or without chronic diseases (such as diabetes, hypertension or cancer) and by socio-economic status (such as income or education level).

Health-adjusted life expectancy is a composite measure that captures a more complete estimate of population health than standard (or ordinary) life expectancy. It combines age- and sex-specific measures of both morbidity and mortality into a single statistic. Health-adjusted life expectancy is defined as the average number of healthy years that a person would live under the mortality and morbidity prevailing at that time [1]. The estimate is made by subtracting the years of ill health—weighted according to severity—from overall period (or actuarial) life expectancy. It is now widely recognized that, in addition to mortality data, information on morbidity (including disability) is needed for properly monitoring and analyzing population health.

Measures such as life expectancy and health-adjusted life expectancy are intuitively understandable for a general audience because they measure health along a yardstick to which most people can relate, namely, in terms of life length or "expectancy." However, the data used to generate these measures do not span a person's or population's life—rather, the life course perspective is simulated using only cross-sectional data (data measured at a specific time period)—hence the terms "period" and "actuarial" can describe life expectancy or health-adjusted life expectancy. The conversion of cross-sectional data to a longitudinal summary measure is particularly important when interpreting estimates for subpopulations.

Two chapters (3 and 4) in this report explore a novel adaptation of the period life table, using it to produce population health summaries for a few illustrative disease groups. Given the strong resemblance of the adaptation to the traditional period life table, readers may be tempted to interpret the disease-specific results in the same manner that they interpret results from conventional period life tables. Yet there are distinct, albeit subtle, differences between the adaptation and the conventional life table approaches. Thus, while some readers may have become accustomed to interpreting life table results such as life expectancy at birth (or residual life expectancy at some other age, e.g., age 65) as a reasonable indicator of the prognosis of a randomly chosen member from that population, such interpretations will not apply under the disease-specific approach. For example, the residual health-adjusted life expectancy reported for those with disease (such as cancer) at age 65, would not be instructive for a 65-year-old cancer patient from that population. Rather, the (residual) life expectancy or health-adjusted life expectancy summaries are offered simply as convenient single number summaries; the adapted period life table approach merely provides a standardized mathematical algorithm for converting a set of age-specific mortality rates into a single-number summary. Such a summary is akin to an age-standardized mortality rate.

It is well known that chronic diseases and conditions not only substantially reduce life expectancy but also decrease the number of healthy years that a person is expected to live. The disease-specific chapters in this report estimate life expectancy and health-adjusted life expectancy for people who are diagnosed with diabetes mellitus, hypertension or cancer. The estimates are based on the mortality and morbidity experience of specific subpopulations for a specific period of time and should be treated as descriptive cross-sectional statistics rather than as predictive estimates. These diseases were chosen because they have high morbidity and mortality, and reasonable data were available to conduct the analyses.

In 2006, approximately 2 million Canadians aged 1 year and older (6.2% of the total population) had diagnosed diabetes [2], and nearly 6 million adults aged 20 years and older (22.7%) had diagnosed hypertension [3]. Diabetes and hypertension often co-exist. Persons who have diagnosed diabetes are 3 times more likely to be diagnosed with hypertension than those without diabetes. Approximately 63% of Canadian adults with diabetes also have hypertension [2]. Both diseases increase the risk of developing other life-threatening diseases such as heart attack, stroke or kidney failure. This leads to poor health and premature mortality and therefore to a reduction of health expectancy.

Cancer is one of the leading causes of death in developed countries worldwide. The number of individuals diagnosed with and dying from cancer is increasing in Canada [4]. On average, 20 Canadians are diagnosed with some type of cancer and 8 persons die from cancer every hour. A high mortality rate and extremely poor health among patients with cancer lead to a large reduction in life expectancy and healthy life expectancy. Canada is one of the few nations in the world with a population-based cancer registry that allows the calculation of population-based survival, which can be used for the estimation of life expectancy. Moreover, in combination with a measure of health-related quality of life, population-based survival information can be used for an evaluation of health-adjusted life expectancy.

Governments at the local, federal/provincial/territorial and the international level consider the advancement of their population's health to be an important goal. Comparison of health-adjusted life expectancy in subpopulations based on income status is of particular interest. There is an increasingly well-articulated concern for the health of the disadvantaged and an interest in narrowing health inequalities between the advantaged and the disadvantaged. Better knowledge about the nature and extent of inequalities in health due to socio-economic status and due to the presence of chronic diseases can help to guide efforts toward reducing those inequalities between corresponding subpopulations [5–8].

While mechanisms for reporting on the average or typical health of Canadians are well entrenched, protocols for the routine measurement of health inequalities are not. Rather, the methods are currently more of a patchwork than an established protocol. Although multiple analyses have been done for Canada [9], a well-established practice of measurement (based on a routine, consistent and regularly repeated protocol) has yet to be established [10].

Health-adjusted life expectancy is still a relatively new summary measure of population health, but its use has already illustrated numerous health disparities between the sexes. Overall, health-adjusted life expectancy has shown that, while women are living longer than men, these additional years of life are not always associated with good health. Chronic conditions are one of the main causes of lowered health-adjusted life expectancy, and for many chronic conditions women are at a higher risk than men. Women are also more likely than men to have 2 or more chronic conditions (or co-morbidities), as well as to report having disabilities that affect daily functioning [11].

This report will add to these observations of sex-related health disparities and examination of income-related health inequalities in Canada. Health-adjusted life expectancy is an effective way of summarizing health status and could be very useful in measuring the extent of health differences arising from socio-economic factors.

The report is divided into 6 chapters. Following this introductory chapter is one that reviews general methods for calculating health-adjusted life expectancy and presents previously published estimates of health-adjusted life expectancy and ordinary life expectancy for the general Canadian population at birth. Chapters 3 to 5 then focus on health-adjusted life expectancy for Canadians with and without diabetes and/or hypertension, for those with and without cancer, and for different income groups. These chapters each describe how the methods and research have been gathered to support the findings for these subpopulations. More detailed information is provided in the appendices for those readers who wish to pursue the subject further, including information on health-adjusted life expectancy by educational level. New data are presented in Chapter 3 (on diabetes and hypertension) and Chapter 4 (on cancer) based on analyses performed by the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy. The final chapter (Chapter 6) offers a discussion of the report's main findings.

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CHAPTER 2

General Methods for Calculating Health-Adjusted Life Expectancy, With Results for the General Population

There are many different methods of calculating health-adjusted life expectancy. All methods can be divided into 2 main categories: prevalence-based and incidence-based methods (see Figure 2-1 and Appendix A for more information). The prevalence-based approach typically uses ordinary (period) life tables and prevalence-based measures of disability or health status. The incidence-based approach uses multi-state cohort life tables (or microsimulation modelling) and incidence-based measures of disability or health status that take account of health status-specific data on the probability of transitioning among the various health states [1].

Using the standard approach to calculate health-adjusted life expectancy, age-specific death rates are first used to derive a period life table, which is then combined with a prevalence-based measure of disability or of health-related quality of life, such as a health utility index or the Quality of Well-Being Scale [2–3]. This prevalence-based approach is often referred to as the Sullivan method, in deference to that author's pioneering work in the field of health expectancy [4]. Population health surveys are commonly used to obtain the data on disability or health-related quality of life. For example, the Canadian Community Health Survey obtains health utility index data from individuals. In mathematical terms, health-adjusted life expectancy redefines the standard expression for life expectancy by modifying the number of life-years lived by the health-related quality of life measure. Life expectancy and health-adjusted life expectancy can thus be expressed as follows:

$$LE_x = \frac{\sum_{i=x}^{w} L_i}{l_x}$$

$$HALE_x = \frac{\sum_{i=x}^{w} (L_i * H_i)}{l_x}$$

Where:

- LE is ordinary life expectancy;
- $HALE$ is health-adjusted life expectancy;
- x is the exact age for which life expectancy or health-adjusted life expectancy is to be estimated;
- i is an index representing the lower limit (x) of the age interval (x, $x + a$);
- L_i is the number of life-years lived in the age group (x, $x + a$);
- l_x is the number of survivors at age x;
- H_i is a score or weight representing the average level of health-related quality of life for the age group (x, $x + a$), with H_i = 1.0 indicating full health; and
- w is the total number of age groups in the life table.

FIGURE 2.1. Methods of Calculating Health-Adjusted Life Expectancy

PREVALENCE-BASED METHODS   INCIDENCE-BASED METHODS

Use a **normal life table**. Require **observed mortality and health-related quality of life (HRQOL) measure**.

- Life-years lived in the "alive" state are divided into healthy and diseased or disabled years using the observed prevalence of the various health states.

Use a **multi-state life table** and data on **transitional probabilities between states**. Use microsimulation models that describe the life course of cohorts in terms of transitions between risk factor classes and changes between disease states over time. Examples include:

- Netherlands Chronic Disease Model
- Population Health Model (POHEM), Statistics Canada

HRQOL measure

- Health Utility Index
- Health State Valuation
- Quality of Well-Being Index

HRQOL measure

- Health Utility Index
- Health State Valuation
- Quality of Well-Being Index

Health-Adjusted Life Expectancy

Health-Adjusted Life Expectancy

The specific methods used in this report to calculate health-adjusted life expectancy for various subgroups of the Canadian population are described in subsequent chapters. The following section of this chapter shows the most recent published results for the overall population.

STATISTICS CANADA RESULTS: HEALTH-ADJUSTED LIFE EXPECTANCY AT BIRTH

Table 2-1 presents previously published estimates from Statistics Canada of health-adjusted life expectancy and ordinary life expectancy at birth for the general Canadian population, based on mortality data for 2000 and 2001. As of 2001, the health-adjusted life expectancy at birth, for all Canadians (excluding those in the territories), was 70.8 years for females and 68.3 years for males. As noted by Wolfson, the difference between life expectancy and health-adjusted life expectancy can be perceived as a measure of the burden of ill health [5]. At birth, this difference was 11.2 years for females and 8.6 years for males. Females spent a greater portion of their life in an unhealthy state (14%, or 11.2 / 82.0) than males (11%).

Across provinces, health-adjusted life expectancy for females ranged from 69.7 in Alberta to 72.0 in Quebec. For males, it ranged from 66.7 in Manitoba to 69.0 in Quebec. The distribution of life expectancy estimates across the provinces was not consistent with the distribution of health-adjusted life expectancy estimates. With respect to life expectancy, the values for females ranged from 80.4 in Newfoundland and Labrador to 82.9 in British Columbia. For males, life expectancy ranged from 75.1 in Newfoundland and Labrador to 78.0 in British Columbia.

The table shows results by province, but similar comparisons could have been done across other geographic dimensions, such as urban versus rural, North versus South or by degree of isolation. For health-adjusted life expectancy at age 25, differences by income are shown in Chapter 5 and differences by education are shown in Appendix G of this report.

TABLE 2-1. Life Expectancy and Health-Adjusted Life Expectancy (HALE) at Birth, by Sex, Canada and Provinces, 2001

	FEMALES		MALES	
	Life Expectancy	HALE	Life Expectancy	HALE
CANADA[1]	82.0	70.8	76.9	68.3
Newfoundland and Labrador	80.4	70.2	75.1	68.4
Prince Edward Island	82.0	71.7	75.2	67.3
Nova Scotia	81.3	70.1	76.2	66.5
New Brunswick	81.8	70.9	76.0	67.4
Quebec	82.1	72.0	76.3	69.0
Ontario	82.0	70.1	77.3	68.2
Manitoba	81.2	70.4	75.5	66.7
Saskatchewan	81.7	70.2	76.2	67.3
Alberta	82.1	69.7	77.0	67.6
British Columbia	82.9	71.2	78.0	68.9

SOURCES: Statistics Canada, CANSIM Table 102-0121 and Catalogue no. 82-221-X
(Available from: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/hlth67-eng.htm)

[1] Canada, excluding the territories

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CHAPTER 3

Health-Adjusted Life Expectancy Among Canadians With and Without Diabetes and/or Adult Hypertension

PURPOSE

This chapter describes the methodology used to calculate life expectancy and health-adjusted life expectancy among Canadians with and without diabetes and/or hypertension, based on mortality data for 2004 to 2006 and morbidity data for 2000 through 2005. The resulting new data on these subpopulations are presented as well.

METHODS

Data analysis for this chapter was performed by the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy. The methods used closely resemble the methods used by Manuel and colleagues [1–3]. Technical documentation (algorithm) on the methods, including data sources and SAS programs used to calculate health-adjusted life expectancy, is provided as a final appendix (Appendix H) for those with a statistics background who would like to duplicate the calculations in this chapter.

DATA SOURCES

While mortality data and population counts are sufficient for calculating life expectancy, a measure of health-related quality of life is also needed to estimate health-adjusted life expectancy, its variance and corresponding 95% confidence intervals. The measure used in this analysis was the Health Utility Index Mark 3 (see Appendix B for more information) [4].

CANADIAN CHRONIC DISEASE SURVEILLANCE SYSTEM

The Canadian Chronic Disease Surveillance System is a collaborative network of provincial and territorial chronic disease surveillance systems, supported by the Public Health Agency of Canada. It was created to improve the breadth of information about the burden of chronic diseases in Canada so that policy-makers, researchers, health practitioners and the general public could make better public and personal health decisions. The Canadian Chronic Disease Surveillance System regularly seeks advice from non-governmental organizations and researchers to explain and interpret the information from the system.

In each province and territory, the health insurance registry database is linked to the physician billing and hospitalization databases to generate summarized data for residents of Canada who have used the Canadian health care system. These summarized data are stored in the Canadian Chronic Disease Surveillance System for routine analysis. If there was sufficient evidence of use due to diabetes and/or hypertension, it was assumed that a person had diagnosed diabetes and/or adult hypertension (20 years and older). The minimum requirement was at least 1 hospitalization or 2 physician claims over a 2-year period with specific code(s) for diabetes and/or hypertension from the International Classification of Diseases (see Table 3-1).

TABLE 3-1. International Classification of Diseases (ICD) Codes for Diabetes and/or Hypertension Used to Compile Data From the Canadian Chronic Disease Surveillance System

DISEASE	ICD-9 [5]	ICD-10 [6]
Diabetes	250	E10–E14
Hypertension	401–405	I10–I13 and I15

For Canadian residents with and without diabetes and/or adult hypertension, age-specific mortality rates for all causes of death are also included in the Canadian Chronic Disease Surveillance System. For this study, the age-specific mortality rates for persons with diabetes and/or adult hypertension were used to calculate life expectancy and health-adjusted life expectancy.

POPULATION SCHEME

Figure 3-1 illustrates the partitions of the Canadian population that were used for this analysis.

FIGURE 3-1. Public Health Agency of Canada Scheme for the Analysis of Health-Adjusted Life Expectancy by Presence or Absence of Diabetes/Hypertension

Population: A+B+C+D
With DM: A+B
Without DM: D+C
With HYP: B+C
Without HYP: D+A
With DM and HYP: B
Without DM and/or HYP: D
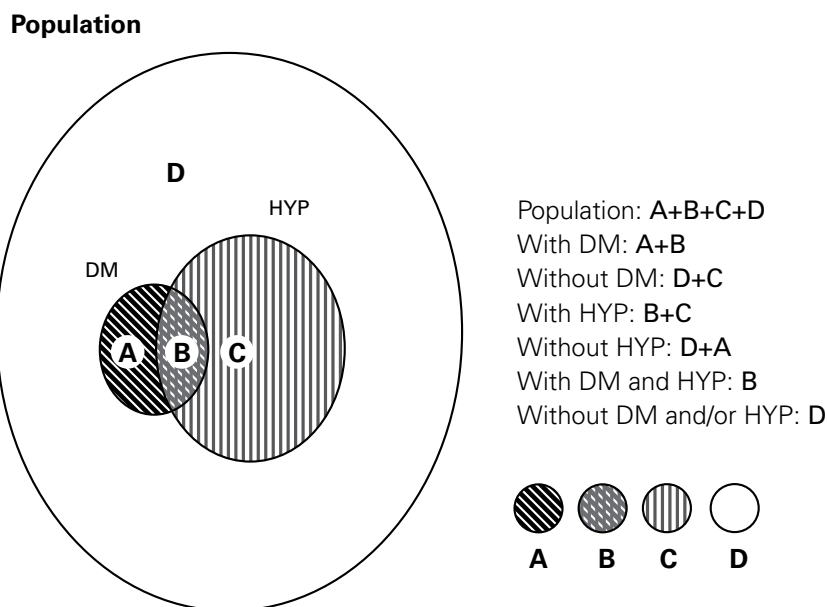
DM = diabetes mellitus; HYP = hypertension

CANADIAN COMMUNITY HEALTH SURVEY

The Canadian Community Health Survey is a cross-sectional survey, supported by Statistics Canada, that collects information related to health status, health care utilization and health determinants for the Canadian population. It relies upon a large sample of respondents and is designed to provide reliable estimates at the health region level.

Prior to 2007, data collection occurred every 2 years for a 12-month period. After major changes to the survey design in 2007, data collection now occurs on an ongoing basis with annual releases. Data are available for 2000/2001, 2003, 2005, 2007, 2008 and 2009.

The Canadian Community Health Survey produces an annual microdata file and a file combining 2 years of data. The survey collection years can also be combined by users to examine subpopulations of rare characteristics. The survey data include information for persons aged 12 years and older. The survey data do not represent people who live in institutions or in remote areas. The household-level response rate was 84.6%, and the person-level response rate was 91.7% [7].

As a measure of health-related quality of life, the Health Utility Index Mark 3 measure from the following 3 Canadian Community Health Survey data files were used for this study: (1) cycle 1.1 2000/2001 share file [8]; (2) cycle 2.1 2003 subsample 1 file [9]; and (3) cycle 3.1 2005 subsample 1 file [10]. The Public Health Agency of Canada has an agreement with Statistics Canada to use the share file from the survey (see Appendix B for more information).

HEALTH UTILITY INDEX [11] MARK 3

In this analysis, the level of the body's physiological or psychological functioning was measured by the Health Utility Index Mark 3 instrument, which was available with the Canadian Community Health Survey data and has been validated for use for studies of type 2 diabetes (see Appendix B for more information) [12]. Information on the availability of the health utility index, by province and territory, is shown in Appendix B (Table B-1).

SURVEY SAMPLE SIZES

All 3 cycles of the Canadian Community Health Survey (cycle 1.1 share file, cycle 2.1 subsample and cycle 3.1 subsample) were combined by the pooled method to increase the sample size and to decrease variation in the estimates [13]. The sample size for the combined file, which spanned the years 2000 through 2005, was 200,809.

Mortality data for Quebec and Nunavut were unavailable from the Canadian Chronic Disease Surveillance System, and health utility index data from the Northwest Territories and Nunavut were unavailable from the 2000/2001 (cycle 1.1) survey file. Therefore, these jurisdictions were excluded from all analyses reported in this chapter.

Table 3-2 shows the sample sizes by disease category from the 2000–2005 combined file.

TABLE 3-2. Sample Sizes by Disease Status Category From the 2000–2005 Combined File of the Canadian Community Health Survey

DISEASE STATUS CATEGORY	SAMPLE SIZE
Without Disease	
Disease-free, total (any disease)	163,019
Without diabetes	190,271
Without hypertension	168,052
With Disease	
With diabetes	10,538
With hypertension	32,757
With diabetes and hypertension	5,505

NOTE: Excluding Quebec, Nunavut and the Northwest Territories

CALCULATING LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY

Chiang's method [14] was used to generate period (2004–2006) life tables for persons without and with disease, by sex and 19 standard age groups (<1, 1–4, 5–9, … , 80–84, 85+ years). The Gompertz function was used to provide an accurate estimate of life expectancy for the last open-ended age interval (85+), in order to close the life table. This method was described by Hsieh [15]. A prevalence-based Sullivan method [16] was used to calculate health-adjusted life expectancy. According to this method, the "life-years lived" variable was adjusted by the health utility index as a measure of health-related quality of life.

The following steps were used to calculate health-adjusted life expectancy by disease status:

1. The Canadian Chronic Disease Surveillance System data were stratified by disease status to obtain the population of people who were diagnosed with diabetes and/or hypertension and the population of people without diabetes and/or hypertension;

2. The age-specific mortality rates from the administrative data collected by the surveillance system were calculated for each disease category, based on 3 years of data;

3. The mean health utility index for each sex and age group was estimated from the combined surveys for the same disease categories (based on the question "Do you have diabetes and/or hypertension?"). The variances were calculated using the Bootvare_V31 macro [17];

4. For each disease category, sex and age group, the mean health utility index and the age-specific mortality rates were merged; and

5. Health-adjusted life expectancy was calculated by sex and age group for each disease category.

AGE GROUP EXCEPTIONS

The Statistics Canada Release Guidelines recommend that at least 10 observations should be used to estimate the health utility index for a specific group, such as age group or sex. For people with chronic conditions, only a small sample population size was available for the younger age groups (1–4 people in a cell). Therefore, the mean health utility index for those age groups was replaced by the mean health utility index for people without disease.

Mortality rates by hypertension status were available only for people 20 years old and over in the data from the Canadian Chronic Disease Surveillance System. Therefore, age-specific mortality rates, calculated for the Canadian population regardless of hypertension status, were applied to the following age groups: <1, 1–4, 5–9, 10–14 and 15–19 years.

Health utility index data for the 3 youngest age groups (<1, 1–4 and 5–9 years) were not available. Therefore, an assumed value of 0.999 was used for those age groups, on the presumption that not everyone in those age groups had perfect health (in which case, the health utility index would have had a value of 1).

VARIANCE ESTIMATIONS

The variance of life expectancy was calculated by the method of Chiang [14].

A large sample size was available for the subpopulation of people without diabetes and hypertension and for the total Canadian population; therefore, the variance of the probability of dying was likely close to zero and would not have contributed much to the variance of health-adjusted life expectancy. Thus, the variance of health-adjusted life expectancy for this subpopulation was calculated by the Bebbington method [18], taking into account the variability of the health utility index only.

However, the sample size for the subpopulations of people with disease was relatively small, and the life table variance was large. Therefore, the variances of health-adjusted life expectancy for the subpopulations with diabetes, with hypertension, and for those with both diabetes and hypertension were calculated, taking into account both the variability of the probability of dying and the variability of the health utility index. This method was developed by Mathers [19]. In future analyses, it is expected that the Mathers method could be used for both large and small samples.

All calculations were performed using specially developed SAS macros. Confidence intervals (95%) for life expectancy and health-adjusted life expectancy were constructed based on the assumption that such averages are normally distributed. Z-tests were used to test the statistical significance of the loss in life expectancy and the absolute difference in life expectancy. The absolute difference is defined as the difference between life expectancy and the health-adjusted life expectancy for the same cohort (see Appendix B for more information).

RESULTS

The loss of life expectancy and health-adjusted life expectancy (in years) was calculated for selected ages. At birth was selected for comparability with other research on health-adjusted life expectancy; age 20 years was selected for diabetes because it represents primarily type 2 diabetes and for hypertension because adult hypertension was studied; and age 55 was selected because 55 is the 2006 mean age of the surveillance system incident cases for both diabetes and hypertension. The loss of life expectancy for persons with diabetes and/or hypertension was defined as the difference between the life expectancy for persons without diabetes and/or hypertension and the life expectancy for persons with diabetes and/or hypertension. The loss of health-adjusted life expectancy for persons with diabetes and/or hypertension was defined as the difference between the health-adjusted life expectancy for persons without diabetes and/or hypertension and the health-adjusted life expectancy for persons with diabetes and/or hypertension.

LIFE EXPECTANCY

Table 3-3 shows the loss of life expectancy among females and males, at selected ages, by disease status. All losses in life expectancy were statistically significant ($p < 0.0001$).

At age 20, the loss of life expectancy (in years) was higher for those with diabetes for both females and males (females: 9.2; males: 8.8), compared with the loss of life expectancy for those with hypertension (females: 3.3; males: 4.1). The loss of life expectancy was highest for those with both diabetes and hypertension (females: 13.4; males: 15.3).

At age 55, the loss of life expectancy (in years) was also higher for those with diabetes for both females and males (females: 6.0; males: 5.0), compared with the loss of life expectancy for those with hypertension (females: 1.5; males: 2.1). The loss of life expectancy was highest for those with diabetes and hypertension (females: 6.6; males: 6.3).

HEALTH-ADJUSTED LIFE EXPECTANCY

Table 3-3 also shows the loss of health-adjusted life expectancy among both sexes, at selected ages, by disease status. All losses in health-adjusted life expectancy were statistically significant ($p < 0.0001$).

At age 20, the loss of health-adjusted life expectancy (in years) was higher for both females and males with diabetes (females: 10.1; males: 9.6), compared with the loss of health-adjusted life expectancy for those with hypertension (females: 6.1; males: 5.7). The loss of health-adjusted life expectancy was highest for those with diabetes and hypertension (females: 16.1; males: 15.9).

At age 55, the loss of health-adjusted life expectancy (in years) was also higher for females and males with diabetes (females: 5.8; males: 5.3), compared with the loss of health-adjusted life expectancy for those with hypertension (females: 2.0; males: 2.7). The loss of health-adjusted life expectancy was highest for those with diabetes and hypertension (females: 6.9; males: 6.8).

See Appendix C for more detailed results.

TABLE 3-3. Life Expectancy (LE),[1] Health-Adjusted Life Expectancy (HALE),[1] and Losses of LE and of HALE, at Selected Ages,[2] by Disease Status and Sex, Canada (Less Quebec, Nunavut and Northwest Territories),[3] 2004 to 2006

SEX	HEALTH EXPECTANCY MEASURE	CANADIAN POPULATION (I)	WITHOUT DM&HYP (II)	WITHOUT DM (III)	WITHOUT HYP (IV)	WITH DM (V)	WITH HYP (VI)	WITH DM&HYP (VII)	LOSS IN HEALTH EXPECTANCY WITH		
									DM (III–V)	HYP (IV–VI)	DM&HYP (II–VII)
At birth											
Females	LE	83.6	85.5	85.0	84.7	74.9	81.5	72.2	10.1*	3.2*	13.3*
	HALE	72.1	74.0	73.3	73.4	62.2	67.2	58.1	11.1*	6.2*	15.9*
Males	LE	78.9	81.0	80.2	80.2	70.9	76.2	65.9	9.3*	4.0*	15.1*
	HALE	69.6	71.8	70.9	71.1	60.1	65.0	56.0	10.8*	6.1*	15.8*
At age 20 years											
Females	LE	64.3	66.1	65.7	65.4	56.5	62.1	52.7	9.2*	3.3*	13.4*
	HALE	53.6	55.6	54.8	55.0	44.7	48.9	39.5	10.1*	6.1*	16.1*
Males	LE	59.6	61.8	61.0	61.0	52.2	56.9	46.5	8.8*	4.1*	15.3*
	HALE	51.3	53.5	52.6	52.8	43.0	47.1	37.6	9.6*	5.7*	15.9*
At age 55 years											
Females	LE	30.6	32.3	32.0	31.6	26.0	30.1	25.7	6.0*	1.5*	6.6*
	HALE	23.6	25.3	24.7	24.7	18.9	22.7	18.4	5.8*	2.0*	6.9*
Males	LE	26.8	28.7	28.0	28.0	23.0	25.9	22.4	5.0*	2.1*	6.3*
	HALE	21.6	23.5	22.8	22.9	17.5	20.2	16.7	5.3*	2.7*	6.8*

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

DM = diabetes mellitus; HYP = hypertension

1 The 95% confidence intervals are shown in Appendix C.

2 **At birth** was selected for comparability with other research on health-adjusted life expectancy. **At age 20 years** was selected for diabetes because it represents primarily type 2 diabetes and for hypertension because adult hypertension was studied. **At age 55 years** was selected because 55 is the 2006 mean age of the surveillance system incident cases for both diabetes and hypertension.

3 Mortality data for Quebec and Nunavut were unavailable from the surveillance system data, and data from the Northwest Territories and Nunavut were unavailable from the combined cycle file derived from survey data. Therefore, these jurisdictions were excluded from all analyses.

* Statistically significant (p < 0.0001)

DISCUSSION

Chronic diseases such as diabetes mellitus and chronic conditions such as high blood pressure (or hypertension) are associated with a significant loss in health-adjusted life expectancy. The estimates here were calculated based on the mortality and morbidity experience of people with and without diabetes and/or hypertension for the period of 2004 to 2006 and should be treated as descriptive cross-sectional statistics rather than as predictive estimates. According to the results of this study, the diabetes cohort at age 55 had a loss of 5.8 years of health-adjusted life expectancy for females, and 5.3 years for males. The cohort of people with high blood pressure at age 55 had a loss of 2.0 years and 2.7 years for females and males, respectively, in their health-adjusted life expectancy.

For health-adjusted life expectancy, the most recent data from Statistics Canada are for the year 2001 (see Table 2-1). However, Statistics Canada has published life expectancy at birth for the years 2004 to 2006. The life expectancy results from Statistics Canada (females: 82.8 years; males: 78.0 years) were roughly similar to the results calculated by the Public Health Agency of Canada for the 2004–2006 study period (females: 83.6 years; males: 78.9 years) [20].

Because it was important to confirm that the Agency's results were consistent with other studies, these results for health-adjusted life expectancy (for Canada less Quebec and 2 territories) were compared with those of previous studies conducted by Manuel and colleagues for Ontario [1–3]. The results were similar by sex and age.

STUDY LIMITATIONS

An important limitation of this study is the missing data for residents of long-term care facilities from the estimates of health-adjusted life expectancy. Because of this limitation, the true value for the entire population would be somewhat lower than what is reported in this chapter. It is also important to note that misclassification of diabetes and hypertension status is present in both the survey data and the surveillance system data used. The Canadian Community Health Survey misclassification is due to self-reporting bias, which has a tendency to under-report disease status. In the Canadian Chronic Disease Surveillance System, misclassification is present in geographic areas where only incomplete data are available. Areas with a larger proportion of salaried physicians provide the least complete data, which results in identifying fewer individuals with disease. Consequently, the disease status concordance between the 2 data sources varies by province and territory [21–25]. Linkage of these 2 data sources (see Appendix D) would provide a means to eliminate the self-reporting bias, which would reduce the effect of misclassification error on the estimates.

This study was also limited by the inability to differentiate between type 1 and type 2 diabetes. The onset of illness is earlier for type 1 diabetes; therefore, the cumulative impact of type 1 diabetes on individual health is likely greater than for type 2 diabetes. However, the impact of diabetes on population health is strongly influenced by type 2 diabetes because it is much more prevalent [3].

STRENGTHS

The major strength of using this methodology to calculate life expectancy and health-adjusted life expectancy for Canadians with chronic diseases is that the data needed for these calculations are currently available on a yearly basis. Using these data should increase the opportunities to publish such results in a timely manner, as the analyses could begin promptly. With the ongoing expansion of the Canadian Chronic Disease Surveillance System to cover other chronic diseases, calculation of life expectancy and health-adjusted life expectancy for people with mental disorders, ischemic heart disease, stroke and chronic obstructive pulmonary disease could be considered.

CHALLENGES

The main challenge in using this methodology to calculate life expectancy and health-adjusted life expectancy for subpopulations with chronic diseases is that the data may not represent the entire Canadian population because there are limitations in the availability of Canadian Community Health Survey data for all provinces and territories (sample size limitations) and all age groups (data are only available for Canadians aged 12 and older). This challenge may be mitigated by combining survey cycles and imputing missing data.

The survey data do not represent Canadians who live in institutions or remote areas.

Statistics Canada plans to collect information to derive the Health Utility Index Mark 3 for the 2009, 2010, 2013 and 2014 data collection cycles of the Canadian Community Health Survey; however, the health utility index will not be available for the 2011 and 2012 data years.

CONCLUSION

This chapter described the methodology used by the Public Health Agency of Canada to calculate life expectancy and health-adjusted life expectancy among Canadians with and without diabetes and/or adult hypertension, based on mortality data for 2004 to 2006 and morbidity data for 2000 to 2005. The analysis has shown that it is possible to calculate health-adjusted life expectancy for all Canadians and for subpopulations with these particular chronic diseases for any 3-year period. Although this methodology can be used as a standard for such calculations for all chronic diseases in Canada, the strengths and challenges of an enhanced methodology using linked hospital data from provinces and territories should also be considered. This potential enhanced methodology is described in Appendix D.

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CHAPTER 4

Health-Adjusted Life Expectancy Among Canadians With and Without Cancer

PURPOSE

This chapter describes the methodology used to calculate life expectancy and health-adjusted life expectancy among Canadians with and without cancer, based on cancer incidence and mortality data for 2002 to 2005. The resulting new data on these subpopulations are presented as well.

METHODS

Data analysis for this chapter was performed by the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy.

DATA SOURCES

CANADIAN CANCER REGISTRY

Cancer incidence data are from the July 2009 version of the Canadian Cancer Registry, a dynamic, person-oriented, population-based database maintained by Statistics Canada. The Canadian Cancer Registry contains information on cases diagnosed from 1992 onward, compiled from reports from every provincial and territorial cancer registry. A detailed description of the registry, including data sources, methodology and accuracy, is available on the Statistics Canada website [1] (see Appendix B also). Mortality data are from the Canadian Mortality Database, also maintained by Statistics Canada. These data are based on information provided by the vital statistics registrars in each province and territory. Annual population estimates are from Statistics Canada's *Demographic Estimates Compendium 2007* [2].

A file containing records of new invasive cancer cases was created using the multiple primary coding rules of the International Agency for Research on Cancer [3]. Cancer cases were classified based on the *International Classification of Diseases for Oncology, Third Edition* [4]. Mortality follow-up—complete through December 31, 2005—was determined through record linkage to the Canadian Mortality Database and from information reported by provincial and territorial cancer registries. For deaths reported by a provincial registry but not confirmed by record linkage, the date of death was assumed to be that submitted by the reporting registry. Because of issues involved in ascertaining the vital status of cases diagnosed in Quebec, the cases from Quebec were excluded.

For this study, the age-specific mortality rates (based on person-years at risk) for cancer were used to calculate life expectancy and health-adjusted life expectancy. The cancer cases were restricted to first primary cancers from 1992 (start of the registry) on, ensuring that persons with cancer were counted only once. The deaths and person-years were then tabulated, stratified by period and age group, and the mortality rates for the 2002–2005 period were calculated.

A "death certificate only" case is a case where only the death certificate information was available. For this analysis, such cases were excluded because there was no information on the date of diagnosis other than the date of death. An analysis was conducted to determine the differences in life expectancy for persons with cancer using data files that included the death certificate only cases and using data files that excluded those cases. The differences in life expectancy were 1.3 years for females and 0.8 years for males.

The ORIUS database [5, 6] was used to calculate mortality from all causes, cancer mortality and person-years at risk in the Canadian population. Deaths and person-years for persons with cancer were subtracted from such data for the Canadian population to obtain values for the non-cancer cohort.

CANADIAN COMMUNITY HEALTH SURVEY

The Canadian Community Health Survey data collected by Statistics Canada, including the Health Utility Index Mark 3, are described in the Methods section of Chapter 3, with additional information provided in Appendix B.

STUDY SAMPLE SIZE

All 3 data cycles of the Canadian Community Health Survey (cycle 1.1 share file, cycle 2.1 subsample and cycle 3.1 subsample) were pooled in order to increase the sample size and decrease the variance of the estimates [7].

Survival data for Quebec were unavailable from the Canadian Cancer Registry, and therefore Quebec was excluded from all analyses reported in this chapter.

Table 4-1 shows the sample sizes from the Canadian Community Health Survey combined file for the years 2000 to 2005 (excluding Quebec).

TABLE 4-1. Sample Size for Cancer Analyses From the 2000–2005 Combined File of the Canadian Community Health Survey

CATEGORY	SAMPLE SIZE
Total	156,020
With cancer	3,204

NOTE: Excluding Quebec

CALCULATING LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY

Chiang's method [8] was used to generate 2002–2005 period life tables for populations with and without disease, based on age-specific mortality rates, by sex for 19 standard age groups (<1, 14, 5–9, … , 80–84, 85+ years). The Gompertz function was used to provide an accurate estimate of life expectancy for the last open-ended age interval (85+), in order to close the life table. This method was described by Hsieh [9]. The prevalence-based Sullivan method [10] was used for the calculation of health-adjusted life expectancy. According to this method, the "life-years lived" variable was adjusted by the Health Utility Index Mark 3 as a measure of health-related quality of life. In addition, cancer-deleted life expectancy (after eliminating deaths due to cancer from the analysis) was calculated using cancer-deleted mortality rates. The specific steps used for calculating life expectancy and health-adjusted life expectancy among Canadians with and without cancer for the 2002–2005 period are described below, and the cancer-deleted life expectancy estimation is described in Appendix B.

Steps used to calculate life expectancy and health-adjusted life expectancy for the Canadian population[1]:

1. The all-cause mortality and Canadian population data[1] for the 2002–2005 period were used;

2. The age-specific mortality rates were calculated, based on 4 years of data;

3. The mean health utility index, from the survey data, was estimated for the total population by sex and age group. The variances of the mean values of the index were also calculated using the BOOTVARE_V31 macro [11];

4. The age-specific mean health utility index and the age-specific mortality rates were merged, by sex and age group; and

5. Life expectancy and health-adjusted life expectancy were calculated by sex and age group.

Steps used to calculate life expectancy and health-adjusted life expectancy for people diagnosed with cancer:

1. The all-cause mortality data for people with cancer and person-years at risk of dying among persons with cancer, for the 2002–2005 period, were used in the analysis;

2. The age-specific mortality rates were calculated, based on 4 years of data;

3. The mean health utility index, from the survey data, was estimated for people with cancer (based on the question "Do you have cancer?") by sex and age group. The variances of the mean values of the index were also calculated using the BOOTVARE_V31 macro [11];

4. The age-specific mean health utility index and the age-specific mortality rates were merged, by sex and age group; and

5. Life expectancy and health-adjusted life expectancy were calculated by sex and age group.

Steps used to calculate life expectancy and health-adjusted life expectancy for people without cancer:

1. The all-cause mortality for people with cancer and person-years at risk of dying among persons with cancer, and the all-cause mortality and population data for the entire Canadian population, for the 2002–2005 period, were used in the analysis;

2. The deaths for people with cancer were subtracted from those for the Canadian population to obtain the number of deaths for people without cancer (numerator). The population without cancer was calculated by subtracting the person-years at risk for people with cancer from the Canadian population (denominator). (Refer to the formula below);

3. The age-specific mortality rates were calculated, based on 4 years of death data;

4. The age-specific mean health utility index values, from the survey data, were estimated for people without cancer (based on the question "Do you have cancer?") by sex and age group. The variances of the mean values of the index were also calculated using the BOOTVARE_V31 macro [11];

5. The mean health utility index and the age-specific mortality rates were merged, by sex and age group; and

6. Life expectancy and health-adjusted life expectancy were calculated by sex and age group.

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[1] Population data were taken from Statistics Canada CANSIM files (Table 051-0001) but were updated to the version last modified 2009-11-30.

Formula to calculate age-specific mortality rates to estimate life expectancy and health-adjusted life expectancy for people without cancer:

$$R_i = \frac{D_{ai} - D_{ci}}{P_{ai} - P_{ci}}$$

Where:

- R_i is the age-specific mortality rate;
- D_{ai} is the number of deaths from all causes in age group i in the Canadian population;
- D_{ci} is the number of deaths from all causes in age group i among people with cancer;
- P_{ai} is the Canadian population in age group i; and
- P_{ci} is the number of person-years at risk of dying among persons diagnosed with cancer.

AGE GROUP EXCEPTIONS

The Statistics Canada Release Guidelines recommend that at least 10 observations should be used to estimate the health utility index for a specific group, such as age group or sex. For people with cancer, only a small sample size was available for the younger age groups (1–4 people in a cell). Therefore, the mean health utility index for those age groups was replaced by the mean index for people without cancer.

The health utility index data for the 3 youngest age groups (<1, 1–4 and 5–9 years) were not available. Therefore, an index value of 0.999 was used for these age groups, assuming that not everyone in those age groups had perfect health (in which case, the index value would have been 1).

VARIANCE ESTIMATIONS

The variance of life expectancy was calculated by the method of Chiang [8].

A large sample size was available for the total population and for persons without cancer; therefore, the variance of the probability of dying was likely close to zero and should not have contributed much to the variance of health-adjusted life expectancy. Thus, the variance of health-adjusted life expectancy for these groups was calculated by the Bebbington method [12], taking into account the variability of the health utility index only.

However, the sample size for persons with disease was relatively small, so the variance of health-adjusted life expectancy for persons with cancer was calculated taking into account both the variability of the probability of dying and the variability of the health utility index. This method was developed by Mathers [13]. In future analyses, it is expected that the Mathers method could be used for both large and small samples.

All calculations were performed using specially developed SAS macros. Confidence intervals (95%) for life expectancy and health-adjusted life expectancy were constructed based on the assumption that those averages are normally distributed. Z-tests were used to test the statistical significance of health gaps and the absolute difference in life expectancy. The loss of life expectancy and health-adjusted life expectancy (years) was calculated. The loss of life expectancy (years) for persons with cancer was defined as the difference between the life expectancy of persons without cancer and the life expectancy of persons with cancer. The loss of health-adjusted life expectancy (years) for persons with cancer was defined as the difference between the health-adjusted life expectancy of persons without cancer and that of persons with cancer.

RESULTS

LIFE EXPECTANCY

Table 4-2 shows the loss of life expectancy among females and males with cancer, at selected ages. All losses in life expectancy were statistically significant (p < 0.0001).

At age 20, the loss of life expectancy was 38.4 years for females and 39.7 years for males. At age 65, the loss of life expectancy was 13.7 years for females and 11.5 years for males.

HEALTH-ADJUSTED LIFE EXPECTANCY

Table 4-2 also shows the loss of health-adjusted life expectancy among females and males with cancer, at selected ages. All such losses in health-adjusted life expectancy were statistically significant (p < 0.0001).

At age 20, the loss of health-adjusted life expectancy was 33.3 years for females and 34.8 years for males. At age 65, the loss of health-adjusted life expectancy was 10.3 years for females and 9.2 years for males.

See Appendix E for more detailed results.

TABLE 4-2. Life Expectancy (LE),[1] Health-Adjusted Life Expectancy (HALE),[1] and Losses of LE and of HALE, at Selected Ages,[2] by Presence or Absence of Cancer and by Sex, Canada (less Quebec),[3] 2002 to 2005

SEX	HEALTH EXPECTANCY MEASURE	CANADIAN POPULATION (I)	WITHOUT CANCER (II)	WITH CANCER (III)	LOSS OF HEALTH EXPECTANCY WITH CANCER (II – III)
At birth					
Females	LE	82.8	85.9	27.1	58.8*
	HALE	71.4	73.8	22.5	51.3*
Males	LE	77.8	81.3	22.9	58.4*
	HALE	68.7	71.5	20.5	51.0*
At age 20 years					
Females	LE	63.5	66.6	28.2	38.4*
	HALE	53.0	55.3	22.0	33.3*
Males	LE	58.6	62.1	22.4	39.7*
	HALE	50.5	53.3	18.5	34.8*
At age 65 years					
Females	LE	21.3	23.2	9.5	13.7*
	HALE	15.7	17.1	6.8	10.3*
Males	LE	17.7	20.3	8.8	11.5*
	HALE	13.8	15.8	6.6	9.2*

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Cancer Registry files, 2002–2005

1 The 95% confidence intervals are shown in Appendix E.

2 **At birth** was selected for comparability with other research on HALE. **At age 20 years** was selected because adult cancers are represented. **At age 65 years** was selected because 65 is the 2005 mean age of the Canadian Cancer Registry incident cases for cancer.

3 Mortality data for Quebec were unavailable from the Canadian Cancer Registry.

* Statistically significant (p < 0.0001)

DISCUSSION

The estimates of life expectancy and health-adjusted life expectancy in this chapter were calculated based on the mortality and morbidity experience of people with and without cancer for the 2002–2005 period. They should be treated as descriptive cross-sectional statistics rather than as predictive estimates of survival, since the mortality and morbidity experience will change. Situation-specific factors include the type and stage of the cancer, treatments available, survival time, and whether the patient has other chronic diseases. The estimates of life expectancy at birth for the population with cancer combine the experiences of people who have cancer for varying lengths of time from early in life to older years. Nevertheless, cancer is primarily a disease that affects Canadians aged 50 years or older [14].

The difference (or the "loss") in life expectancy or health-adjusted life expectancy at birth between cohorts of people without cancer and with cancer summarizes the differences in mortality and morbidity among those people during a lifetime. Age-specific mortality rates among people with cancer are much higher than mortality rates among people without the disease across all ages and both sexes. Therefore, their life expectancy is much lower than the life expectancy of people without cancer. The loss in life expectancy at birth for people with cancer (i.e., the difference in life expectancy between populations of people without cancer and with cancer, as it was defined in this study) was estimated to be 58.8 years for women and 58.4 years for men. At age 20, the loss in life expectancy was estimated at 38.4 and 39.7 years for women and men, respectively. The loss in health-adjusted life expectancy at birth for people with cancer was estimated to be 51.3 years for women and 51.0 years for men. At age 20, the loss in health-adjusted life expectancy was estimated at 33.3 and 34.8 years for women and men, respectively.

Life expectancy for people without cancer and "cancer-deleted" life expectancy are both presented in the report (see Appendix E). Cancer-deleted life expectancy is a surrogate for the life expectancy of a population without cancer. When compared with the life expectancy of the general population, it provides an indication of the burden of cancer. The mechanism used to eliminate cancer from the population in the cancer-deleted estimation process is to calculate life expectancy based on the mortality experience of a population after removing deaths due to cancer from the analysis. This adjustment works well for cancers with very short survival times. Calculating life expectancy and health-adjusted life expectancy among people without cancer allows a more accurate assessment of cancer burden than does calculating cancer-deleted estimates.

This analysis of mortality among people with and without cancer by means of life expectancy and health-adjusted life expectancy calculations appears to be the first of its kind. No publications on life expectancy and health-adjusted life expectancy for people without and with cancer were located in the literature search to compare with these results. Therefore, the results reported in this chapter should be considered preliminary and interpreted with caution. For example, the results of losses in health-adjusted life expectancy at age 20 of 33.3 years for women and 34.8 years for men seem to be huge, although the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy is confident that the calculations are correct.

In this study, the life expectancy at birth for people without cancer was estimated to be 85.9 years for women and 81.3 years for men. The corresponding cancer-deleted life expectancy at birth was 86.2 and 81.6 years, respectively. The difference at birth between the life expectancy for the population without cancer and the life expectancy for the total Canadian population, or the gain in life expectancy after eliminating cancer, was 3.1 years for females and 3.5 years for males. The corresponding gain in life expectancy after eliminating cancer deaths (using the cancer-deleted calculation method) was 3.4 years for females and 3.7 years for males. These results were very close to published results on the gain in life expectancy after eliminating cancer deaths [15].

The most recent health-adjusted life expectancy data from Statistics Canada are for 2001 (see Table 2-1). However, Statistics Canada has calculated life expectancy at birth for 2006 (based on deaths from 2005 to 2007). The 2005–2007 life expectancy results from Statistics Canada (females: 83.0 years; males: 78.4 years) are similar to the results calculated by the Public Health Agency of Canada for the 2002–2005 period (females: 82.8 years; males: 77.8 years) [16].

In summary, the methodology for calculating health-adjusted life expectancy used by the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy in this cancer analysis can be used as a Canadian standard for such calculations across other chronic diseases. The strengths and limitations of using this methodology as a standard are described in the Chapter 3 Discussion section since the methodology is similar to that used to calculate health-adjusted life expectancy for subpopulations with and without diabetes and/or hypertension.

STUDY LIMITATIONS

One limitation arising from the use of Canadian Cancer Registry data is due to missing diagnosis dates on some of the registry data. For the 2002–2005 cancer diagnoses, the records for just under 1% of the cases with first primary cancers were missing the day for the date of diagnosis. In addition, 6.4% had a survival of less than 31 days. Survival of less than 1 month may also indicate a larger percentage of uncertainty regarding the survival time from diagnosis. "Death certificate only" cases were excluded from this analysis.

An important limitation of this study is the lack of data for residents of long-term care facilities from the health-adjusted life expectancy calculation. Because of this omission, the actual population-based health-adjusted life expectancy value would be somewhat lower than the reported estimate in this chapter [12]. It is also important to note that agreement between administrative data and self-reported data varies by province and territory for many chronic diseases (e.g., diabetes, hypertension, arthritis, asthma, heart disease and stroke) [17–22]. The Technical Team assume that this is also true for cancer. The overall effect of these variations on the health-adjusted life expectancy statistics is unknown.

CONCLUSION

This chapter described the methodology used by the Public Health Agency of Canada to calculate life expectancy and health-adjusted life expectancy among Canadians with and without cancer, based on data for 2002 to 2005. This methodology, which is similar to that used in Chapter 3, can be used as a standard for such calculations for all chronic diseases in Canada. See Appendix D for recommendations from an external consultant to enhance this methodology.

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CHAPTER 5

Health-Adjusted Life Expectancy by Income

BACKGROUND

Until recently in Canada, no nationally representative population-based cohort studies have examined mortality by socio-economic status in the total population [1]. Few investigations in the Canadian context have focused on socio-economic differences in summary measures of population health, and those that have done so have relied primarily on macro-level indicators (such as neighbourhood income) [2] rather than micro-level indicators (such as household income), thereby almost certainly diminishing the strength of the association between socio-economic status and health [3].

The landmark 1991 Canadian census mortality follow-up study [1] took a more comprehensive approach by tracking a 15% sample of 1991 census respondents across 11 years of mortality records. The results of that work provide more comprehensive, robust and policy-relevant information on socio-economic differentials in mortality in Canada, as well as an empirical foundation for numerous future research projects [4].

According to James and colleagues, a decrease in the rate of deaths from conditions amenable to medical care made the largest contribution to reducing socio-economic differences in mortality over a 25-year period after the establishment of universal health insurance in Canada [5].

This chapter is intended to present recent published Canadian figures for health-adjusted life expectancy by income. Because of the many challenges generally encountered when linking mortality data with income data in order to calculate health-adjusted life expectancy by income, "work-around" solutions must often be sought. Appendix F describes a continuum of such approaches to measuring health-adjusted life expectancy by income. In addition, Appendix G presents a Canadian analysis of health-adjusted life expectancy by educational attainment, which is widely used as an indicator of socio-economic status.

HEALTH-ADJUSTED LIFE EXPECTANCY BY NEIGHBOURHOOD INCOME TERTILES, 2001

Health-adjusted life expectancy by neighbourhood income tertile in 2001 was published by Statistics Canada [6]. The following data sources were used:

- Classification of 1996 enumeration areas by income tertile;
- 2001 abridged life tables by income tertile;
- Canadian Community Health Survey, cycle 1.1 (2000/2001);
- National Population Health Survey, institutional file, cycle 2 (1996/1997 cross-sectional file); and
- 2001 census institutional counts.

STATISTICS CANADA METHODS

Wilkins and colleagues classified 1996 census enumeration areas into neighbourhood income tertiles based on income per single-person equivalent, which is a household size-adjusted average household income (pre-tax, post-transfer) at the enumeration area level [7]. Then, 1996 life tables by neighbourhood income tertiles were constructed. Deaths were coded to the enumeration area based on postal codes. The household-size adjusted average income for each enumeration area was calculated, and then enumeration areas were assigned to the bottom, middle or highest neighbourhood income tertile. Life tables were then constructed using the deaths assigned to each neighbourhood income tertile.

Later, in order to produce similar results for 2001, the 1996 percentage of deaths in each neighbourhood income tertile was applied to the 2001 life tables [6].

Using the enumeration area link in the Canadian Community Health Survey, respondents were placed in 1 of the 3 neighbourhood income tertiles. The mean health utility index was calculated for each tertile by age, sex and province. The 1994 household longitudinal file of the National Population Health Survey was analyzed to determine the tertile distribution for institutional residents. The postal codes of respondents who lived in the community in 1994 but were living in an institution during a subsequent survey cycle were assigned to a tertile based on their enumeration area of residence in 1994. This tertile distribution was then applied to determine the percentage of institutional residents in each neighbourhood income tertile.

Health-adjusted life expectancy was calculated for each province according to the method described below for each neighbourhood income tertile:

- Part A: (average health utility index for institutional residents * proportion of population in institutions in the province) + (average health utility index for household population * proportion of population in households in the province) = overall health utility index score by sex and age group in each province.
- Part B: overall health utility index by sex and age group * years of life lived in each age group = health-adjusted years of life lived.
- Part C: health-adjusted years of life lived were then summed and divided by the total number of persons surviving at given ages to provide health-adjusted life expectancy at birth and age 65 by province.

For details concerning the data sources and the calculations of the coefficient of variation for health-adjusted life expectancy, see the Statistics Canada technical notes [8].

STATISTICS CANADA RESULTS [6]

In 2001, women had a higher health-adjusted life expectancy than men, both at birth and at age 65. This difference was more apparent at birth, with women living to 70.8 years in full health and men living to 68.3 years in full health. Canadians in higher neighbourhood income tertiles generally lived longer, healthier lives than those in lower neighbourhood income tertiles.

Women in the highest neighbourhood income tertile had a health-adjusted life expectancy of 72.3 years at birth, whereas men in the highest neighbourhood income tertile had a health-adjusted life expectancy of 70.5 years. Comparisons of health-adjusted life expectancy at birth across income tertiles showed that women in the highest neighbourhood income tertile had a health-adjusted life expectancy that was 3.2 years higher than that of women in the lowest tertile. Similarly, men in the highest tertile had a health-adjusted life expectancy that was 4.7 years higher than that of men in the lowest neighbourhood income tertile (Figure 5-1).

FIGURE 5-1. Health-Adjusted Life Expectancy by Sex and Neighbourhood Income Tertile, at Birth and Age 65, Canada, 2001

Legend:
- Lowest Income Group
- Middle Income Group
- Highest Income Group
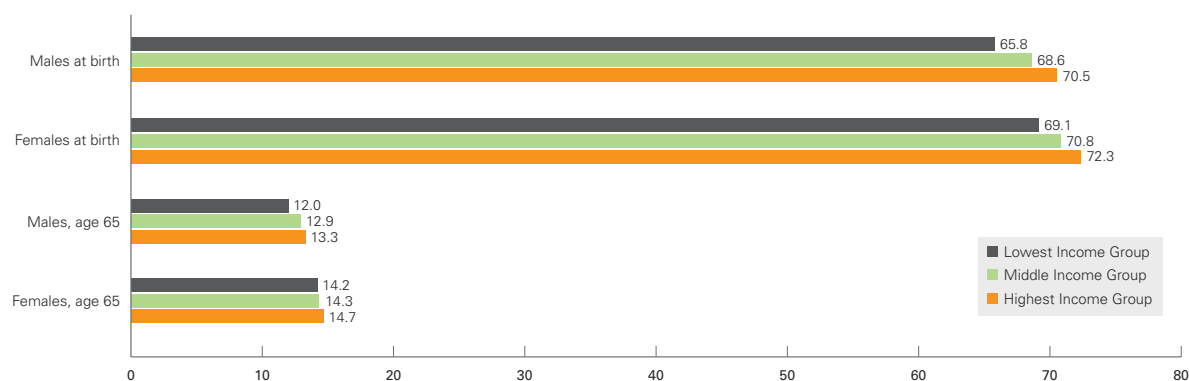
SOURCE: Statistics Canada (Reference 6)

HEALTH-ADJUSTED LIFE EXPECTANCY BY INCOME DECILES, 1991 TO 2001

A recent study (by McIntosh and colleagues) of income-related disparities in health-adjusted life expectancy for Canadian adults from 1991 to 2001 is the first study to provide nationally representative estimates of socio-economic inequalities in health-adjusted life expectancy for the adult household population of Canada, using individual-level measures of socio-economic status, mortality and morbidity [3].

MCINTOSH ET AL. METHODS [3]

Death data were obtained from the 1991–2001 Canadian census mortality follow-up study conducted by Statistics Canada in collaboration with the Canadian Population Health Initiative [1]. With probabilistic linkage techniques, a 15% sample (n = 2,735,152) of the non-institutional population aged 25 or older who completed the 1991 census long-form questionnaire (the cohort) was matched to 11 years of death records (June 4, 1991, to December 31, 2001) from the Canadian Mortality Database. Data on health-related quality of life (i.e., average health utility index weights) were derived from the Health Utility Index Mark 3 instrument administered to all respondents to the 2000/2001 Canadian Community Health Survey (cycle 1.1).

For the census mortality linked file, deciles (tenths) of population ranked by income adequacy were created for each economic family or unattached individual in the non-institutional census population of all ages. For the Canadian Community Health Survey, income deciles were constructed in the same manner, except that total household income was used rather than total economic family income.

Health-adjusted life expectancy was estimated using a modified version of the Sullivan method [9]. Chiang's method [10] was used to calculate abridged (5-year age group) period life tables, and corresponding standard errors and 95% confidence intervals for each population subgroup of interest (by age, sex and income decile).

MCINTOSH ET AL. RESULTS [3]

The remaining health-adjusted life expectancy at age 25, by income decile and sex, is shown in Table 5-1 [3]. The differences in health-adjusted life expectancy between the highest and lowest deciles were 9.5 years for women and 14.1 years for men. For both sexes, the disparities in health-adjusted life expectancy between the highest and lowest income groups were substantially greater than those for life expectancy alone.

The results of the supplemental analyses of health disparities across educational attainment categories are shown in Table G-2 of Appendix G. Health-adjusted life expectancy was longer at each successively higher level of education.

TABLE 5-1. Remaining Health-Adjusted Life Expectancy (Years) at Age 25, by Income Decile and Sex, Canada, 1991 to 2001

	WOMEN			MEN		
		95% confidence interval			95% confidence interval	
	Years	from	to	Years	from	to
Decile 1 (lowest)	42.9	42.4	43.3	37.0	36.4	37.5
Decile 2	45.6	45.2	46.0	40.0	39.5	40.4
Decile 3	48.4	48.0	48.8	43.0	42.6	43.3
Decile 4	49.3	48.8	49.8	43.7	43.3	44.1
Decile 5	49.7	49.2	50.2	46.4	46.0	46.7
Decile 6	51.2	50.7	51.7	46.5	46.1	46.9
Decile 7	50.7	50.2	51.3	47.4	47.1	47.7
Decile 8	51.8	51.1	52.6	48.4	48.0	48.8
Decile 9	52.2	51.7	52.8	49.0	48.6	49.3
Decile 10 (highest)	52.4	51.4	53.4	51.1	50.8	51.4
Difference: Decile 10 minus Decile 1	**9.5**	**8.5**	**10.6**	**14.1**	**13.5**	**14.8**

SOURCES: 1991-2001 Canadian census mortality follow-up study, and 2000/2001 Canadian Community Health Survey (cycle 1.1) [adapted, with permission, from Erratum (in press 2010) to McIntosh et al., 2009 (Reference 3)]

DISCUSSION

From 1971 to 1996, differences in life expectancy (at birth) between the richest and poorest income quintiles diminished by well over 1 year for each sex. For most causes of death, socio-economic disparities in mortality diminished markedly over time [7].

However, mortality is only one aspect of population health [3]. Two recent reviews [11, 12] reminded readers that, when the worse morbidity experience of lower socio-economic groups is combined with their worse mortality experience, the socio-economic disparities in health become more pronounced than those based on mortality alone. The McIntosh et al. study results confirmed that the disparities in health-adjusted life expectancy between the highest and lowest income deciles were considerably greater than those for life expectancy alone [3]

Canadian women and men in the highest tertile income group in 2001 had a health-adjusted life expectancy of 72.3 and 70.5 years, respectively. Comparison of health-adjusted life expectancy across income groups revealed that, at birth, women in the highest tertile income group had a health-adjusted life expectancy that was 3.2 years higher than women in the lowest tertile income group. Similarly, men in the highest income group had a health-adjusted life expectancy that was 4.7 years higher than men in the lowest income group [6].

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CHAPTER 6

Discussion

Life expectancy is an indicator of the average number of years that an individual would be expected to live. It is a basic and commonly used measure of population health [1–4]. In contrast, health-adjusted life expectancy is a summary measure of population health that attempts to reflect a more complete picture of health than conventional life expectancy. It is a measure of not only quantity of life but also quality of life [5–7]. This report provides a perspective and some new data on life expectancy and health-adjusted life expectancy among Canadians by chronic disease status (presence or absence of diabetes mellitus, hypertension and cancer) and presents recent published estimates of health-adjusted life expectancy in Canada by socio-economic status (income).

Health-adjusted life expectancy calculated by the Sullivan method estimates the number of remaining years, at a particular age, that an individual can expect to live in a healthy state (however health may be defined). For example, for the 2002–2005 period, women in Canada (Quebec data unavailable) at age 20 years could expect to live a further 63.5 years, of which 53.0 years (83%) would be spent in a healthy state (Chapter 4).

In Canada, life expectancy is increasing [5–8]. In 1990, life expectancy at birth was 80.9 years for women and 74.6 years for men [8]; in the 2004–2006 period examined in this report (Chapter 3), life expectancy at birth was estimated at 83.6 years for women and 78.9 years for men (data unavailable for Quebec and 2 territories). Canadian women lived longer than men by an average of 4.7 years, but Canadian men lived a greater proportion of their life in good health than did Canadian women (88.2% versus 86.2%). Health-adjusted life expectancy at birth reflects many chronic diseases that do not develop until a person is older. Therefore, health-adjusted life expectancy at more advanced ages (such as the mean age at incidence for a particular disease) was also reported.

The prevalence of diabetes and obesity has been increasing in Canada, with higher rates among elderly Canadians and among Aboriginal peoples [3]. This report (Chapter 3) compared people with and without diabetes and/or hypertension and estimated the impact of these diseases on life expectancy and health-adjusted life expectancy for the 2004–2006 period. The presence of diabetes was associated with a larger reduction in life expectancy than the presence of hypertension. At age 20, the loss of life expectancy was higher for both women with diabetes (9.2 years) and men with diabetes (8.8 years), as compared with the loss of life expectancy for those with hypertension (women: 3.3 years; men: 4.1 years). Furthermore, the loss of life expectancy was highest for those with both diabetes and hypertension (women: 13.4 years; men: 15.3 years). A similar trend was observed for health-adjusted life expectancy. At age 20, the loss of health-adjusted life expectancy was greater when diabetes was present (women: 10.1 years; men: 9.6 years), as compared with the loss of health-adjusted life expectancy related to hypertension (women: 6.1 years; men: 5.7 years). Again, the loss of health-adjusted life expectancy was greater when both diabetes and hypertension were present (women: 16.1 years; men: 15.9 years).

This report (Chapter 4) also calculated life expectancy and health-adjusted life expectancy in the 2002–2005 period for people diagnosed with cancer. The analysis showed that cancer had a substantial impact on life expectancy. People with cancer have a much lower life expectancy and health-adjusted life expectancy than people without cancer. At age 20, the loss of life expectancy for women with cancer was 38.4 years and the loss for men with cancer was 39.7 years. The loss of health-adjusted life expectancy at age 20 for those with cancer was 33.3 years for women and 34.8 years for men. The results showed that, if cancer deaths could be eliminated, the life expectancy (at birth) of the entire population would increase substantially: by 3.4 years for women and 3.7 years for men (see Table E-1 in Appendix E).

As previously stated, health-adjusted life expectancy is a measure of life expectancy in full health. It has been increasing faster than life expectancy, but the reasons for this increase are unknown [2–5]. It is likely that there were decreases in the prevalence rates of cancer and heart disease that are attributable to improvements in the health care system and in chronic disease interventions [4]. Canadians have been experiencing continuing increases in life expectancy and in health-adjusted life expectancy [5, 8].

In the analyses of health-adjusted life expectancy by chronic disease status, the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy used the health utility index from the Canadian Community Health Survey, which was only available for Canadians aged 12 years and older. There were also data limitations related to coverage for all provinces and territories, with the result that the estimates may not perfectly reflect life expectancy and health-adjusted life expectancy for the entire population [9–11]. Because of those limitations, the actual population-based health-adjusted life expectancy values would be lower than estimated in this report. In addition, the survey data were based on self-reporting that may contain self-reporting errors, whereas the surveillance system data were based on reported disease status from physicians and/or hospitals. Another important limitation was the lack of data for residents of long-term care facilities. However, this report has demonstrated that linked databases containing information on mortality and on disease prevalence can be used to monitor and estimate health-adjusted life expectancy for subpopulations with other chronic diseases. The reader should keep in mind that the disease-specific results presented in this report are descriptive cross-sectional estimates, not predictive estimates.

Life expectancy and health-adjusted life expectancy were also strongly associated with socio-economic status [12]. A decrease in the rate of deaths from conditions amenable to medical care made the largest contribution to reducing socio-economic differences in mortality over a 25-year period after the establishment of universal health insurance in Canada [9]. Income-related disparities in health-adjusted life expectancy were found to be considerably larger than those for the conventional life expectancy indicator [13–15]. In a recent study of income-related disparities (for Canadian adults from 1991 to 2001) that provided the first nationally representative estimates of socio-economic inequalities in health-adjusted life expectancy in Canada based on individual and family income [12], health-adjusted life expectancy at age 25 within the highest income decile was 52.4 years for women and 51.1 years for men; within the lowest income decile, it was 42.9 years for women and 37.0 years for men. Therefore, the disparities in health-adjusted life expectancy between the highest and lowest deciles were 9.5 years for women and 14.1 years for men [12]. The previously published results described in this report (Chapter 5 and Appendix G) have provided strong and consistent evidence for an inverse association between socio-economic status and health-adjusted life expectancy.

This first report by the Public Health Agency of Canada on health-adjusted life expectancy in Canada has provided policy-relevant information on differences among Canadians in health-adjusted life expectancy based on their chronic disease status and socio-economic status, as well as recommendations from an external consultant for future research at the national level. The use of data sources available on an ongoing basis and the documentation of the methods used could allow an evaluation of the trends of these indicators in future.

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APPENDICES

APPENDIX A

Prevalence-Based and Incidence-Based Methods of Calculation

The various methods of calculating health-adjusted life expectancy can be divided into 2 main categories: prevalence-based and incidence-based methods. These methods are different calculations that measure different outcomes [1]. Incidence- and prevalence-based health expectancy indicators are each calculated using different types of life tables.

Incidence-based indicators use a multi-state life table and cohort data on transition probabilities between states. The states to be distinguished must at least include "healthy," "diseased" and "dead," and the respective transition probabilities are "incidence," "remission" and "case fatality." True transition probabilities are estimated from longitudinal data derived from a cohort followed over time. This method is used in the chronic disease model developed in the Netherlands. It describes the life course of cohorts in terms of transitions between risk factor classes and changes between disease states over time [2]. The World Health Organization proposes to use a simplified approach that can be implemented using currently available cross-sectional data on the prevalence of each health state [3].

Prevalence-based health expectancy indicators start out from a period life table, which has only two states: "alive" and "dead." Years in an "alive" state are then divided into healthy and diseased years using the observed prevalence of the diseased state. This prevalence-based method is also known as the Sullivan method, in deference to Sullivan's pioneering work on the subject published in 1971 [4]. According to a modification of this method, the "life-years lived" (in each state [5, 6], or the average in all states [7]) are adjusted by the health-related quality of life measure.

Prevalence-based methods cannot account for sudden changes in disability transition rates, but they provide a good estimate of the true multi-state value if there are smooth and relatively regular changes in disability prevalence over a longer time [5, 8].

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APPENDIX B

Supplement to Methods for Calculating Health-Adjusted Life Expectancy by Chronic Disease Status

DATA SOURCES

Mortality and population data can be obtained from administrative vital statistics and census data sources, as well as from disease registries. To calculate health-adjusted life expectancy for Canadians with and without diabetes and/or hypertension, the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy used mortality and population data from the Canadian Chronic Disease Surveillance System and health utility index data from the Canadian Community Health Survey. To calculate health-adjusted life expectancy for Canadians with and without cancer, the Technical Team used mortality data from the Canadian Cancer Registry (from the ORIUS database), population data from Statistics Canada and health utility index data from the Canadian Community Health Survey.

CANADIAN COMMUNITY HEALTH SURVEY

TABLE B-1. Health Utility Index Mark 3 Availability by Province and Territory

CANADIAN COMMUNITY HEALTH SURVEY CYCLE	PROVINCE/TERRITORY WITH HEALTH UTILITY INDEX DATA AVAILABLE
Cycle 1.1 2000/2001 share file	Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia and Yukon
Cycle 2.1 2003 subsample 1 file	Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories and Nunavut
Cycle 3.1 2005 subsample 1 file	Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories and Nunavut

SHARE FILE

A share file is composed of a subset of survey respondents who agreed to share their survey responses with Health Canada. They answered YES to the following question:

Statistics Canada would like your permission to share the information collected in this survey with provincial and territorial ministries of health [, Health Canada and the Public Health Agency of Canada / and Health Canada]. Your provincial ministry of health may make some of this information available to your local health region, but names, addresses, telephone numbers and health numbers will not be provided. All information will be kept confidential and used only for statistical purposes.

Do you agree to share the information provided?

SUBSAMPLE 1 FILE

Subsample files [1] are questionnaire modules that were asked of only a subset of residents from the share file. The aim was to permit calculation of provincial and national estimates and increase survey participation, while minimizing response burden. Subsample 1 included the health utility index variable.

HEALTH UTILITY INDEX MARK 3

The Health Utility Index Mark 3 is a multi-attribute utility measure that defines health states according to 8 attributes (vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain), with 5 or 6 levels of functioning for each [2]. Overall scores on the index range from -0.36 (the worst possible health state) through 0.0 (dead) to 1.0 (perfect health). Some health states are considered worse than dead and consequently are assigned negative scores. Single attribute utility scores range from 0.0 (lowest level of functioning) to 1.0 (full functional capacity). Differences of 0.03 or more in overall scores and of 0.05 or more in single attribute utility scores are considered to be clinically important.

CANADIAN CANCER REGISTRY

The Canadian Cancer Registry is built from administrative data collected in each province and territory. Each provincial and territorial cancer registry supplies data on cancer patients and tumours in a standard, pre-edited format, in a machine-readable form. Each year, new cancer tumour records are loaded on this patient-oriented database that is housed and maintained at Statistics Canada. Subsequent changes to registrations due to errors or omissions are also transmitted to Statistics Canada, as the information becomes available.

CALCULATING LIFE EXPECTANCY IN THE CANCER ANALYSIS

Steps used to calculate cancer-deleted life expectancy:

1. The all-cause mortality rates for people with cancer and for people with all causes of death, for the 2002–2005 period, were used in the analysis;

2. The deaths from all causes for people with cancer were subtracted from those for all people and all causes of death. (Refer to the formula below);

3. The age-specific mortality rates were calculated based on 4 years of death data; and

4. Life expectancy was calculated by sex and age group.

Formula to calculate age-specific mortality rates (needed to estimate cancer-deleted life expectancy and cancer-deleted health-adjusted life expectancy):

$$R_i = \frac{D_{ai} - D_{ci}}{P_{ai}}$$

Where:

- R_i is the age-specific mortality rate;
- D_{ai} is the number of deaths from all causes in age group i in the Canadian population;
- D_{ci} is the number of deaths from all causes in age group i among people with cancer; and
- P_{ai} is the Canadian population in age group i.

References for Appendix B

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APPENDIX C

Supplement to Chapter 3 Results

FIGURE C-1. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) by Sex and Age, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
■ LE, Females	83.6	83.0	79.1	74.1	69.2	64.3	59.4	54.4	49.6	44.7	39.9	35.2	30.6	26.1	21.9	17.9	14.2	11.0	8.2
■ LE, Males	78.9	78.3	74.4	69.4	64.5	59.6	54.9	50.1	45.3	40.5	35.8	31.2	26.8	22.5	18.5	14.9	11.6	8.8	6.4
■ HALE, Females	72.1	71.4	67.5	62.5	58.0	53.6	49.2	44.7	40.4	35.9	31.7	27.6	23.6	19.8	16.2	12.7	9.6	7.0	4.8
■ HALE, Males	69.6	69.0	65.1	60.2	55.7	51.3	47.0	42.6	38.2	33.8	29.6	25.5	21.6	17.9	14.5	11.3	8.3	5.9	4.1

Age
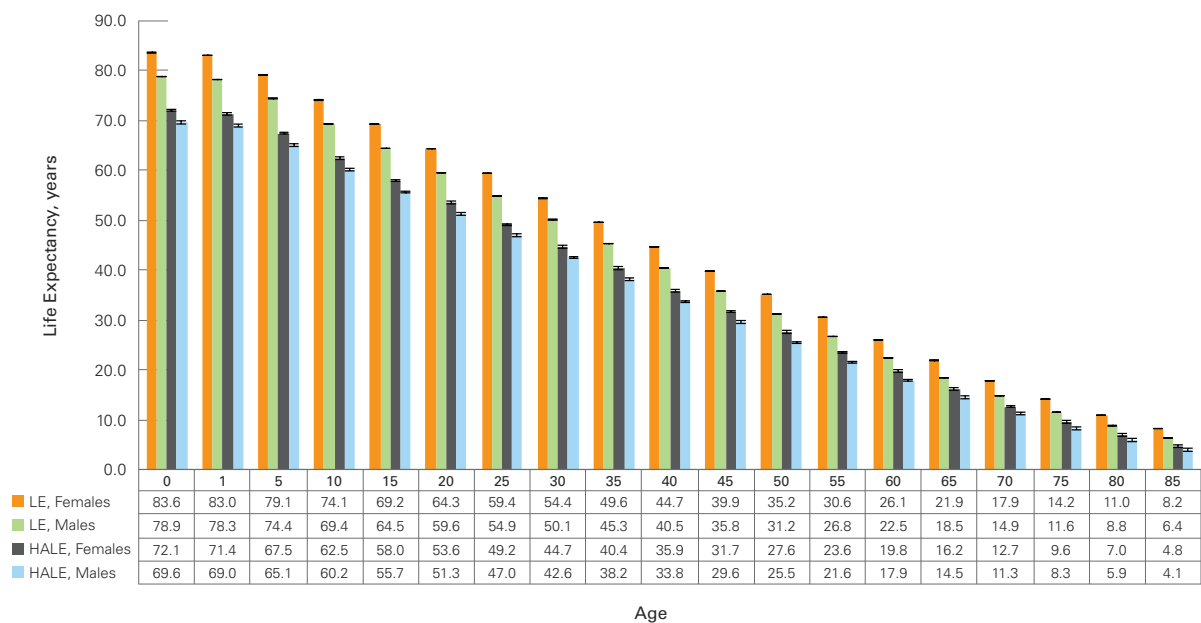
(1) Age groups used in the analysis represent: 0-1, 1-4, 5-9, ..., 80-84, 85+ years. The label in the figure shows only the first year of the age group interval, because the life expectancy and HALE were calculated for the beginning of the age interval.

(2) The 95% confidence interval (shown as error bars at the top of each bar) shows an estimated range of values which is likely to include the true value 19 times out of 20.

Sources: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

MEAN HEALTH UTILITY INDEX MARK 3 FOR PERSONS WITHOUT DISEASE COMPARED WITH MEAN INDEX BY DISEASE CATEGORY

The mean Health Utility Index Mark 3 for persons without disease was about the same for both sexes (Figure C-2). The mean index for each disease category varied slightly from the mean index for both females and males without disease, for each of the diseases (Figure C-3). This variation was caused by the smaller sample size population for the mean Health Utility Index Mark 3 for each disease category.

FIGURE C-2. Mean Health Utility Index Mark 3 for Persons Without Disease, Canada (Less Quebec, Nunavut and Northwest Territories), 2001 to 2005

	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
■ F, w/o DM	0.999	0.999	0.999	0.909	0.895	0.896	0.912	0.893	0.905	0.890	0.866	0.856	0.851	0.846	0.845	0.825	0.760	0.711	0.584
▲ M, w/o DM	0.999	0.999	0.999	0.904	0.896	0.902	0.917	0.915	0.910	0.897	0.894	0.872	0.869	0.862	0.859	0.843	0.790	0.739	0.639
◆ F, w/o HYP	0.999	0.999	0.999	0.909	0.896	0.897	0.912	0.895	0.908	0.895	0.870	0.866	0.861	0.846	0.851	0.830	0.768	0.707	0.607
■ M, w/o HYP	0.999	0.999	0.999	0.905	0.896	0.904	0.918	0.916	0.913	0.899	0.894	0.874	0.876	0.862	0.866	0.851	0.802	0.741	0.639
✕ F, free of DM+HYP	0.999	0.999	0.999	0.909	0.896	0.897	0.912	0.896	0.908	0.896	0.870	0.868	0.863	0.848	0.855	0.837	0.770	0.714	0.601
● M, free of DM+HYP	0.999	0.999	0.999	0.905	0.896	0.904	0.918	0.917	0.913	0.899	0.896	0.876	0.880	0.869	0.872	0.850	0.802	0.755	0.636

Age

SOURCE: Canadian Community Health Survey data files, Statistics Canada, 2000–2005

DM = diabetes mellitus; F = females; HYP = hypertension; M = males; w/o = without

FIGURE C-3. Mean Health Utility Index Mark 3 by Disease Status, Canada (Less Quebec, Nunavut and Northwest Territories), 2001 to 2005

	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
■ F, with DM	0.999	0.999	0.999	0.823	0.939	0.937	0.890	0.777	0.886	0.773	0.812	0.760	0.793	0.746	0.778	0.710	0.713	0.650	0.615
▲ M, with DM	0.999	0.999	0.999	0.895	0.752	0.948	0.882	0.865	0.868	0.852	0.812	0.786	0.795	0.778	0.788	0.817	0.777	0.615	0.541
◆ F, with HYP	0.999	0.999	0.999	0.909	0.856	0.812	0.893	0.772	0.839	0.785	0.822	0.790	0.805	0.819	0.816	0.791	0.740	0.703	0.572
■ M, with HYP	0.999	0.999	0.999	0.905	0.801	0.812	0.882	0.885	0.851	0.866	0.869	0.842	0.817	0.830	0.816	0.818	0.767	0.696	0.610
✕ F, with DM+HYP	0.999	0.999	0.999	0.909	0.896	0.896	0.833	0.745	0.860	0.549	0.769	0.726	0.771	0.728	0.771	0.703	0.698	0.676	0.587
● M, with DM+HYP	0.999	0.999	0.999	0.904	0.895	0.902	0.917	0.975	0.838	0.719	0.766	0.751	0.772	0.764	0.750	0.780	0.755	0.593	0.641

Age

SOURCE: Canadian Community Health Survey data files, Statistics Canada, 2000–2005

DM = diabetes mellitus; F = females; HYP = hypertension; M = males

LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY FOR PERSONS WITH DIABETES, BY SEX

LIFE EXPECTANCY

Life expectancy for females without diabetes and for those with diabetes was greater than the corresponding life expectancy for males. These differences were statistically significant for all ages.

HEALTH-ADJUSTED LIFE EXPECTANCY

Health-adjusted life expectancy for females without diabetes and for those with diabetes was greater than that for males. These differences were statistically significant ($p < 0.0001$) among females and males without diabetes for all ages. For females and males with diabetes, these differences were statistically significant ($p < 0.05$) for those aged 35 years and over.

LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY FOR PERSONS WITH HYPERTENSION, BY SEX

Life expectancy and health-adjusted life expectancy for females without and with hypertension were greater than the life expectancy and the health-adjusted life expectancy for the corresponding males. These differences were statistically significant ($p < 0.05$) for all ages.

LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY FOR PERSONS WITH DIABETES AND HYPERTENSION, BY SEX

LIFE EXPECTANCY

Life expectancy for females with diabetes and hypertension was greater than that for their male counterparts. These differences were statistically significant for all ages.

HEALTH-ADJUSTED LIFE EXPECTANCY

Health-adjusted life expectancy for females with diabetes and hypertension was greater than that for the corresponding males. These differences were statistically significant ($p < 0.001$) for persons aged 45 to 84 years.

FIGURE C-4. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males Without Diabetes, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006
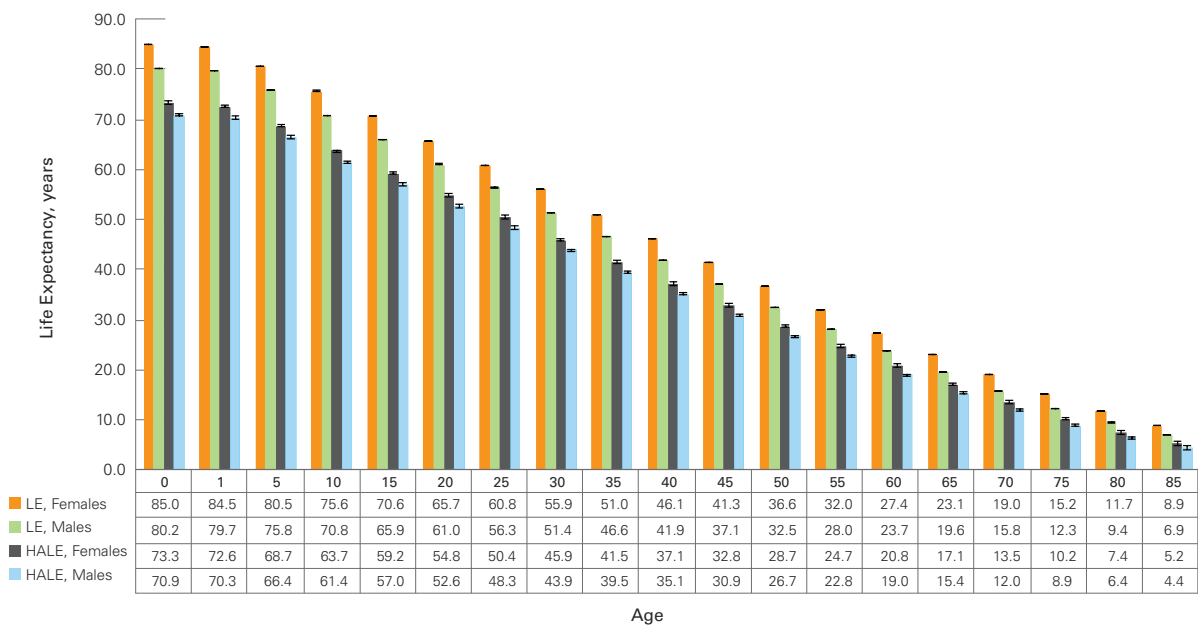
	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
LE, Females	85.0	84.5	80.5	75.6	70.6	65.7	60.8	55.9	51.0	46.1	41.3	36.6	32.0	27.4	23.1	19.0	15.2	11.7	8.9
LE, Males	80.2	79.7	75.8	70.8	65.9	61.0	56.3	51.4	46.6	41.9	37.1	32.5	28.0	23.7	19.6	15.8	12.3	9.4	6.9
HALE, Females	73.3	72.6	68.7	63.7	59.2	54.8	50.4	45.9	41.5	37.1	32.8	28.7	24.7	20.8	17.1	13.5	10.2	7.4	5.2
HALE, Males	70.9	70.3	66.4	61.4	57.0	52.6	48.3	43.9	39.5	35.1	30.9	26.7	22.8	19.0	15.4	12.0	8.9	6.4	4.4

Age

FIGURE C-5. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males With Diabetes, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

Age	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
LE, Females	74.9	74.3	70.5	65.5	60.9	56.5	52.3	47.7	43.2	38.7	34.4	30.1	26.0	22.0	18.4	14.9	11.8	9.1	7.0
LE, Males	70.9	70.3	66.5	61.5	56.8	52.2	47.9	43.8	39.5	35.3	31.0	26.9	23.0	19.3	15.9	12.7	9.8	7.5	5.6
HALE, Females	62.2	61.6	57.7	52.8	48.9	44.7	40.6	36.5	33.0	29.0	25.6	22.1	18.9	15.7	12.9	10.1	7.8	5.8	4.3
HALE, Males	60.1	59.5	55.6	50.6	46.4	43.0	38.8	35.1	31.4	27.6	24.0	20.6	17.5	14.5	11.8	9.2	6.6	4.3	3.0

Age
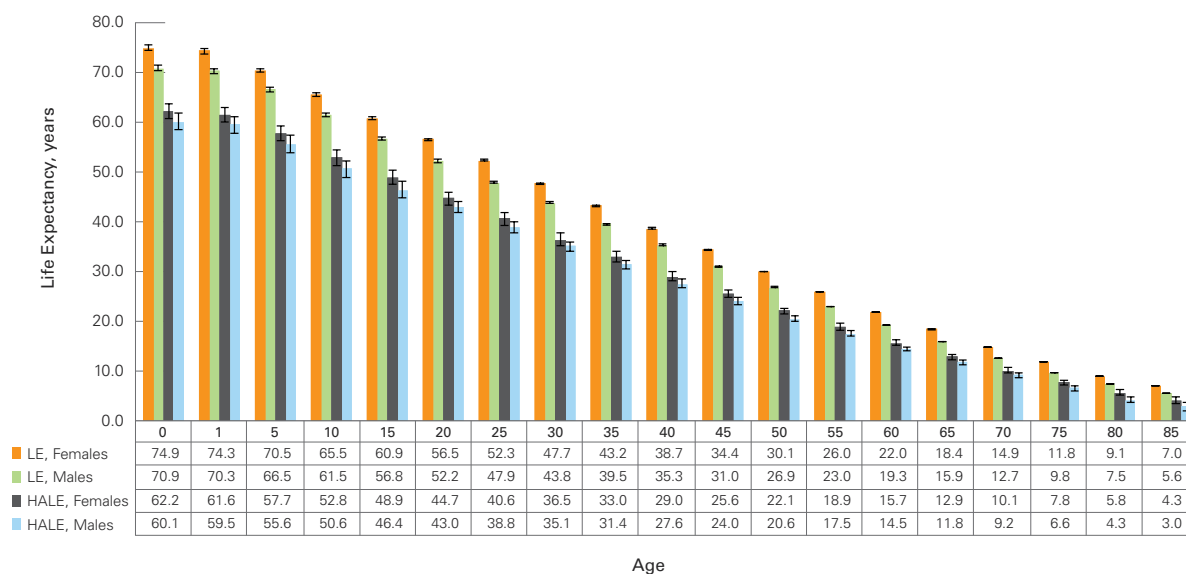
SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

OVERALL LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY FOR PERSONS WITHOUT AND WITH HYPERTENSION COMPARED WITH THAT FOR PERSONS WITHOUT AND WITH DIABETES AND HYPERTENSION

Among all of the disease status categories, life expectancy and health-adjusted life expectancy were longest for persons without diabetes and hypertension (Figure C-6) and shortest for persons with both diabetes and hypertension (Figure C-9).

FIGURE C-6. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males Without Diabetes and Hypertension, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

Age	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
LE, Females	85.5	84.9	81.0	76.0	71.1	66.1	61.2	56.3	51.4	46.5	41.7	37.0	32.3	27.8	23.4	19.3	15.4	11.9	9.0
LE, Males	81.0	80.5	76.5	71.6	66.6	61.8	57.0	52.2	47.4	42.6	37.9	33.2	28.7	24.4	20.2	16.4	12.9	9.8	7.3
HALE, Females	74.0	73.4	69.4	64.5	60.0	55.6	51.1	46.7	42.3	37.8	33.5	29.3	25.3	21.3	17.6	13.9	10.5	7.7	5.4
HALE, Males	71.8	71.2	67.3	62.3	57.8	53.5	49.2	44.8	40.3	36.0	31.7	27.5	23.5	19.6	16.0	12.5	9.4	6.8	4.6

Age

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

FIGURE C-7. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males Without Hypertension, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006
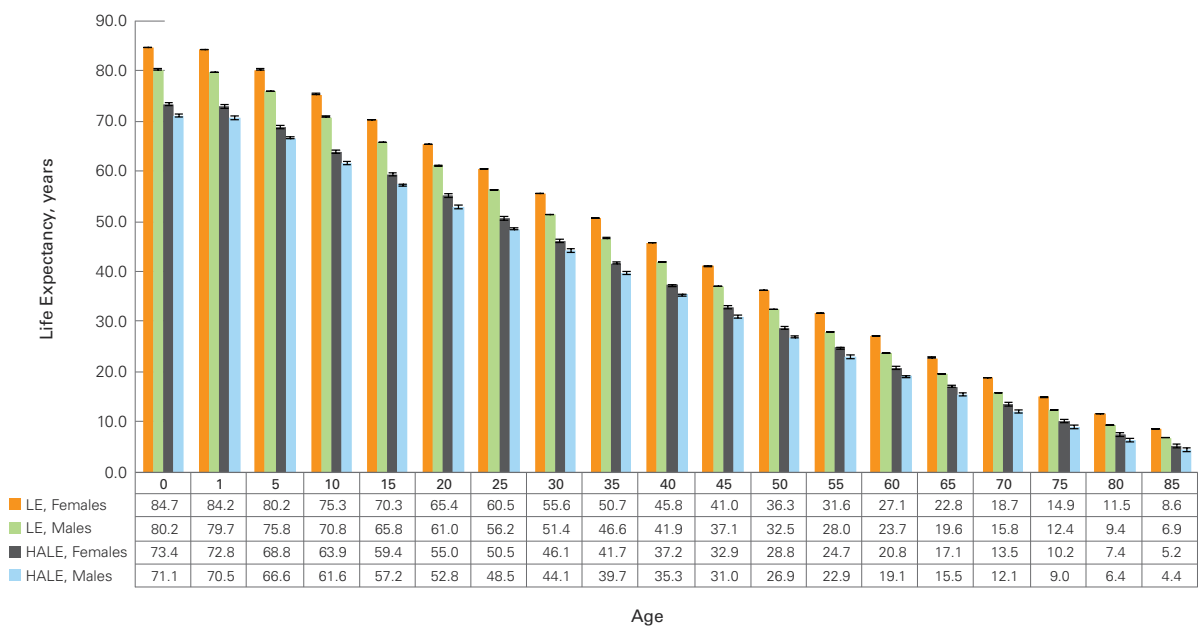
Age	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
LE, Females	84.7	84.2	80.2	75.3	70.3	65.4	60.5	55.6	50.7	45.8	41.0	36.3	31.6	27.1	22.8	18.7	14.9	11.5	8.6
LE, Males	80.2	79.7	75.8	70.8	65.8	61.0	56.2	51.4	46.6	41.9	37.1	32.5	28.0	23.7	19.6	15.8	12.4	9.4	6.9
HALE, Females	73.4	72.8	68.8	63.9	59.4	55.0	50.5	46.1	41.7	37.2	32.9	28.8	24.7	20.8	17.1	13.5	10.2	7.4	5.2
HALE, Males	71.1	70.5	66.6	61.6	57.2	52.8	48.5	44.1	39.7	35.3	31.0	26.9	22.9	19.1	15.5	12.1	9.0	6.4	4.4

Age

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

FIGURE C-8. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males With Hypertension, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
LE, Females	81.5	80.9	77.0	72.0	67.0	62.1	57.7	53.0	48.3	43.7	39.1	34.5	30.1	25.8	21.7	17.8	14.3	11.1	8.5
LE, Males	76.2	75.6	71.7	66.7	61.8	56.9	52.5	48.0	43.4	38.8	34.4	30.0	25.9	21.8	18.0	14.5	11.4	8.7	6.5
HALE, Females	67.2	66.6	62.6	57.6	53.1	48.9	45.3	41.1	37.4	33.5	29.9	26.2	22.7	19.1	15.7	12.4	9.4	6.9	4.9
HALE, Males	65.0	64.3	60.4	55.4	50.9	47.1	43.5	39.5	35.4	31.5	27.6	23.8	20.2	16.9	13.7	10.7	7.9	5.6	4.0

Age

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

FIGURE C-9. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males With Diabetes and Hypertension, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

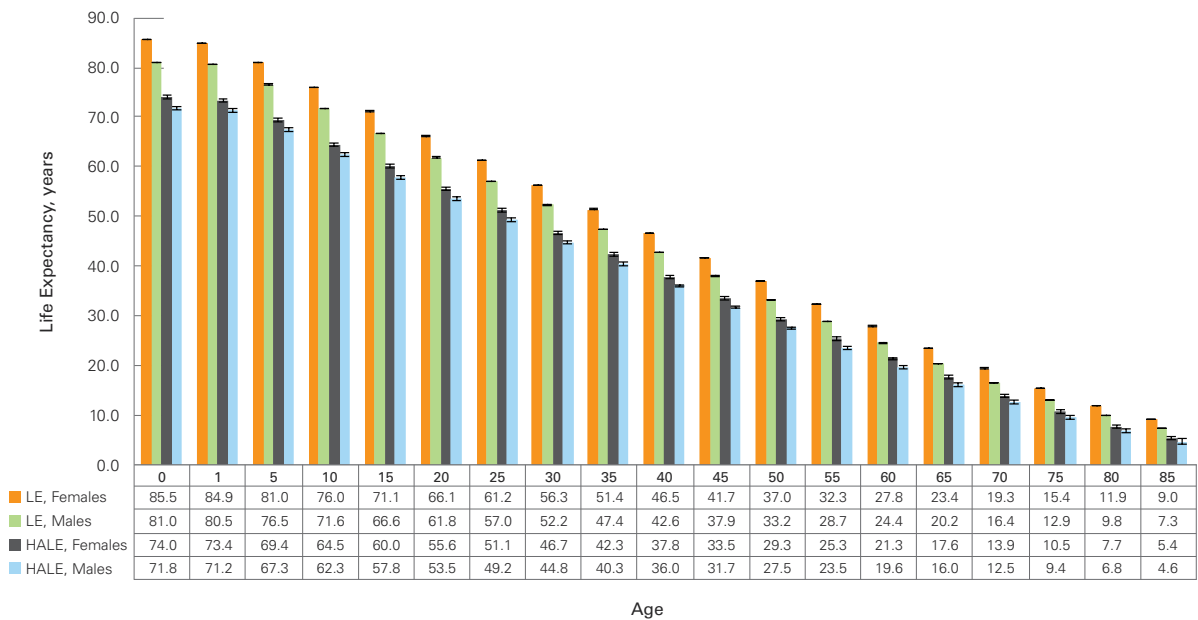|	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
LE, Females	72.2	71.5	67.6	62.6	57.6	52.7	49.6	45.9	42.0	37.9	33.8	29.7	25.7	21.9	18.3	14.9	11.9	9.2	7.1
LE, Males	65.9	65.2	61.3	56.3	51.4	46.5	44.6	41.3	37.5	33.8	29.9	26.0	22.4	18.9	15.6	12.6	9.8	7.5	5.7
HALE, Females	58.1	57.4	53.4	48.5	43.9	39.5	36.4	33.2	30.3	26.6	24.5	21.3	18.4	15.4	12.7	10.0	7.8	5.8	4.2
HALE, Males	56.0	55.3	51.4	46.4	41.9	37.6	35.5	32.3	28.3	25.2	22.4	19.4	16.7	13.9	11.3	9.0	6.6	4.6	3.7

Age

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

DIFFERENCES IN LIFE EXPECTANCY AND HEALTH-ADJUSTED LIFE EXPECTANCY BY SEX

The reported health utility index scores were higher among males with a disease, as compared with female with a disease. This finding is consistent with other studies [1]. Therefore, the differences between life expectancy and health-adjusted life expectancy for females, by disease categories, were smaller than the differences between life expectancy and health-adjusted life expectancy for males (Table C-2). The differences in life expectancy and health-adjusted life expectancy between females and males by disease categories were about the same (Table C-1).

TABLE C-1. Differences in Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) at Birth Between Females (F) and Males (M), Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

DIFFERENCES	WITHOUT DM & HYP	WITHOUT DM	WITHOUT HYP	GENERAL POPULATION	WITH HYP	WITH DM	WITH DM & HYP
LE(F) – LE(M)	4.5	4.8	4.5	4.7	5.3	4.0	6.3
HALE(F) – HALE(M)	2.6	2.4	2.3	2.5	2.2	2.1	2.1

SOURCES: Canadian Community Health Survey (CCHS) data files, Statistics Canada, 2000–2005 combined file, and Canadian Chronic Disease Surveillance System (CCDSS) data files, 2004–2006
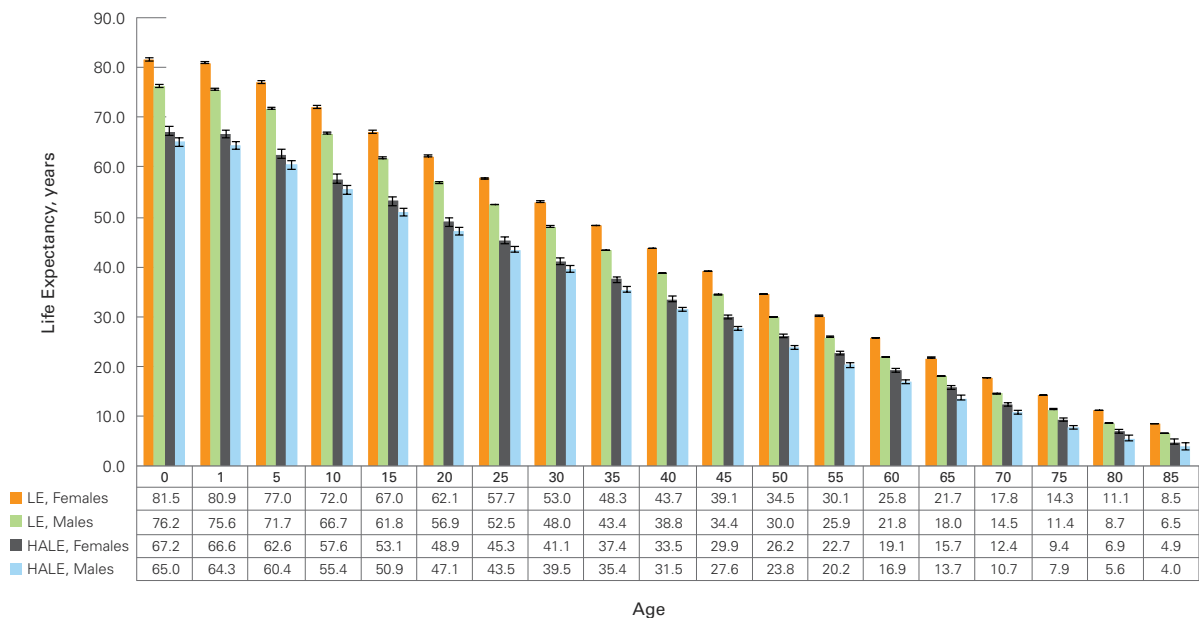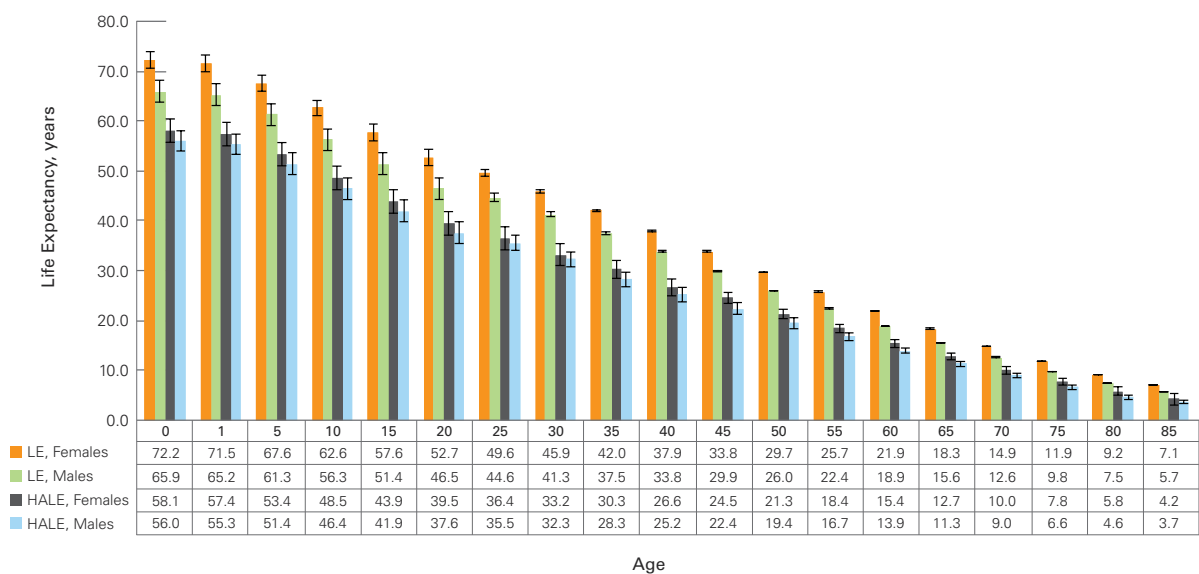
LOSS IN HEALTH-ADJUSTED LIFE EXPECTANCY

The loss in health-adjusted life expectancy (years) for persons with diabetes and/or hypertension (Tables C-2 and C-3) was defined as the difference between the health-adjusted life expectancy for persons without diabetes and/or hypertension and the health-adjusted life expectancy for those with diabetes and/or hypertension. Confidence intervals (95%) for life expectancy and health-adjusted life expectancy were built based on the assumption that these averages were normally distributed. Z-tests were used to test the statistical significance of the loss in health-adjusted life expectancy (years) and the absolute difference in life expectancy.

PROPORTION OF YEARS EXPECTED TO BE UNHEALTHY, BY DISEASE CATEGORY

(Life expectancy – health-adjusted life expectancy) / life expectancy is the proportion of years lived in an unhealthy condition. Table C-2 shows that, when the disease category changed from without diabetes and hypertension to with hypertension, the proportion of unhealthy years increased from 13% to 18% for females and from 11% to 15% for males. Tables C-2 and C-3 together show that, when the disease category changed from without diabetes and hypertension to with diabetes, the proportion of unhealthy years increased from 13% to 17% for females and from 11% to 15% for males.

Females with both diabetes and hypertension spent the highest proportion of years lived in poor health (20%).

TABLE C-2. Life Expectancy (LE), Health-Adjusted Life Expectancy (HALE), Loss in HALE, and Absolute (LE – HALE) and Relative ((LE – HALE) / LE) Measures for Females and Males Free of Both Diabetes (DM) and Hypertension (HYP) and Those Without and With Hypertension, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

MEASURE	FEMALES (95% CONFIDENCE INTERVAL)[1]				MALES (95% CONFIDENCE INTERVAL)[1]			
	WITHOUT DM AND HYP	WITHOUT HYP	WITH HYP	LOSS IN HALE	WITHOUT DM AND HYP	WITHOUT HYP	WITH HYP	LOSS IN HALE
LE at birth, years	**85.5** (85.4–85.6)	**84.7** (84.7–84.8)	**81.5** (81.3–81.8)		**81.0** (80.9–81.1)	**80.2** (80.2–80.3)	**76.2** (75.9–76.4)	
HALE at birth, years	**74.0** (73.6–74.4)	**73.4** (73.1–73.8)	**67.2** (66.4–68.1)	**6.2***(5.3–7.1)	**71.8** (71.4–72.2)	**71.1** (70.8–71.4)	**65.0** (64.1–65.8)	**6.1*** (5.2–7.0)
LE – HALE, years	**11.5*** (11.1–11.9)	**11.3*** (10.9–11.7)	**14.3*** (13.4–15.2)		**9.2*** (8.8–9.6)	**9.1*** (8.8–9.4)	**11.2*** (10.3–12.1)	
(LE – HALE) / LE	**0.13**	**0.13**	**0.18**		**0.11**	**0.11**	**0.15**	

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005 combined file, and Canadian Chronic Disease Surveillance System data files, 2004–2006

1 The 95% confidence interval shows an estimated range of values that is likely to include the true prevalence rate 19 times out of 20.

* Statistically significant (p < 0.0001)

TABLE C-3. Life Expectancy, Health-Adjusted Life Expectancy, Loss in HALE, and Absolute (LE – HALE) and Relative ((LE – HALE) / LE) Measures for Females and Males Without and With Diabetes (DM) and Among Those With DM and Hypertension (HYP), Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

MEASURE	FEMALES (95% CONFIDENCE INTERVAL)				MALES (95% CONFIDENCE INTERVAL)			
	WITHOUT DM	WITH DM	WITH BOTH DM AND HYP	LOSS IN HALE	WITHOUT DM	WITH DM	WITH BOTH DM AND HYP	LOSS IN HALE
LE at birth, years	**85.0** (85.0–85.1)	**74.9** (74.3–75.6)	**72.2** (70.5–73.8)		**80.2** (80.2–80.3)	**70.9** (70.4–71.4)	**65.9** (63.6–68.1)	
HALE at birth, years	**73.3** (72.9–73.6)	**62.2** (60.7–63.8)	**58.1** (55.7–60.5)	**11.1*** (9.5–12.7)	**70.9** (70.6–71.2)	**60.1** (58.4–61.8)	**56.0** (53.9–58.2)	**10.8*** (9.1–12.5)
LE – HALE, years	**11.7*** (11.4–12.0)	**12.7*** (11.0–14.4)	**14.1*** (11.2–17.0)		**9.3** (9.0– 9.6)	**10.8*** (9.0–12.6)	**9.9*** (6.8–13.0)	
(LE – HALE) / LE	**0.14**	**0.17**	**0.20**		**0.12**	**0.15**	**0.15**	

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005 combined file, and Canadian Chronic Disease Surveillance System data files, 2004–2006

* Statistically significant (p < 0.0001)

TABLE C-4. Life Expectancy (LE), Health-Adjusted Life Expectancy (HALE), and Losses of LE and of HALE (With 95% Confidence Intervals), at Selected Ages,[1] by Disease Status and Sex, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

HEALTH EXPECTANCY MEASURE	CANADIAN POPULATION (I)	WITHOUT DM&HYP (II)	WITHOUT DM (III)	WITHOUT HYP (IV)	WITH DM (V)	WITH HYP (VI)	WITH DM&HYP (VII)	LOSS OF HEALTH EXPECTANCY WITH		
								DM (III–V)	HYP (IV–VI)	DM&HYP (II–VII)
Females						At birth				
LE	83.6(83.6-83.7)	85.5(85.4-85.6)	85.0(85.0-85.1)	84.7(84.7-84.8)	74.9(74.3-75.6)	81.5(81.3-81.8)	72.2(70.5-73.8)	10.1*	3.2*	13.3*
HALE	72.1(71.8-72.3)	74.0(73.7-74.3)	73.3(73.0-73.5)	73.4(73.1-73.7)	62.2(60.7-63.8)	67.2(66.4-68.1)	58.1(55.5-60.7)	11.1*	6.2*	15.9*
Males										
LE	78.9(78.8-78.9)	81.0(80.9-81.1)	80.2(80.2-80.3)	80.2(80.2-80.3)	70.9(70.4-71.4)	76.2(76.0-76.4)	65.9(63.6-68.1)	9.3*	4.0*	15.1*
HALE	69.6(69.4-69.9)	71.8(71.5-72.1)	70.9(70.7-71.2)	71.1(70.9-71.4)	60.1(58.4-61.9)	65.0(64.1-65.8)	56.0(53.4-58.6)	10.8*	6.1*	15.8*
Females						At age 20 years				
LE	64.3(64.2-64.3)	66.1(66.1-66.2)	65.7(65.7-65.7)	65.4(65.3-65.4)	56.5(56.2-56.8)	62.1(61.9-62.4)	52.7(51.1-54.4)	9.2*	3.3*	13.4*
HALE	53.6(53.3-53.9)	55.6(55.1-55.9)	54.8(54.5-55.1)	55.0(54.6-55.3)	44.7(43.4-46.1)	48.9(48.1-49.7)	39.5(37.1-41.9)	10.1*	6.1*	16.1*
Males										
LE	59.6(59.6-59.7)	61.8(61.7-61.8)	61.0(61.0-61.1)	61.0(61.0-61.0)	52.2(51.9-52.5)	56.9(56.7-57.2)	46.5(44.3-48.7)	8.8*	4.1*	15.3*
HALE	51.3(51.1-51.6)	53.5(53.1-53.9)	52.6(52.3-52.9)	52.8(52.5-53.1)	43.0(41.9-44.1)	47.1(46.3-47.8)	37.6(35.4-39.7)	9.6*	5.7*	15.9*
Females						At age 55 years				
LE	30.6(30.6-30.6)	32.3(32.3-32.4)	32.0(31.9-32.0)	31.6(31.6-31.7)	26.0(25.9-26.1)	30.1(30.1-30.2)	25.7(25.6-25.8)	6.0*	1.5*	6.6*
HALE	23.6(23.4-23.9)	25.3(24.9-25.6)	24.7(24.4-25.0)	24.7(24.4-25.1)	18.9(18.3-19.6)	22.7(22.3-23.0)	18.4(17.6-19.3)	5.8*	2.0*	6.9*
Males										
LE	26.8(26.7-26.8)	28.7(28.7-28.8)	28.0(28.0-28.1)	28.0(28.0-28.1)	23.0(23.0-23.1)	25.9(25.8-25.9)	22.4(22.3-22.5)	5.0*	2.1*	6.3*
HALE	21.6(21.4-21.8)	23.5(23.2-23.9)	22.8(22.5-23.1)	22.9(22.6-23.2)	17.5(17.0-18.1)	20.2(19.8-20.6)	16.7(15.9-17.4)	5.3*	2.7*	6.8*

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

DM = diabetes mellitus; HYP = hypertension

1 **At birth** was selected for comparability with other research on health-adjusted life expectancy. **At age 20 years** was selected for diabetes because it represents primarily type 2 diabetes and for hypertension because adult hypertension was studied. **At age 55 years** was selected because 55 is the 2006 mean age of the surveillance system incident cases for both diabetes and hypertension.

* Statistically significant (p < 0.0001)

TABLE C-5. Differences in Health-Adjusted Life Expectancy (HALE) at Birth Between Pairs of Disease Categories Among Females and Males Who Were Free of Both Diabetes (DM) and Hypertension (HYP) or Those With DM and HYP, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

	FEMALES (95% CI)	MALES (95% CI)
HALE (free of both DM and HYP) – HALE (with HYP)	**6.8***(5.9–7.7)	**6.8***(5.9–7.7)
HALE (free of both DM and HYP) – HALE (with DM)	**11.8***(10.2–13.4)	**11.7***(9.9–13.5)
HALE (with HYP) – HALE (with HYP and DM)	**9.1***(6.7–11.6)	**9.0***(6.7–11.3)
HALE (with DM) – HALE (with HYP and DM)	**4.1***(1.3–6.9)	**4.1***(1.3–6.9)

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005 combined file, and Canadian Chronic Disease Surveillance System data files, 2004–2006

* Statistically significant (p < 0.0001)

References for Appendix C

1. Manuel DG, Schultz SE. Health-related quality of life and health-adjusted life expectancy of people with diabetes in Ontario, Canada, 1996–1997. Diabetes Care 2004;27(2):407–414.

APPENDIX D

Recommendations to Enhance the Public Health Agency of Canada Standard Methodology for Calculating Health-Adjusted Life Expectancy by Chronic Disease Status

Doug Manuel, MD, MSc, FRCPC
Senior Scientist, Ottawa Hospital Research Network
CIHR/PHAC Chair in Applied Public Health
Senior Medical Consultant, Statistics Canada
Associate Professor, Family Medicine and Community Medicine and Epidemiology, University of Ottawa
Co-Lead, Population Health Improvement Research Network
External Consultant, Public Health Agency of Canada Steering Committee on Health-Adjusted Life Expectancy

Recommendation 1:
Calculate health-adjusted life expectancy using anonymous individual data that link together health-related quality of life, disease occurrence (incidence and prevalence) and mortality.

Summary measures of population health for diseases and conditions combine together 3 types of data: disease or condition occurrence (disease incidence and/or prevalence), mortality and health-related quality of life data. In Canada, the most robust sources for these types of data are the following:

- *Disease or condition incidence and prevalence data*—disease registries and databases, including the Canadian Chronic Disease Surveillance System, and specifically designed disease registries such as the Canadian Cancer Registry;
- *Mortality data*—death certificates, which are summarized in the Canadian Mortality Database; and
- *Health-related quality of life data*—population health surveys, including the Canadian Community Health Survey and the National Population Health Survey.

Canada is an international leader for developing data systems that directly and anonymously link together, and was also the first country to invent computerized record linkage (the Generalized Iterative Record Linkage System, or GIRLS). As well, respondents of the Canadian Community Health Survey and the National Population Health Survey were asked for permission to link their survey responses to other health data, including those needed to estimate summary measures of population health. However, the current report calculates health-adjusted life expectancy for persons with and without diabetes and/or hypertension using less optimal, unlinked data from these sources: the Canadian Community Health Survey, for measuring disease occurrence (prevalence only); the Canadian Chronic Disease Surveillance System, for mortality data; and the Canadian Community Health Survey, for health-related quality of life data. There are 2 chief concerns. First, the disease occurrences measured in the Canadian Community Health Survey were based on self-responses, which can underestimate disease occurrence as compared with estimates from other sources such as the Canadian Chronic Disease Surveillance System and the Canadian Cancer Registry. Second, the method of indirectly combining disease data likely introduced measurement error because the different disease databases capture different spectrums of disease severity.

There are several options for using linked data for future calculations of health-adjusted life expectancy, including these:

- *Option 1:* Request that the provinces and territories link the Canadian Chronic Disease Surveillance System (CCDSS) data with the Canadian Community Health Survey (CCHS, cycles 1, 2 and 3) data and that they send the new disease status variable and the identification number from the Canadian Community Health Survey to the Public Health Agency of Canada and/or Statistics Canada (see Figures D-1 to D-3).

- *Option 2:* Request that the provinces and territories provide information regarding people with diseases diagnosed within the Canadian Chronic Disease Surveillance System and other disease registries to the Longitudinal Health Administrative Data initiative. Then, within the Longitudinal Health Administrative Data initiative, the disease databases will be linked to the Canadian Community Health Survey.

Recommendation 2:
Develop methods for Canadian surveillance of summary measures of population health.

This Public Health Agency of Canada report represents one of the first national reports to discuss health-adjusted life expectancies for people with chronic diseases. The rationale for the report's methods was described in the report. In particular, the report methods can be:

- regularly updated to provide information on whether Canadians' health is improving. The objective led to use of the Health Utility Index Mark 3 (HUI3), reported in the Canadian Community Health Survey—an observed measure of health-related quality of life—as opposed to the assigned disability weights used in other reports such as those by the World Health Organization.

- reported for subpopulations with important diseases or conditions, different socio-economic groups and subpopulations with various health behaviours. Again, the data used in the report facilitate this objective; in particular, the Canadian Community Health Survey collects information on different socio-economic indicators as well as exposure to different health behaviours, such as smoking. Linked data provide additional information to report summary measures of population health for specific groups.

Furthermore, summary measures of population health should be integrated into the wider context of the Public Health Agency of Canada's surveillance program. Preferably, the method and supporting data used to calculate health-adjusted life expectancy or other summary measures of population health can also estimate:

- the burden of a wide range of diseases, including mental health disorders and acute and infectious diseases;

- summary measures for important subpopulations, including provinces and health regions, males and females, socio-economic groups, immigrant groups, and Aboriginal people;

- the projected or future burden of disease; and

- the potential contribution of different risk factors or preventive strategies for the current or future burden of disease.

  – Risk factors include behavioural risk factors, such as smoking, obesity, eating unhealthy food, physical inactivity, having unsafe sex, injection drug use and consuming alcohol and drugs, as well as unhealthy social conditions and physical environments, such as neighbourhood environments that are unsafe, lack social cohesion or support, and/or make it difficult to be physically active or have a healthy diet.

  – Preventive strategies include strategies to ameliorate risks, such as social policy and legislation, community-wide interventions for smoking prevention, changes to municipal planning, preventive screening (e.g., Pap smears or colorectal screening), and individual preventive therapy (e.g., treatment of hypertension).

Options:

1. The Public Health Agency of Canada should elicit feedback on the report's content and methods;

2. Based on policy and scientific feedback, the Public Health Agency of Canada should further develop options and methods for future reporting; and

3. The Agency should consider developing and supporting the development of summary measures of population health, in particular approaches that build on the strengths of Canada's data systems.

FIGURE D-1. Data Linkage at the Provincial and Territorial Level—Enhanced Methodology
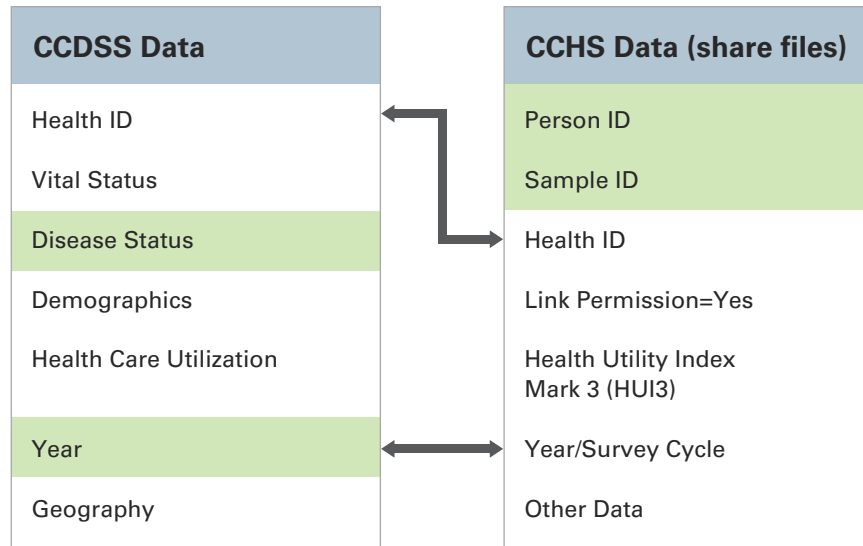
Legend:
CCDSS: Canadian Chronic Disease Surveillance System
CCHS: Canadian Community Health Survey

FIGURE D-2. Record Linkage at the Public Health Agency of Canada—Enhanced Methodology
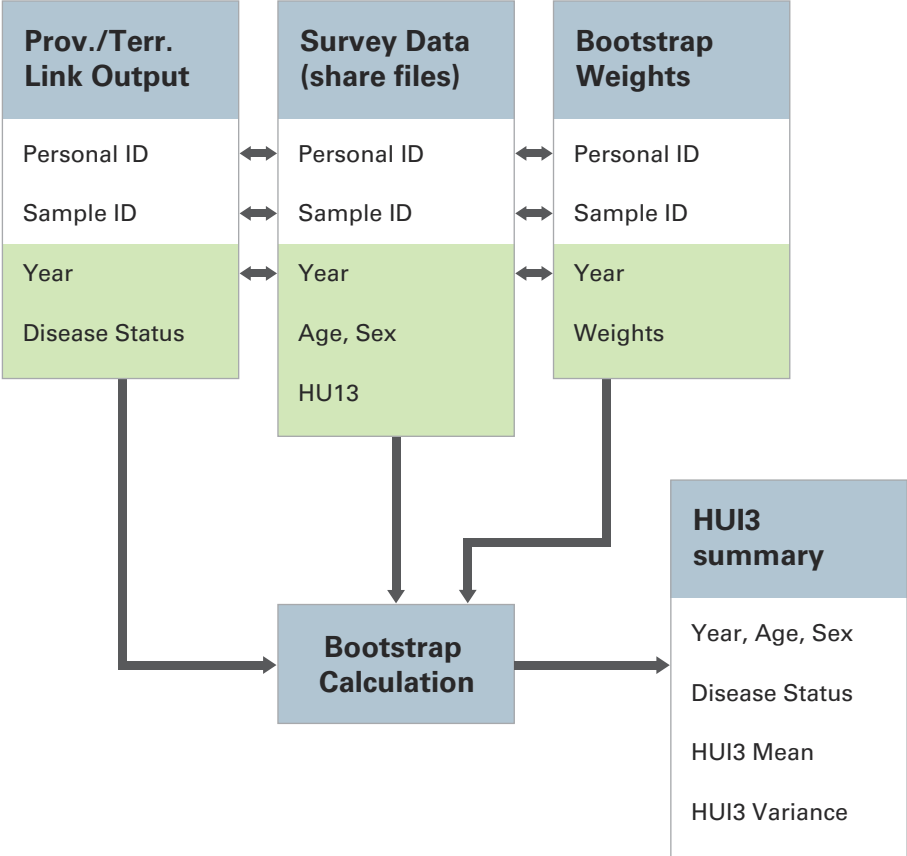
FIGURE D-3. Public Health Agency of Canada Calculation of Health-Adjusted Life Expectancy—Enhanced Methodology

HUI3 Summary	P/T Mortality
Year, Age, Sex	Year, Age, Sex
Disease Status	Disease Status
HUI3 Mean	Deaths
HUI3 Variance	Population

Life Table Calculation

Health-Adjusted Life Expectancy
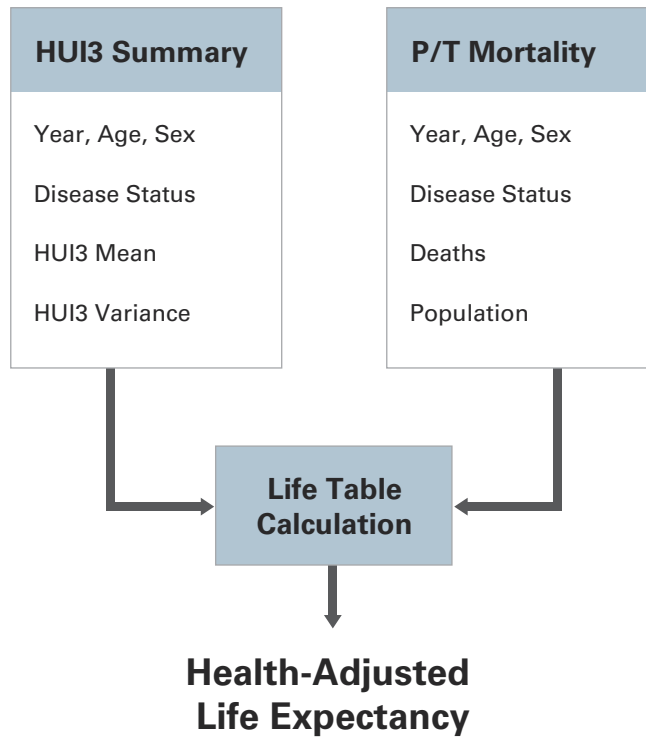
APPENDIX E

Supplement to Chapter 4 Results

FIGURE E-1. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males With or Without Cancer and for the Canadian Population, Canada (Less Quebec), 2002 to 2005
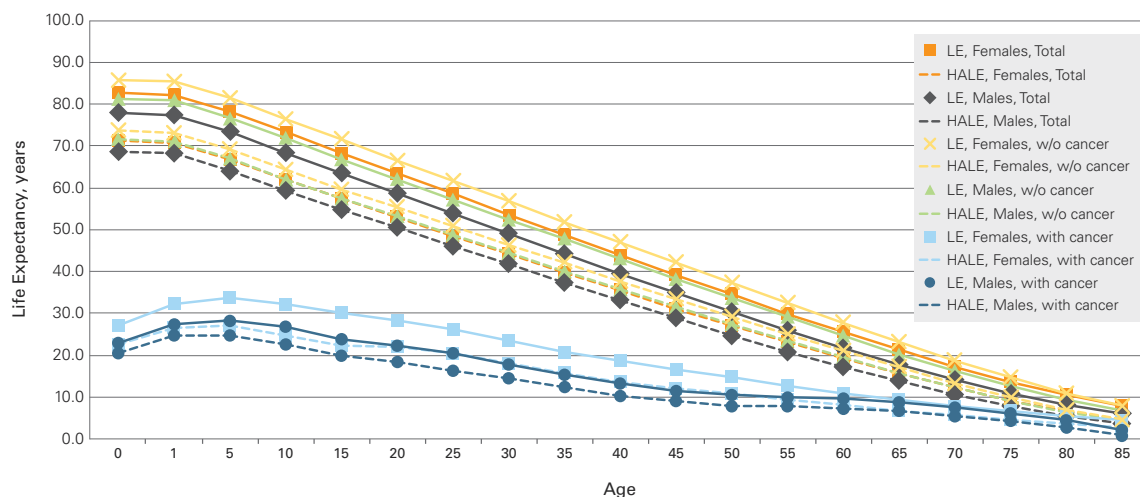
SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Cancer Registry and Canadian Vital Statistics Death databases, Statistics Canada, 2002–2005

MEAN HEALTH UTILITY INDEX MARK 3 BY DISEASE CATEGORY

FIGURE E-2. Mean Health Utility Index by Disease Category, Canada (Less Quebec), 2000 to 2005
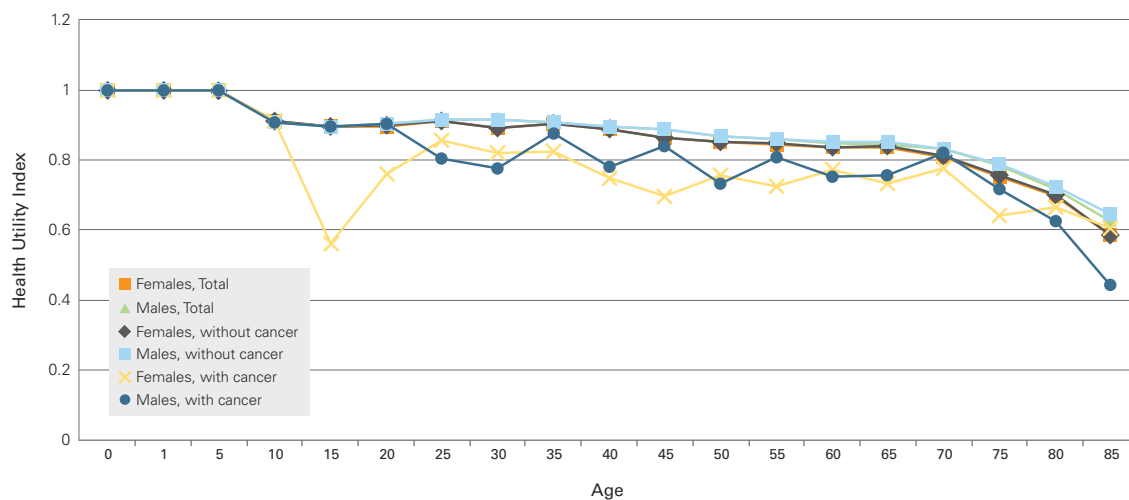
SOURCE: Canadian Community Health Survey data files, Statistics Canada, 2000–2005

FIGURE E-3. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females in the Canadian Population and for Those Without or With Cancer, Canada (Less Quebec), 2002 to 2005

	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
■ LE-Total	82.8	82.2	78.3	73.3	68.4	63.5	58.6	53.7	48.8	43.9	39.2	34.5	29.9	25.5	21.3	17.3	13.7	10.5	7.9
■ HALE-Total	71.4	70.8	66.9	61.9	57.4	53.0	48.6	44.1	39.7	35.4	31.1	27.0	23.1	19.3	15.7	12.3	9.2	6.6	4.6
■ LE, without cancer	85.9	85.4	81.4	76.5	71.5	66.6	61.7	56.8	51.9	47.0	42.1	37.3	32.5	27.8	23.2	18.8	14.7	11.0	8.0
■ HALE, without cancer	73.8	73.2	69.2	64.3	59.7	55.3	50.9	46.4	42.1	37.6	33.3	29.1	25.0	21.0	17.1	13.3	9.9	7.0	4.7
■ LE, with cancer	27.1	32.2	33.7	32.1	30.0	28.2	26.2	23.5	20.9	18.6	16.5	14.7	12.8	11.0	9.5	8.0	6.8	5.6	4.5
■ HALE, with cancer	22.5	26.6	27.0	24.7	22.4	22.0	20.6	18.1	15.8	13.6	12.0	10.9	9.4	8.2	6.8	5.7	4.4	3.6	2.7

Age

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Cancer Registry and Canadian Vital Statistics Death databases, Statistics Canada, 2002–2005

FIGURE E-4. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Males in the Canadian Population and for Those Without or With Cancer, Canada (Less Quebec), 2002 to 2005
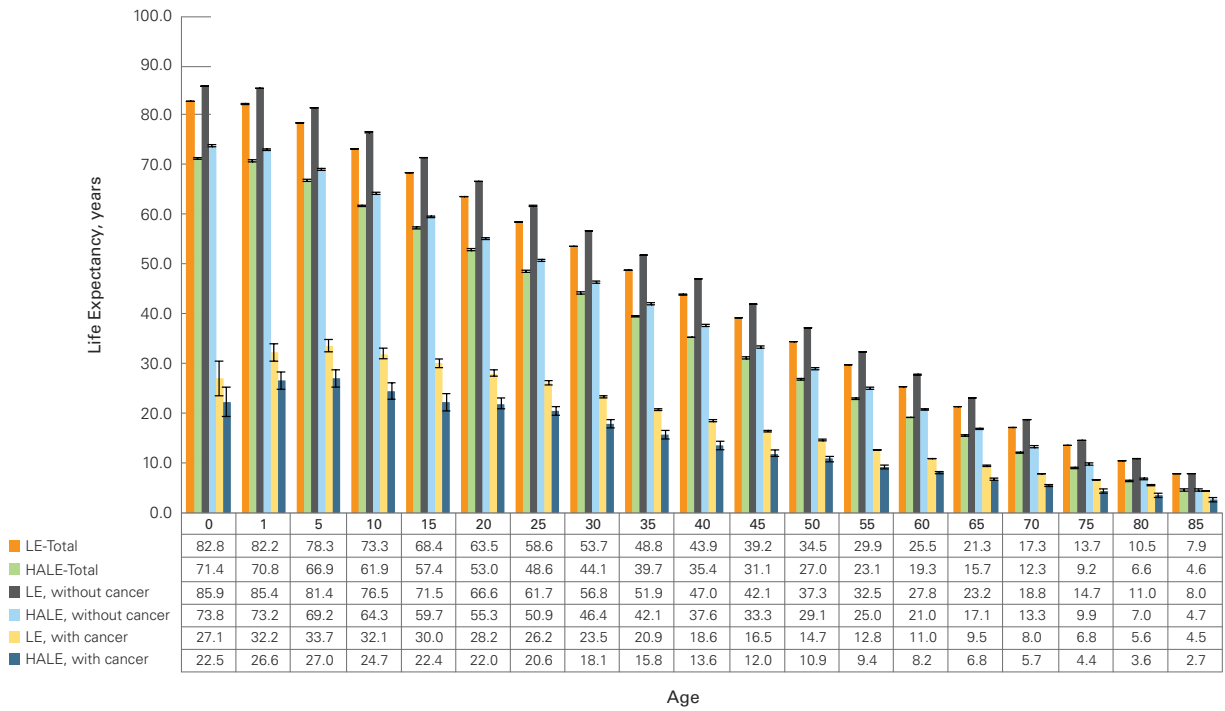

	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
■ LE, Total	77.8	77.2	73.3	68.3	63.4	58.6	53.8	49.0	44.2	39.5	34.8	30.3	25.9	21.6	17.7	14.1	10.9	8.2	6.0
■ HALE, Total	68.7	68.2	64.2	59.3	54.8	50.5	46.2	41.8	37.4	33.0	28.8	24.7	20.9	17.2	13.8	10.7	7.8	5.5	3.7
■ LE, without cancer	81.3	80.8	76.8	71.9	66.9	62.1	57.3	52.5	47.8	43.0	38.3	33.6	29.1	24.6	20.3	16.3	12.6	9.3	6.8
■ HALE, without cancer	71.5	71.0	67.0	62.1	57.6	53.3	48.9	44.5	40.1	35.8	31.6	27.4	23.4	19.5	15.8	12.3	9.1	6.4	4.4
■ LE, with cancer	22.9	27.5	28.2	26.7	23.8	22.4	20.5	17.9	15.3	13.2	11.5	10.6	10.1	9.6	8.8	7.5	6.1	4.4	2.1
■ HALE, with cancer	20.5	24.6	24.6	22.7	19.9	18.5	16.4	14.4	12.5	10.3	9.1	8.0	7.8	7.2	6.6	5.6	4.1	2.6	0.9

Age
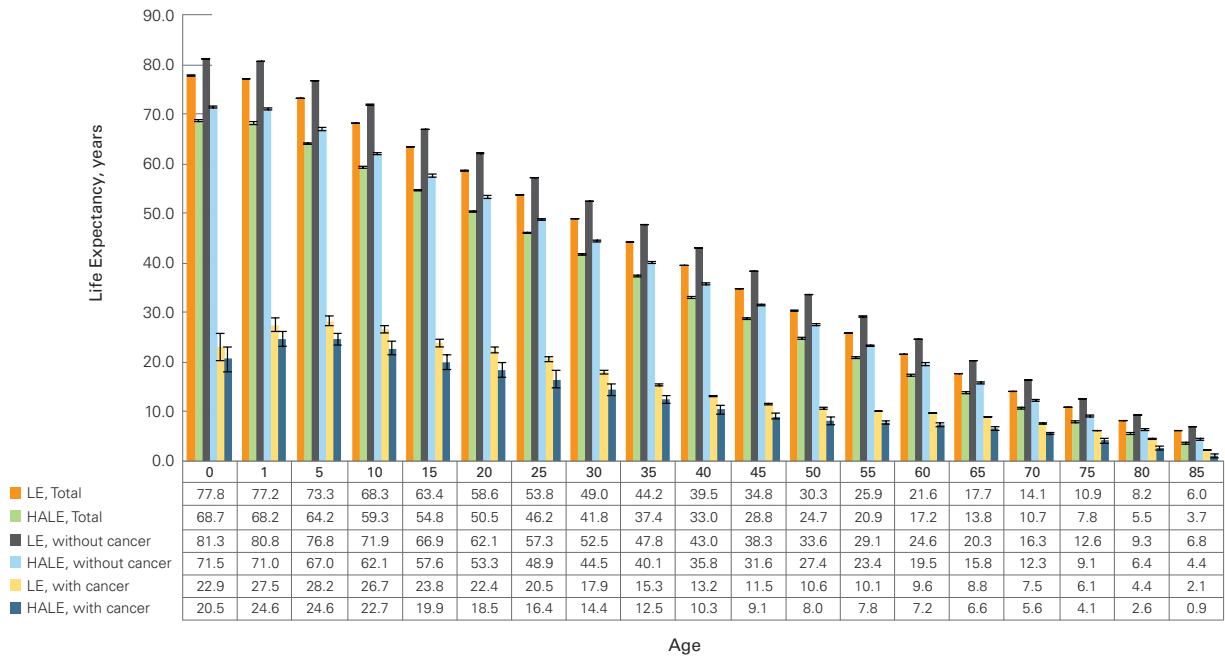
LIFE EXPECTANCY

Table E-1 shows the gain in life expectancy after eliminating deaths with cancer among females and males, for selected ages.

Given the present burden of disease, eliminating cancer deaths would lengthen overall life expectancy in Canada by 3.4 years for females and 3.7 years for males. Researchers found similar results using data from the United States [1].

TABLE E-1. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) (and 95% Confidence Intervals), Losses of LE and of HALE due to Cancer and Gain of LE After Eliminating Cancer Deaths, at Selected Ages,[1] by Disease Status and Sex, Canada (Less Quebec), 2002 to 2005

SEX	HEALTH EXPECTANCY	TOTAL POPULATION (I)	WITHOUT CANCER (II)	WITH CANCER (III)	CANCER-DELETED HEALTH EXPECTANCY (IV)	LOSS OF HEALTH EXPECTANCY DUE TO CANCER (II–III)	GAIN OF LE AFTER ELIMINATING CANCER DEATHS (IV–I)
At birth							
Females	LE	**82.8** (82.8–82.8)	**85.9** (85.9–86.0)	**27.1** (23.5–30.7)	**86.2**	**58.8***	**3.4**
	HALE	**71.4** (71.2–71.7)	**73.8** (73.6–74.1)	**22.5** (19.5–25.5)	**N/A**	**51.3***	
Males	LE	**77.8** (77.7–77.8)	**81.3** (81.2–81.3)	**22.9** (20.1–25.7)	**81.5**	**58.4***	**3.7**
	HALE	**68.7** (68.5–69.0)	**71.5** (71.3–71.8)	**20.5** (18.1–23.0)	**N/A**	**51.0***	
At age 20 years							
Females	LE	**63.5** (63.4–63.5)	**66.6** (66.6–66.6)	**28.2** (27.6–28.9)	**66.8**	**38.4***	**3.3**
	HALE	**53.0** (52.8–53.2)	**55.3** (55.1–55.6)	**22.0** (21.6–23.1)	**N/A**	**33.3***	
Males	LE	**58.6** (58.6–58.6)	**62.1** (62.1–62.1)	**22.4** (21.8–22.9)	**62.4**	**39.7***	**3.8**
	HALE	**50.5** (50.3–50.7)	**53.3** (53.0–53.5)	**18.5** (16.9–20.0)	**N/A**	**34.8***	
At age 65 years							
Females	LE	**21.3** (21.3–21.3)	**23.2** (23.2–23.3)	**9.5** (9.4–9.5)	**23.4**	**13.7***	**2.1**
	HALE	**15.7** (15.6–15.9)	**17.1** (16.9–17.3)	**6.8** (6.5–7.1)	**N/A**	**10.3***	
Males	LE	**17.7** (17.7–17.8)	**20.3** (20.3–20.4)	**8.8** (8.7–8.8)	**20.6**	**11.5***	**2.9**
	HALE	**13.8** (13.6–14.0)	**15.8** (15.6–16.1)	**6.6** (6.2–7.0)	**N/A**	**9.2***	

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005 combined file, and Canadian Cancer Registry files, 2002–2005

1   **At birth** was selected for comparability with other research on health-adjusted life expectancy. **At age 20 years** was selected because adult cancers are represented. **At age 65 years** was selected because 65 is the 2005 mean age of the Canadian Cancer Registry incident cases for cancer.

*   Statistically significant (p < 0.0001)

References for Appendix E

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A Continuum of Approaches to Measuring Health-Adjusted Life Expectancy by Income

INTRODUCTION

A continuum of approaches to measuring income-related health inequalities was described in a PowerPoint presentation given to the Public Health Agency of Canada by Russell Wilkins, from Statistics Canada [October 27, 2009]. The following is an Agency interpretation of the slides of that presentation.

Access to death data (vital statistics) and census counts is readily available. However, mortality rates are not easily linked to income (or any other measures of social position). The associated challenges require "work-around" solutions. The rigour and sophistication of these work-around solutions varies, defining a continuum going from crude patchwork solutions to rigorous solutions. The rigorous solutions strive to establish links between deaths (and census characteristics) and measures of socio-economic position using person-level microdata. In the absence of person-level micro data, area-based methods that rely on neighbourhood-level data as proxies for individual-level data are possible (whereby all individuals within a neighbourhood inherit the neighbourhood attribute). Wilkins aptly points out that the choice of method will depend on the purpose and the resources available. He contrasts the objective of the biannual monitoring versus a more rigorous analysis that can only be repeated far less frequently (say every 10 years).

AN IDEALIZED STUDY

The ideal circumstance for quantifying income inequalities in health would involve direct personal identifying information on each census form so that each individual identified in the census could be followed up in the Canadian Mortality Database (using deterministic and probabilistic linkages) to determine their vital status (i.e., alive or dead). Personal identifier information would simplify and enhance the reliability of follow-up. In addition (perhaps by exploiting the unique personal identifier), the income information would ideally represent the lifetime averaged (family) income rather than just the income at the initiation of the study (which is what is available under the Silver and Gold approaches).

Further, as elaborated by the Public Health Agency of Canada Technical Team on Health-Adjusted Life Expectancy, the idealized circumstances would involve an individual-level link to the Canadian Community Health Survey. Under ideal circumstances, all individuals who completed a long-form census questionnaire would have also been regularly surveyed by a similar type of survey. Further, the Canadian Community Health Survey responses would be available longitudinally (in an individual-linked manner) so that individual life-course information could be obtained. This life-course information would document the individual's sequence of health states, and perhaps personal utility weights accorded to those health states, over their life path leading up to the close of follow-up.

This idealized study is clearly an unrealistic aspiration but is helpful for pointing out the limitations of the continuum of study designs that are discussed below. The strengths of this ideal study are a helpful counterpoint to the more practical studies, a counterpoint that helps to reveal the limitations that come with the more pragmatic studies.

THE BRONZE APPROACH

THE MODEL STUDY

The neighbourhood income quintile study extends the traditional mortality rate reporting by using place of residence as a proxy for income. To improve the reliability of location as a proxy for income, Wilkins and colleagues [1] exclude rural areas, choosing instead to restrict their attention to census metropolitan areas. Thus, strictly speaking, their results only apply to metropolitan areas, though they are representative of metropolitan areas throughout Canada. An additional exclusion is made to enhance the reliability of location as a proxy for income; all individuals who reside within institutions are excluded. Thus, the neighbourhood income quintile study design seems to be nationally representative of non-institutionalized Canadians residing in census metropolitan areas (representing a sizeable proportion of all Canadians).

The preceding commented upon the inclusion criteria but does not detail how mortality rates are obtained, nor does it reveal how the mortality rates are linked with income. In the neighbourhood income quintile study, the mortality rates are determined in the traditional way (just as they would be for the purposes of routine Statistics Canada updating of the national mortality rates) with one exception. In the case of the neighbourhood income quintile, place of residence becomes a key attribute. Each eligible individual record (be it a census or death record) must be coded to place of residence. In this case, place of residence was defined to a spatial resolution of census tract. The authors of the neighbourhood income quintile study managed to code each death record to census tract, and the census records were already coded to census tract. Note, however, that for this study design, no link is possible between the individual-level census and individual-level death records. Indeed, the point of the neighbourhood income quintile study design is that the absence of an individual link does not preclude macro-level summaries. Instead, a population and death count could be obtained for each census tract.

But how are these census tract-specific counts (death and population) linked to income? This link is established by assigning an income attribute to each census tract—with the assumption that the area-level attribute can be applied to all the residents of the census tract. The income attribute is obtained by following 3 steps for each census tract. First, the economic family income, adjusted for family size, is determined for all eligible persons within the census tract. Second, the percentage of the census tract's population falling below the "low income cut-off" is calculated. (This census tract attribute is the proxy for identifying income groups for individual records.) Third, all census tracts falling within the same census metropolitan area are ranked according to this attribute (percentage of population below the low income cut-off), and these ranks are used to assign each census tract to an income (rank-determined) group (be it a quintile, when dividing the population into fifths, or tertile, when the division is into thirds). The census metropolitan area-specific income groups are then pooled (i.e., pooling bottom quintiles from all census metropolitan areas to form an overall bottom quintile and repeating for all other quintiles). In this way an income group label is applied to each census tract. The death and population counts from all census tracts sharing membership in the same income group are then pooled, so that total death and total population counts are obtained for each income group. Each income group is then treated as a separate subpopulation; each is separately summarized using, for example, the ordinary life table.

The death and population counts are naturally those obtained cross-sectionally; in the case of the neighbourhood income quintile, the analysis was repeated cross-sectionally for multiple periods (1971, 1986, 1991, 1996 and 2001). The data thus lend themselves naturally to a period life table analysis (repeated for each period, and done separately for each income group within the period).

The income attribute is a neighbourhood-level attribute. Since there is bound to be some residual heterogeneity in income within census tracts, the use of the neighbourhood income attribute as a proxy for an individual's income is expected to misclassify many individuals. As Wilkins et al. note (within the neighbourhood income quintile paper) [1], the error is likely to result in an underestimate of the inequalities between income groups. It is also worth noting that the income group to which each record (death or population count) is assigned is determined cross-sectionally in time. Yet, presumably the income relevant to health outcomes would be some measure of "life-to-date" income rather than merely the income at a single "point in time." This shortfall of

relying on income measured at a point in time is not unique to the neighbourhood income quintile study. The higher quality study by McIntosh and colleagues [2] also relies on income measured at a single point in time. The timing of the measurement of income vis-à-vis the life paths of the populations being summarized is somewhat different between the neighbourhood income quintile study and the McIntosh et al. study designs. In the case of the neighbourhood income quintile study, the timing is coincident with the (calendar) time of all deaths contributing to the period summaries, whereas in the McIntosh et al. study the timing is coincident with the enrolment time. It is unclear whether this distinction has any material implications for the comparability of the results coming from the 2 studies.

GENERAL CHARACTERIZATION OF A BRONZE STUDY

Under a bronze approach, neighbourhood (in which an individual resides) is used as a proxy link for income. Small neighbourhoods called census tracts are assigned an income-related rank. While this rank is based on individual-level data (economic family incomes are summarized by neighbourhood by calculating the proportion of persons whose family incomes are below the low income cut-off), only the summary measure (proportion below the low income cut-off) is assigned to each neighbourhood. Census tracts within each census metropolitan area are then ranked according to their summary measure, and these ranks are used to determine membership in an income category (be it a quintile, when dividing ranks into fifths, or a decile, when dividing ranks into tenths). Eligible census tracts (those within census metropolitan areas) that share the same income category across different census metropolitan areas are then pooled to obtain Canada-level income categories. Each category is then treated as a separate subpopulation (the shared characteristic being their membership in the appropriate income category).

Their deaths and population counts will be used to obtain (age- and sex- specific) mortality rates for each income group. The prognoses of each income group can then be compared with those who (by virtue of their proportion of income below the low income cut-off) gain membership into another ranked income group.

THE TIN APPROACH

Wilkins appears to suggest that a work-around can ease the demands of the Bronze approach even further by sidestepping the need for regularly updated health utility index data [1]. He suggests that disability-adjusted life expectancy approaches can obviate the need for regular updates to the health utility index, since these approaches can exploit information on the prevalence of disease or disabled health states. If one can link identifiable disability states with standard health-related quality of life scores (scores that need not be updated as frequently as the prevalence data), then it would be possible to compute disability-adjusted life expectancy (a "cousin" of health-adjusted life expectancy; both are examples of health expectancy measures) by income. These disability-adjusted life expectancy estimates by income could be updated (vis-à-vis the mortality rates) as regularly as neighbourhood income quintile-linked mortality rates can be updated. This would seem to suggest that annual or semi-annual prevalence estimates would be readily available and presumably for a sufficient number of health conditions. The prevalence estimates would have to be stratified by severity. The disability-adjusted life expectancy measures would capture trends (broad trends) in mortality and prevalence of disabling states, but they would not measure finer changes in self-rated functionality or self-related health (since under this approach an updated set of health utility index weights would not be sought). The 1991 and 1996 disability-adjusted life expectancy for Canada (see 1994 Canberra conference proceedings) [3] could easily be converted into this kind of health-adjusted life expectancy by simply substituting average health utility index weights for each component health state of the disability-adjusted life expectancy

Of course, the prevalence measures would have to be available by neighbourhood income quintile, which would be determined by geocoding from the postal codes available on the health surveys. It is not yet clear if or how this method could be applied to disease-specific health expectancies. Perhaps such work could exploit disease registry data and/or proxy approaches such as those using prescription or health administrative data to infer existing health state condition.

THE SILVER APPROACH

The Silver approach uses the Canadian census mortality follow-up study [4] as a starting point. Described as a landmark study, this study has made use of a sample of Canadians who filled out the Canadian census long-form to form a national cohort of Canadians for a longitudinal follow-up study. This study used the 1991 census as the enrolment point and has extended follow-up until 2001. A key contribution of this study has been the matching of the individuals who were enrolled in the study to personal identifier information that was then used to follow up on each individual for his or her survival status, using the Canadian Mortality Database. Two papers have described the use of this unique, broadly representative, longitudinal study for examining differences in health across income [4, 5].

Wilkins proposes 2 paths under the label "Silver." One path requires a degree of extrapolation, relying upon rate-ratios (which would be obtained from a study such as the McIntosh et al. study) and using these estimates in conjunction with contemporary (more regularly updated) life tables to obtain updated estimates of health gaps across income. Yet, this approach only adjusts previously measured income-related health gaps (measured in terms of rate-ratios) to represent the more up-to-date mortality rate patterns. Since it relies on dated rate-ratios, this approach is not a comprehensive update of the prevailing health gaps across income. Under this "estimation approach," the rate-ratio distinguishing the different income groups from the referent group (age-specific) and as estimated from the Canadian census mortality follow-up study [1] would be presumed to remain applicable (i.e., fixed) to the contemporary life table data. This approach is closely aligned with a "cause-modified life table" [6]. It can serve as an illustration of what the contemporary inequalities are likely to be (a surrogate update), but it would be less suited to a monitoring role, since it does not rely upon complete contemporary data but instead relies upon a previously measured set of rate-ratios. For this reason, the resulting projections do not provide an independent estimate of the health inequalities.

The Silver approach may be the best pragmatic study. It is capable of providing an update of the health inequalities, expressible in terms of gaps in life expectancy or health-adjusted life expectancy. The update, however, is partial since it relies on the previously measured rate-ratios (between the highest income category and the other, lower, income categories of interest) in its update. The update will be in error to the extent that these rate-ratios have changed.

THE GOLD APPROACH

Under the Gold approach, mortality rates by income would be measured directly rather than relying upon previously measured rate-ratios to obtain them indirectly (as per the Silver approach). The Gold approach would require the creation of a new cohort for mortality follow-up, based on a sample from the 2001 census. The follow-up period from 2001 through 2011 would be centred on 2006 (as opposed to 1996 for the 1991–2001 study). Such an initiative would require a fair amount of investment, of the type that was required to put together the census mortality follow-up study undertaken by Wilkins et al. [4].

SUMMARY

The crude approaches that rely on neighbourhood income quintiles are presumably the most straightforward to operationalize and repeat with the passage of time (enabling one to track changes in population health status over time). We can easily (via census) link population to neighbourhood and presumably can also get income from the census. We can further link deaths to neighbourhood and can therefore categorize those deaths according to neighbourhood income. The Bronze approach does seem relatively straightforward to repeat in a fairly regular manner. Proof of this would be found in the ongoing practice of Statistics Canada, which regularly updates its mortality rate estimates by age and sex. The Bronze approach augments this ongoing process in a relatively minor way. It requires that rates be calculated by neighbourhood income quintiles and that each rate be linked with its neighbourhood income attribute (proportion of families falling below the low income cut-off).

The other advantage of this approach, or more specifically an approach that relies upon neighbourhood income quintiles, is that it enables one to compute the force of mortality for those under 25 or, more to the point, for those individuals who because of their age are unlikely to have filed tax forms and are thus unlikely to be found within a tax bridging file.

References for Appendix F

1. Wilkins R, Berthelot JM, Ng E. Trends in mortality by neighbourhood income in urban Canada from 1971 to 1996. Health Rep 2002;13(Suppl):45–71.

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3. Wilkins R, Chen J, Ng E. Changes in health expectancy in Canada from 1986 to 1991. In: Mathers CD, McCallum J, Robine JM (editors). Advances in health expectancies: Proceedings of the 7th meeting of the International Network on Health Expectancy (REVES). Canberra: Australian Institute of Health and Welfare; 1994. p. 115–132.

4. Wilkins R, Tjepkema M, Mustard C, Choiniere R. The Canadian census mortality follow-up study, 1991 through 2001. Health Rep 2008;19(3):25–43.

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6. Brand KP. Approximations and heuristics for the 'cause modified' life-table. Risk Anal 2005;25(3):1–15.

APPENDIX G

Health-Adjusted Life Expectancy by Educational Attainment

In 1996, Wolfson estimated health-adjusted life expectancy by educational attainment [1]. Because Canadian life tables by education were not available, these estimates were based on mortality by education observed in the 1986 Manitoba census-mortality linkage study. The differentials observed in Manitoba were applied to the national mortality data to obtain estimates for Canada as a whole.

Health-adjusted life expectancy was calculated by combining mortality rate data (stratified by sex, age group and place of residence) with similarly stratified morbidity data. To estimate morbidity, mean health utility index scores were tabulated for the population by sex, age group and place of residence (household or institution). The health utility index scores were obtained from the 1994 National Population Health Survey. The mean scores (by sex and age group) for persons residing in households were multiplied by the proportion living there. For persons in institutions, the scores were multiplied by the proportion residing there. The resulting 2 figures were summed to provide overall health utility index scores by sex and age group.

Next, a cross-sectional life table was constructed in the traditional manner. Then, the years of life lived in each age group were multiplied by the corresponding mean health utility index score. The resulting health-adjusted life-years lived were summed and divided by the total number of persons surviving at given ages to provide the estimate of health-adjusted life expectancy.

Wolfson's results indicated that life expectancy and health-adjusted life expectancy generally increased with educational attainment [1]. The differences in health-adjusted life expectancy across educational attainment levels reflected a compounding effect: those with more education not only had longer life expectancies, they also enjoyed a lower burden of ill health during those years, whereas those with less education had shorter life expectancies compounded by a higher burden of ill health during those years. However, the difference between these measures diminished as education level rose, as shown in Table G-1.

TABLE G-1. Life Expectancy and Health-Adjusted Life Expectancy (HALE) at Age 30, by Sex and Educational Attainment, Canada, 1990 to 1992

EDUCATIONAL ATTAINMENT	LIFE EXPECTANCY	HALE	DIFFERENCES	
			(LE – HALE)	(LE – HALE)/LE
	Years	Years	Years	%
Men				
Lowest quartile	44.5	37.5	7.0	16
Second quartile	45.2	39.5	5.7	13
Third quartile	47.6	41.8	5.8	12
Highest quartile	47.7	42.8	4.9	10
Women				
Lowest quartile	51.0	41.0	10.0	20
Second quartile	52.0	44.1	7.9	15
Third quartile	52.2	44.5	7.7	15
Highest quartile	53.2	46.3	6.9	13

SOURCE: Social and Economic Studies Division, Statistics Canada [adapted from Wolfson, 1996 (Reference 1)]

The results from a more recent and comprehensive study of income disparities in health-adjusted life expectancy showed steady improvement in remaining health-adjusted life expectancy disparities at age 25 with increasing levels of education (Table G-2) [2]. Women in the group with the highest level of educational attainment had a remaining HALE of 53.1 years, while men in the corresponding group had a remaining HALE of 50.7 years. The differences in remaining health-adjusted life expectancy between the groups with the highest and lowest levels of educational attainment were 7.4 years for women and 9.1 years for men.

TABLE G-2. Remaining Health-Adjusted Life Expectancy (Years) at Age 25, by Highest Level of Educational Attainment and Sex, Canada, 1991 to 2001

	WOMEN			MEN		
		95% confidence interval			95% confidence interval	
	Years	from	to	Years	from	to
Less than secondary (lowest)	45.7	45.4	46.0	41.6	41.3	41.8
Secondary graduation	49.9	49.7	50.2	45.6	45.4	45.8
Postsecondary diploma	51.8	51.5	52.1	48.7	48.4	49.0
University degree (highest)	53.1	52.6	53.6	50.7	50.4	51.0
Difference: highest minus lowest	7.4	6.9	8.0	9.1	8.7	9.5

SOURCES: 1991-2001 Canadian census mortality follow-up study, and 2000/2001 Canadian Community Health Survey (cycle 1.1) [adapted, with permission, from Erratum (in press 2010) to McIntosh et al., 2009 (Reference 2)]

References for Appendix G

1. Wolfson MC. Health-adjusted life expectancy. Health Rep 1996;8(1):41–46.

2. McIntosh CN, Fines P, Wilkins R, Wolfson MC. Income disparities in health-adjusted life expectancy for Canadian adults, 1991 to 2001. Health Rep 2009;20(4):1–10. Erratum in press 2010.

APPENDIX H

Algorithm for Health-Adjusted Life Expectancy Calculations by Chronic Disease Status

OBJECTIVE

This algorithm describes the methodology and application of SAS macros for life expectancy (LE) and health-adjusted life expectancy (HALE) calculations for persons with and without diabetes mellitus. The same methodology was applied for estimating LE and HALE for persons with and without hypertension (Chapter 3) and cancer (Chapter 4).

BACKGROUND REQUIREMENTS

1. Knowledge of an abridged life table and its construction [1];

2. Basic knowledge of the data collection methods and data elements of the Statistics Canada surveys: the Canadian Community Health Survey (CCHS) and the National Population Health Survey (NPHS);

3. Knowledge of a bootstrap methodology [2–4] and how to use the BOOTVARE_V3.1 or/and the Macroe_ V3.1 macros developed by Statistics Canada; and

4. Basic Statistical Analysis System (SAS) programming skills (data extracting and manipulations, use of basic SAS procedures such as *proc means* and *proc sort,* use of custom-developed SAS macros) [5].

INPUT DATA REQUIREMENTS

Mortality and population data are needed, on the input file, to calculate LE, LE variance and the 95% confidence interval. The health utility index (HUI) and its variance are also needed to estimate HALE, HALE variance and the 95% confidence interval. Other measures of health-related quality of life could be used instead of the HUI. Mortality and population data can be obtained from administrative vital statistics and census data sources as well as from disease registries, etc.

The HUI and its variance can be estimated from health surveys, such as the CCHS, using the bootstrap methodology. The data are available for Canadians aged 12 years and older; therefore, the value of the HUI for the first 3 age groups should be added in the SAS data step. According to Statistics Canada guidelines, the estimate can be used or released if its coefficient of variation (CV) is less than 33.3 and the estimation is based on a sample size greater than or equal to 10 for the shared file, and greater than or equal to 30 for the public use file. The HUI for some age groups (usually the younger age groups) where this condition is not satisfied must be changed, using the appropriate assumptions. Information on the availability of the HUI, by province and territory, is shown in Appendix B (Table B-1).

The microdata files and their respective bootstrap weights files for each cycle can be used separately or combined together in order to increase the sample size for small populations. The methodology used to combine the survey data can be found in the article by Thomas and Wannell [6]. For this analysis, the data files from the first 3 survey cycles were combined by the pooled approach. The names of the microdata and respective bootstrap files as well as names of the sample weight and bootstrap weight variables can be found in the survey documentation or in the documentation of the BOOTVARE macro provided by Statistics Canada [4].

BOOTSTRAP METHOD

Complex surveys, such as Statistics Canada surveys, collect the data using a complex survey design. It is either very difficult or impossible to derive a formula for the variance estimation for such designs; therefore, the bootstrap method, based on resampling with replacement, is suggested to estimate variance for a selected indicator. Statistics Canada developed 2 SAS macros for use with the survey data: the BOOTVARE_V3.1 and the Macroe_V3.1. Generally, the BOOTVARE_V3.1 macro calls the Macroe_V3.1 macro. The BOOTVARE_V3.1 macro has detailed comments illustrating use and can be modified by removing the SAS comment signs in the appropriate areas. The program is divided into 2 sections. The SAS program indicates where the user should make changes, so that the program works with a custom file. In the first section of the program, the user-defined variables must be indicated, where specified, and the files containing the variables to analyze, along with the bootstrap weights, should be read in. In the second section, the user should indicate the type of analysis to perform, where specified. Advanced SAS users can use the Macroe_V.3.1 alone. This macro was designed to obtain point and variance estimates for the total, ratio, difference between ratios, and linear and logistic regression parameters. It is recommended, but not necessary, to run a specific SAS procedure to obtain the point estimates before running the macro. The results for the point estimates from the SAS procedure and the macro should be the same. Comparing point estimates produced by the macro and some other method is an indication that the macro has produced expected results. For this particular application, the point estimate and the variance of the HUI mean is analyzed; therefore, the *proc means* and *%ratio* (a sub macro of the Macroe_V3.1 macro) should be used.

All relevant macro documentation, BOOTVARE_V3.1 and Macroe_V3.1 macros can be found at the Statistics Canada website [4].

For this application, the microdata file should have the following variables: person ID, sample ID, age, sex, province of residence, disease status (yes/no) and the HUI for each survey respondent. The bootstrap weights file must contain 500 bootstrap weights and 2 identifier variables (person ID, sample ID) for all survey respondents. These 2 files may be used separately or merged together by sample and person IDs. It is more convenient to use the merged file instead of 2 separate data files, and it is recommended to remove all observations with missing values for the HUI. The new age group variable, for the standard 5-year age groups (10–14, … , 80–84, 85+ years) and a dummy variable (denom_var) should be used for the calculation of sample means. These also should be defined in the input file. The value of 1 has to be assigned to the dummy variable for all observations.

FIGURE H-1. Bootstrap Flowchart
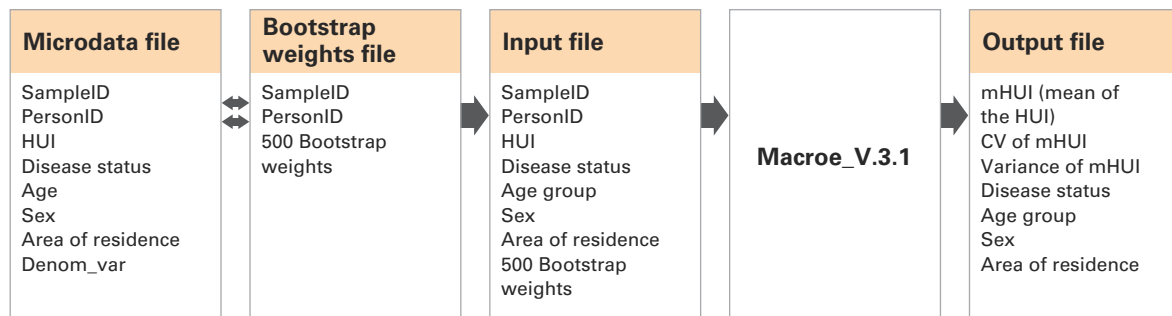
MACRO DEFINITION

```
%let ident=;  /* Specify names of the identifier variables. */
%let fwgt= ;  /* Specify a name of the weight variable to weight the estimates to
               represent the Canadian population.*/

%let bsw= ;   /* Specify a name of the prefix of a bootstrap weight variable. */
%let R=1;     /* Assign the mean bootstrap to the value of 1 for the CCHS. */
%let B=;      /* Specify a number of bootstrap subsamples. The maximum number for
               the CCHS is 500.*/

%let classes= ; /* Specify names of the class variables. */
%let Mfile= ;   /* Specify a name of the file containing row data. */
%let bsamp=;    /* Specify a name of the file containing bootstrap weights. */

%include "location_of_the_Macro\Macroe_v31.sas"; /*Specify the directory and the
              */
                                    /*name of the file that contains the macro.
              */

%ratio (numerator_var, denom_var);              /*macro call*/
%output;
```

EXAMPLE OF THE POINT AND VARIANCE ESTIMATE CALCULATIONS FOR MEAN HUI AMONG PEOPLE WITH OR WITHOUT DIABETES, BY SEX AND AGE GROUP

In this example, the data set *HUI_data_with_bootstrap_weights* is a merged file containing the IDs, the HUI, diabetes status, age group, sex, area of residence and 500 bootstrap weights for all survey respondents from the first 3 cycles for whom data are available.

```
/*Specify a dummy variable to be used as a denominator to calculate a point
estimate for the mean of the HUI (mHUI) and set its value to 1. With a dummy
variable, we calculate the number of observations that we have in each class. */

data HUI_data_with_bootstrap_weights;
set HUI_data_with_bootstrap_weights;
denom_var=1;
run;

/* It is required to sort the data by the class variables in order to run proc
means and %ratio macro. */

proc sort data= HUI_data_with_bootstrap_weights;
by DM_Status Sex AgeGroup;
run;

/* Run proc means to get the weighted point estimates for HUI mean by DM_Status,
Sex and AgeGroup. Use your sample weights variable. Specify the name of your
output data file. Pay attention to the cell sample size that was used to produce
the estimates. Do not use the estimates if the sample size is less than 10.
If this is the case, change its value to an appropriate value, making some
assumptions.*/
```

```
proc means data= HUI_data_with_bootstrap_weights mean;
format hui best12.;
var hui;
class DM_Status Sex AgeGroup;
weight FWGT;
output out=hui_ave_CCHS2000_2005 mean=hui;
run;


/* Run Bootstrap using the same input data file as in proc means above. */

%let ident=SAMPLEID PERSONID;
%let fwgt=fwgt;
%let bsw=bsw;
%let R=1;
%let B=500;
%let classes=DM_Status Sex AgeGroup;
%let Mfile= HUI_data_with_bootstrap_weights;
%let bsamp= HUI_data_with_bootstrap_weights;
%include "location_of_the_Macro \Macroe_v31.sas";
%ratio (hui, denom_var);
%output;


/* The output data set allrats (all ratios) has all types of ratios. Delete those
that are not used later, rename variables and change their types. */

data CCHS2000_2005_HUI_BST_DM;
set work.allrats(keep=n1 var1 var2 estimate rep_mod bs_var bs_cv DM_Status Sex
agegroup);
if agegroup="All" OR DM_Status="All" OR Sex="All" then delete;
rename estimate=hui bs_var=var_hui;
length Agegroup1 3;
Agegroup1=put(Agegroup,$8.);
drop agegroup;
rename Agegroup1=Agegroup;
hui_r=round(hui,0.001);
run;


/* Sort CCHS2000_2005_HUI_BST_DM by the same classes as before. Check if the point
estimates coincide with the estimates in hui_ave_CCHS2000_2005. If the results are
the same, the macro has produced expected results. If they are not the same, check
your SAS code for any errors and correct them.

Pay attention to the CV of the estimates. If the CV is greater than 33.3 (as is
usually the case for the younger age groups for disease-specific populations),
do not use these estimates. Change the mHUI value to the value for the disease-
deleted population, making appropriate assumptions. */

proc sort data=CCHS2000_2005_HUI_BST_DM;
by DM_Status Sex AgeGroup;
run;
```

```
/*There are no data for the first 3 age groups in the CCHS; therefore, set up the
HUI value for the first 3 age groups, making appropriate assumptions. The mHUI
substitutions for other age groups, where necessary, could be made in this data
step as well.*/

data AgeGroups1to3;
INPUT AgeGroup Sex $ DM_Status $  hui_r;

cards;
 1 M 0   0.999
 1 F 0   0.999
 2 M 0   0.999
 2 F 0   0.999
 3 M 0   0.999
 3 F 0   0.999
 1 M 1   0.999
 1 F 1   0.999
 2 M 1   0.999
 2 F 1   0.999
 3 M 1   0.999
 3 F 1   0.999
;
run;


/* Create a complete data set for all age groups. */

data CCHS2000_2005_HUI_DM_complete;
length DM_Status Sex $1;
set CCHS2000_2005_HUI_BST_DM (keep=AgeGroup Sex DM_Status hui_r var_hui bs_cv)
AgeGroups1to3;
Area='CA';
if var_hui=. then var_hui=0;
if bs_cv=. then bs_cv=0;
run;


/*Sort the data. */

proc sort data=CCHS2000_2005_HUI_DM_complete;
by DM_Status Sex AgeGroup Area;
run;
/* The mortality_population_data is a data set containing information about
mortality and population counts. In this example, CCDSS data for the 3 most recent
years available were used. They were classified by diabetes status, sex and 19 age
groups (<1, 1-4,5-9,…,80-84,85+). */



/* Sort the data set by the same classes as stated above. */

proc sort data= mortality_population_data;
by DM_Status Sex AgeGroup;
run;
```

```
/*Create the input data set for HALE calculations and save it in a permanent
library for convenience. */

LIBNAME Data "directory_for_the permanent SAS library";


data Data.MortAgeSpecificHUI;
merge CCHS2000_2005_HUI_DM_complete mortality_population_data;
by DM_Status Sex Agegroup;
run;
```

TABLE H-1. Example of the Input Data Set for the HALE Calculations

(MortAgeSpecificHUI)

DM_Status	Sex	Agegroup	Mortality	Population	var_hui	bs_cv	hui_r	Area
0	F	1	2437	490833	0	0	0.999	CA
0	F	2	303	1627096	0	0	0.999	CA
0	F	3	206	2187259	0	0	0.999	CA
…	…	…	…	…	…	…	…	CA
…	…	…	…	…	…	…	…	CA
0	F	18	31048	737398	0.000204	2.01	0.711	CA
0	F	19	78939	745682	0.000356	3.23	0.584	CA
0	M	1	2966	514756	0	0	0.999	CA
0	M	2	366	1705100	0	0	0.999	CA
0	M	3	260	2299751	0	0	0.999	CA
…	…	…	…	…	…	…	…	CA
…	…	…	…	…	…	…	…	CA
0	M	18	28833	459111	0.000268	2.22	0.739	CA
0	M	19	42966	342928	0.000996	4.94	0.639	CA
1	F	1	2437	490833	0	0	0.999	CA
1	F	2	1	1240	0	0	0.999	CA
1	F	3	0	4608	0	0	0.999	CA
…	…	…	…	…	…	…	…	CA
…	…	…	…	…	…	…	…	CA
1	F	18	12789	179072	0.001038	4.96	0.650	CA
1	F	19	20808	143637	0.00306	8.99	0.615	CA
1	M	1	2966	514756	0	0	0.999	CA
1	M	2	1	1511	0	0	0.999	CA
1	M	3	0	5366	0	0	0.999	CA
…	…	…	…	…	…	…	…	CA
…	…	…	…	…	…	…	…	CA
1	M	18	13796	142323	0.001571	6.45	0.615	CA
1	M	19	14455	82627	0.006886	15.33	0.541	CA

LE AND HALE CALCULATIONS

A custom SAS macro developed by PHAC named the AbridgedLifeTable19AgeGroupsHALE is applied to calculate LE and HALE together with their variances and 95% confidence intervals. It requires deaths, populations, the mean HUI (mHUI) and its variance by sex and 19 standard age groups (<1, 1–4, 5–9, … , 80–84, 85+ years). The Macro uses Chiang's method [1] to calculate LE and its variance and Sullivan's method [7] to calculate HALE. The variance of HALE can be calculated by Bebbington's method [8] or Mather's method [9]. Bebbington's method accounts for the variance of the HUI only and can be effectively used for populations with a large sample size. Mather's method suggests using both the variance of the HUI and a life table itself for populations with a limited sample size.

FIGURE H-2. Flowchart for the LE - HALE Calculations

Both the **INPUT** data set and the **OUTPUT** life table are SAS data sets.
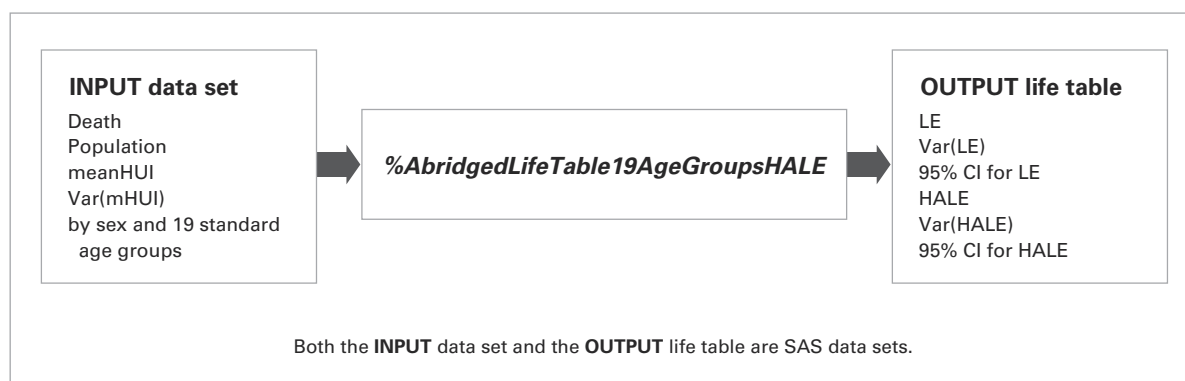
AbridgedLifeTable19AgeGroupsHALE   MACRO CALL

MACRO DEFINITION

```
%MACRO AbridgedLifeTable19AgeGroupsHALE(
            input_mortality, /* Specify a name and location for the input data*/
            input_population, /* files that have population and death counts.*/
            output_liftable, /*Specify a name and location for the output file.*/
             chiang_ax=Chiang19ConstantsBySex,
             age_group=AgeGroup,
             sex=Sex,
             deaths=Mortality,     /* Specify a name of the death variable. */
             population=Population,/* Specify a name of the population variable.
*/
             HUI=,                  /* Specify a name of the HUI variable. */
          var_hui=              /* Specify a name of the HUI variance
variable.*/
             varHALEmethod=,        /* Choose the method for the HALE variance */
          print=Y);            /* calculations. Use 'mather' for Mather's
method
and 'bebbington' for Bebbington's method. Bebbington's method [8] uses the HUI
variance only, and Mather's method [9] uses both the variance of the HUI and the
variance of the life table itself. It is recommended to use Mather's method when
the sample size of the underlying population is limited. */
```

EXAMPLE OF MACRO CALL

```sas
%INCLUDE "location_of_the_Macro\AbridgedLifeTable19AgeGroupsHALE.sas";
LIBNAME OUT "directory_to_save_the_output_file_in";

/* Stratify the MortAgeSpecificHUI data by DM_status. */

data MortAgeSpecificHUI_0;    /*The input data file has mortality, */
set Data.MortAgeSpecificHUI;  /* population counts and the mean HUI by sex and*/
where DM_Status='0';               /*19 age groups for people without diabetes. */
run;

%AbridgedLifeTable19AgeGroupsHALE(
        input_mortality=MortAgeSpecificHUI_0,
        input_population=MortAgeSpecificHUI_0,
        output_liftable=out.LifeTable_withoutDM,
        chiang_ax=Chiang19ConstantsBySex(WHERE=(Sex IN ('F','M'))),
         age_group=AgeGroup,
         sex=Sex,
         deaths=Mortality,
         population=Population,
        HUI=hui_r,
        var_hui=var_hui,
         varHALEmethod=bebbington, /*Bebbington's method is used. */
        print=Y);

data MortAgeSpecificHUI_1;    /*The input data file has mortality, */
set Data.MortAgeSpecificHUI; /* population counts and the mean HUI by sex and*/
where DM_Status='1';               /*19 age groups for people with diabetes.*/
run;


%AbridgedLifeTable19AgeGroupsHALE(
        input_mortality=MortAgeSpecificHUI_1,
        input_population=MortAgeSpecificHUI_1,
        output_liftable=out.LifeTable_withDM,
        chiang_ax=Chiang19ConstantsBySex(WHERE=(Sex IN ('F','M'))),
         age_group=AgeGroup,
         sex=Sex,
         deaths=Mortality,
         population=Population,
        HUI=hui_r,
        var_hui=var_hui,
         varHALEmethod=mather, /*Mather's method is used. */
        print=Y);
```

TABLE H-2. Output Data Dictionary

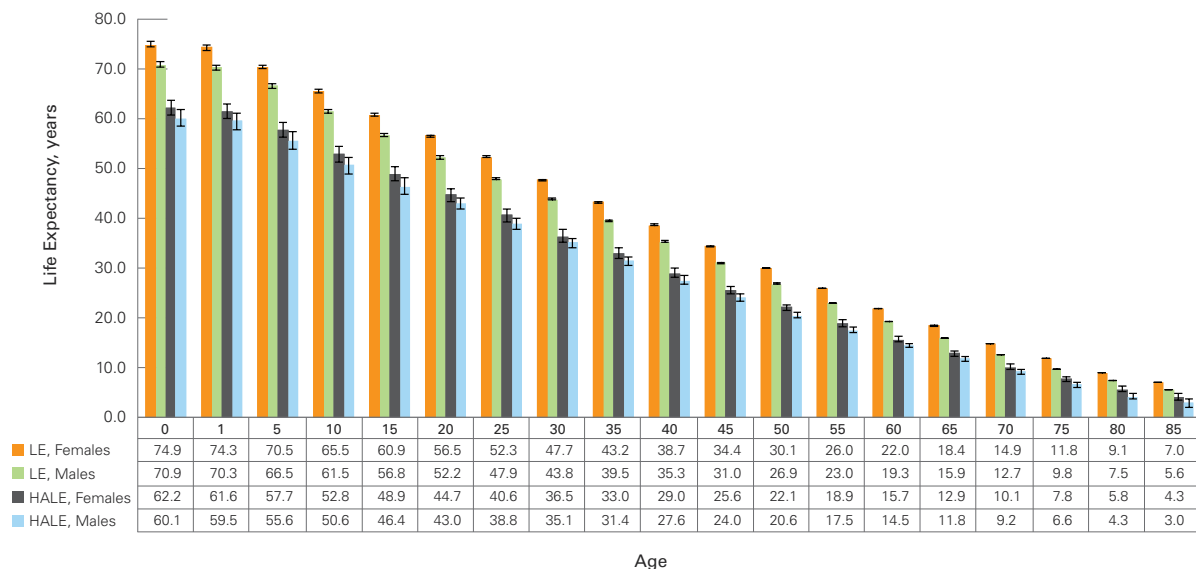| VARIABLE NAME	DESCRIPTION
lx	Number living at age x_i
dx	Number dying in interval (x_i to x_{i+1})
AgeGroup	Age group. The macro uses 19 standard age groups (<1, 1–4, 5–9, … , 80–84, 85+ years).
Sex	Males, Females
Mortality	Observed mortality
Population	Observed population
hui	Health utility index (HUI)
var_hui	Variance of the HUI
qx	Probability of dying in interval x_i to x_{i+1}
se_qx	Variance of probability of dying in interval x_i to x_{i+1} , $\times 10^8$
Tx	Total number of years lived beyond age x_i
Txa	Adjusted total number of years lived beyond age x_i
_Lx	Number of years lived in interval (x_i to x_{i+1})
_Lxa	Adjusted number of years lived in interval (x_i to x_{i+1})
ex	Life expectancy (LE), years
exa	Health-adjusted life expectancy (HALE), years
diff_LE	LE - HALE, years
var_ex	Variance of LE
LOWER_LE	Lower boundary of LE confidence interval
UPPER_LE	Upper boundary of LE confidence interval
low_diff_LE	*Difference between the point estimate of LE and its lower boundary
upper_diff_LE	*Difference between the point estimate of LE and its upper boundary
var_exa	Variance of HALE
LOWER_HALE	Lower boundary of HALE confidence interval
UPPER_HALE	Upper boundary of HALE confidence interval
low_diff_HALE	*Difference between the point estimate of HALE and its lower boundary
upper_diff_HALE	*Difference between the point estimate of HALE and its upper boundary

* It could be used to build the confidence interval in MS Excel.

TABLE H-3. Example of the Life Table Output: Life Table for Persons Diagnosed With Diabetes Mellitus

lx	dx	AgeGroup	DM_Status	Sex	Mortality	Population	var_hui	hui_r	Qx	se_qx	Tx	Txa	_Lx	_Lxa	ex
100000	494.3674	1	1	F	2437	490833	0	0.999	0.004944	0.997911	7493276	6224159	99569.9	99470.33	74.93276
99505.63	320.3762	2	1	F	1	1240	0	0.999	0.00322	1033.295	7393706	6124689	397266.4	396869.2	74.3044
99185.26	0	3	1	F	0	4608	0	0.999	0	0	6996440	5727820	495926.3	495430.4	70.53911
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
48918.9	14912.45	18	1	F	12789	179072	0.001038	0.650	0.30484	505.1178	445720.9	281426.5	208804.6	135723	9.111424
34006.45	34006.45	19	1	F	20808	143637	0.00306	0.615	1	0	236916.2	145703.5	236916.2	145703.5	6.966802
100000	573.2556	1	1	M	2966	514756	0	0.999	0.005733	1.101612	7090558	6012604	99489.8	99390.31	70.90558
99426.74	262.8182	2	1	M	1	1511	0	0.999	0.002643	696.8749	6991068	5913214	397118.3	396721.1	70.31376
99163.93	0	3	1	M	0	5366	0	0.999	0	0	6593950	5516492	495819.6	495323.8	66.49545
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
37949.42	14805.19	18	1	M	13796	142323	0.001571	0.615	0.39013	672.8253	283160.4	164492.1	152734.1	93931.47	7.461521
23144.22	23144.22	19	1	M	14455	82627	0.006886	0.541	1	0	130426.3	70560.61	130426.3	70560.61	5.635371

exa	diff_LE	var_ex	LOWER_LE	UPPER_LE	low_diff_LE	upper_diff_LE	var_exa	LOWER_HALE	UPPER_HALE	low_diff_HALE	upper_diff_HALE
62.24159	12.69117	0.099895	74.31328331	75.55224275	0.619479719	0.619479719	0.608853	60.71222145	63.77095937	1.529368964	1.529368964
61.55118	12.75322	0.100833	73.6820191	74.92678247	0.622381689	0.622381689	0.61488	60.01425656	63.08809558	1.536919508	1.536919508
57.7487	12.79041	0.046218	70.1177461	70.96047891	0.421366406	0.421366406	0.584173	56.25064749	59.24675085	1.498051678	1.498051678
…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…
5.752919	3.358505	0.000443	9.070162517	9.15268528	0.041261381	0.041261381	0.090813	5.162267792	6.34357044	0.590651324	0.590651324
4.284583	2.682219	0	6.966802365	6.966802365	0	0	0.148506	3.529269041	5.039897869	0.755314414	0.755314414
60.12604	10.77954	0.074432	70.37084353	71.44030998	0.534733228	0.534733228	0.773617	58.40211013	61.84996623	1.723928054	1.723928054
59.47307	10.84069	0.075237	69.77614179	70.85137074	0.537614473	0.537614473	0.782524	57.73924386	61.20689162	1.73382388	1.73382388
55.63003	10.86542	0.042537	66.09120687	66.89968726	0.404240196	0.404240196	0.764995	53.91573712	57.34432625	1.714294565	1.714294565
…	…	…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…	…	…
4.334509	3.127012	0.000445	7.420160678	7.502881447	0.041360385	0.041360385	0.106883	3.693726505	4.975291302	0.640782398	0.640782398
3.048736	2.586635	0	5.635370653	5.635370653	0	0	0.218666	2.132204974	3.965266073	0.916530549	0.916530549

FIGURE H-3. Life Expectancy (LE) and Health-Adjusted Life Expectancy (HALE) for Females and Males With Diabetes, Canada (Less Quebec, Nunavut and Northwest Territories), 2004 to 2006

Age	0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
LE, Females	74.9	74.3	70.5	65.5	60.9	56.5	52.3	47.7	43.2	38.7	34.4	30.1	26.0	22.0	18.4	14.9	11.8	9.1	7.0
LE, Males	70.9	70.3	66.5	61.5	56.8	52.2	47.9	43.8	39.5	35.3	31.0	26.9	23.0	19.3	15.9	12.7	9.8	7.5	5.6
HALE, Females	62.2	61.6	57.7	52.8	48.9	44.7	40.6	36.5	33.0	29.0	25.6	22.1	18.9	15.7	12.9	10.1	7.8	5.8	4.3
HALE, Males	60.1	59.5	55.6	50.6	46.4	43.0	38.8	35.1	31.4	27.6	24.0	20.6	17.5	14.5	11.8	9.2	6.6	4.3	3.0

SOURCES: Canadian Community Health Survey data files, Statistics Canada, 2000–2005, and Canadian Chronic Disease Surveillance System data files, 2004–2006

This chart was built in MS Excel using the output life table above. It shows life expectancy and health-adjusted life expectancy for people diagnosed with diabetes. *Low_diff* and *upper_diff* variables were used to build the confidence intervals for LE and HALE.

References for Appendix H

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