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Mortality Projections for Social Security Programs in Canada

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Foreword

Worldwide, the 20th century brought tremendous reductions in mortality at all ages for both males and females. The reductions in mortality, combined with the aging of the baby boomers and lower fertility rates, are projected to increase the proportion of the Canadian population aged 65 and older in the coming decades. This paper examines past mortality trends in Canada and discusses how these trends may change over the next 75 years, thus influencing the growth of the elderly population. In addition, this paper describes the methodology and assumptions used to project future mortality rates in Canada, including assumed annual rates of mortality improvement and resulting projected life expectancies. These projections by the Office of the Chief Actuary are used for the purpose of actuarial valuations of the Canada Pension Plan and the Canada's national Old Age Security Program. This paper also discusses mortality by causes of death, provides international mortality comparisons, and looks at stochastic time series methods that are used to help quantify the variability in the mortality rate projections.

I. Executive Summary

A. Purpose

The population of Canada is projected to age significantly over the coming decades. Increasing life expectancies, the aging of the baby boomers, and low fertility rates are the predominant factors that will contribute to the increase in the proportion of the elderly. As a result, the population at ages 65 and over is expected to increase significantly over the next 30 years. Older age groups will experience even higher rates of growth.

Prospects of longer life are viewed as a positive change for individuals and a substantial social achievement, but often lead to concern over their implications for public spending on old age support. The projected cost of public pensions in Canada is directly linked to the expected growth in the elderly population. In turn, the growth in the elderly population depends on how current mortality will evolve over the long term. The projection of mortality thus becomes a key element of any population projection.

The purpose of this report is to present an overview of the methodology and assumptions used by the Office of the Chief Actuary (OCA) for projecting the mortality component of the population projections that are in turn used to project the long-term financial status of the Canada's Old Age Security (OAS) Program and the Canada Pension Plan (CPP).

The OAS basic pension is a monthly benefit available to most Canadians aged 65 years or older, who meet residence and legal status requirements, subject to a repayment amount or recovery tax for those with sufficiently high income. The OAS Program includes a Guaranteed Income Supplement which is a monthly benefit paid to residents of Canada who receive the full or a partial OAS basic pension and who have little or no other income. In addition, the CPP pays a monthly retirement pension to people who have worked and contributed to the CPP. The CPP also acts as an insurance plan, providing disability, death, survivor, and children's benefits for those who qualify. The CPP provides monthly income in the case of disability and provides a monthly income to surviving spouses or common-law partners in the case of death.

The methodology and assumptions described in this report reflect those included in the 26th Actuarial Report on the Canada Pension Plan as at 31 December 2012 (Office of the Superintendent of Financial Institutions Canada, Office of the Chief Actuary, 2013). The mortality projections cover a long period of time (75 years) and the assumptions are determined by placing more emphasis on historical long-term trends than on recent short-term trends.

B. Scope

Section II presents an overview of historical Canadian population trends as presented in the 26th CPP Actuarial Report. Section III presents the mortality projections used in the report, along with the methodology used and international comparisons. Section IV details the implications of living to advanced ages. Section V breaks down mortality by cause and presents the impact on life expectancy of various scenarios. A brief look at the Old Age Security beneficiaries mortality is presented in Section VI, while Section VII does the same for beneficiaries of the Canada Pension Plan. Section VIII details the methodology used for the sensitivity analysis of the mortality rates in the 26th CPP Actuarial Report. The conclusions of the study follow in Section IX. Lastly, various appendices in Section X provide additional charts and further details in respect of the methodology used, and list the references used and contributors to this study.

C. Main Findings

- The chance of a newborn reaching age 65 has significantly increased over time, going from 57% in 1925 to 87% in 2010 for males, and from 60% to 91% for females over the same period. By 2075, it is projected that 93% of male newborns and 95% of female newborns will reach age 65.

- Over the recent 30 years from 1979 to 2009, increases in life expectancy in Canada have been largely due to the reduction of mortality rates after age 65, as a result of a decrease of deaths caused by diseases of the heart. Over the same period, malignant neoplasms surpassed diseases of the heart to become the most important cause of death among those aged 65 and older.

- Over the last decade in Canada, life expectancy at age 65 increased by two years, a rate of growth of about twice of what has been observed over each of the previous decades since 1929. It is further projected to increase from 21 to 24 years for men and from 23 to 26 years for women by 2075. This means that Canadians are expected to live beyond age 90 on average in the future.

- Life expectancies at birth of Canadians are projected to increase from 86 to 90 for men and from 89 to 93 for women over the period of 2013 to 2075.

- Currently, five out of ten Canadians aged 20 are expected to reach age 90, while only one out of ten is expected to live to 100.

- A life expectancy at birth of 100 years would be possible if no one died until one's late nineties, and if the same mortality rates at advanced ages as those experienced in 2009 applied.

- If mortality rates continue to decrease at the same rate as experienced over the last 15 years, a life expectancy at birth of 100 could be reached in 2094 for men and in 2121 for women. In addition, male life expectancy could exceed that of females from 2026 onward.

- It is expected that Canada will continue to have one of the highest life expectancies of the world along with Japan, France, Switzerland, Italy and Australia.

II. General Population Mortality Trends

Worldwide, the 20th century brought tremendous gains in life expectancies at all ages for both males and females. Relative to the entire period of human history, the 20th century was a time of exceptionally rapid rates of decline in mortality. Based on mortality levels in 1901 (Statistics Canada Abridged Life Tables), roughly 50 percent of the Canadian population would have died before reaching age 65. Based on mortality levels of today, about 10 percent of the Canadian population will die before reaching age 65. Since 1901, life expectancy at birth increased by an estimated 33 years in Canada with most of the change occurring before 1950. Life expectancy at age 65 has also increased dramatically, but in contrast to life expectancy at birth, most of the change occurred after 1950.

Table 1 reveals that the gap between female and male life expectancies at birth increased to reach over seven years by the mid-1970s. Since then, the gap has been narrowing as males have made greater gains in life expectancy compared to females. The gap between female and male life expectancies at age 65 has also narrowed but only more recently.

Table 1: Life Expectancies at Birth and Age 65 (Canada)[(1)]

	Life Expectancy at Birth			Life Expectancy at Age 65		
Year	**Males**	**Females**	**Difference**	**Males**	**Females**	**Difference**
1901	47.1	50.1	3.0	11.0	12.0	1.0
1911	50.9	54.2	3.3	11.3	12.4	1.1
1921	56.0	58.2	2.2	13.3	13.9	0.6
1931	59.0	61.7	2.6	13.3	14.2	0.8
1941	62.0	65.7	3.7	12.8	14.2	1.3
1951	66.4	70.9	4.4	13.4	15.0	1.6
1956	67.5	72.8	5.3	13.5	15.8	2.3
1961	68.4	74.5	6.1	13.6	16.3	2.7
1966	68.8	75.4	6.6	13.6	16.9	3.3
1971	69.6	76.6	7.0	13.9	17.6	3.7
1976	70.4	77.7	7.3	14.0	18.1	4.1
1981	72.0	79.1	7.1	14.7	19.0	4.3
1986	73.2	79.8	6.6	15.0	19.1	4.2
1989	73.9	80.4	6.5	15.3	19.6	4.3
1991	74.4	80.7	6.3	15.6	19.7	4.1
1996	75.4	81.1	5.7	16.0	19.9	3.9
1999	76.2	81.6	5.4	16.4	20.2	3.8
2001	76.9	82.0	5.1	17.0	20.4	3.4
2006	78.3	82.9	4.6	18.1	21.3	3.1
2009	79.0	83.4	4.4	18.6	21.7	3.1
2011	79.5	83.7	4.2	19.0	21.9	2.9
2012	79.8	83.9	4.1	19.2	22.0	2.8

(1) These are calendar year life expectancies based on the mortality rates of the given attained year. Years 1901 and 1911 are taken from Statistics Canada Abridged Life Tables. Years 1921 to 2009 are taken from the Canadian Human Mortality Database (CHMD). Years 2011 and 2012 are taken from the 26th CPP Actuarial Report.

The main reason for the slowdown in the rise of life expectancy at birth is due to the fact that infant and child mortality rates have declined significantly. Vaccinations and other medical interventions, together with improved sanitation and overall quality of life, have all contributed substantially to reducing infant and child mortality. As a result, those at younger ages have already experienced most of the increase in life expectancy they are likely to see.

Since mortality in the early years of life is very low, it is more difficult to raise life expectancy at birth.

Empirical evidence in Table 2 shows a slowdown in the rate of increase in life expectancy at birth between the first part and later part of the 20th century. Over the recent past 20 years (1989-2009), 59% of the increase in life expectancy for males (3.0 out of 5.1 years) came from mortality improvements (i.e. reductions in mortality rates) at ages 65 and over. For females, the corresponding proportion is 67% (2.0 out of 3.0 years) over the same period. These proportions reached 75% (2.1 out of 2.8 years) for males and 83% (1.5 out of 1.8 years) for females over the most recent 10-year period (1999-2009), and this trend is expected to continue in the future. As a result, life expectancy of the Canadian population at age 65 has grown by almost two years (from 18.6 to 20.5 years) over the last 10 years (1999-2009), a rate of growth of about twice of what has been observed over each of the previous decades since 1929. Furthermore, as highlighted in Table 3, the increase in life expectancy at age 65 is now (1999-2009) mainly the result of improvements in mortality coming from ages 75 and over (60% of the increase for males and 80% of the increase for females).

Table 2: Contribution to Increase in Life Expectancy at Birth (by age group, 1929-2009)

	1929-1949		1949-1969		1969-1989		1989-2009		1999-2009	
Change attributable to	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Infant (<1)	4.1	3.2	1.9	1.6	1.0	0.8	0.2	0.1	0.0	0.0
Child (1-14)	2.3	2.3	0.6	0.6	0.4	0.3	0.1	0.1	0.1	0.1
Young adult (15-44)	1.9	3.0	0.4	1.0	0.7	0.5	0.7	0.2	0.3	0.1
Older adult (45-64)	0.2	1.1	0.3	1.1	1.5	0.9	1.4	0.6	0.5	0.3
Elderly (65+)	0.5	1.1	0.3	2.1	1.3	2.0	3.0	2.0	2.1	1.5
Multivariate Effect	-0.1	-0.2	-0.1	-0.2	-0.1	-0.2	-0.3	-0.1	-0.2	-0.1
Change in Life Expectancy	8.9	10.6	3.5	6.2	4.7	4.4	5.1	3.0	2.8	1.8

Table 3: Contribution to Increase in Life Expectancy at Age 65 (by age group, 1929-2009)

	1929-1949		1949-1969		1969-1989		1989-2009		1999-2009	
Change attributable to	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Age Group 65-74	0.3	1.0	0.1	1.3	1.1	0.9	1.7	0.8	0.9	0.4
Age Group 75-79	0.3	0.4	0.1	0.6	0.3	0.5	0.8	0.5	0.5	0.3
Age Group 80-84	0.1	0.2	0.1	0.4	0.1	0.4	0.6	0.5	0.4	0.3
Age Group 85-89	0.1	0.1	0.1	0.2	0.1	0.3	0.3	0.3	0.3	0.3
Age Group 90+	0.0	0.0	0.0	0.1	0.0	0.2	0.2	0.2	0.2	0.3
Multivariate Effect	-0.1	-0.1	0.0	-0.2	-0.1	-0.2	-0.2	-0.1	-0.2	-0.1
Change in Life Expectancy	0.8	1.6	0.4	2.4	1.6	2.2	3.3	2.1	2.3	1.5

III. Mortality Projections for Social Security Programs in Canada

A. Methodology and Assumptions for Population Mortality Projections

The methodology and assumptions used for mortality projections that are presented in this section are taken from the 26th CPP Actuarial Report. The "best-estimate" mortality assumptions reflect the best judgment of the Office of the Chief Actuary as to the future pattern of mortality by age and sex of the Canadian population.

1. Annual Rates of Mortality Improvement

The mortality rates from the Université de Montréal, Canadian Human Mortality Database (CHMD), are the starting point for the mortality rate projections. According to the CHMD, life expectancies at birth for males and females in Canada were 79.0 years and 83.4 years, respectively, in 2009.

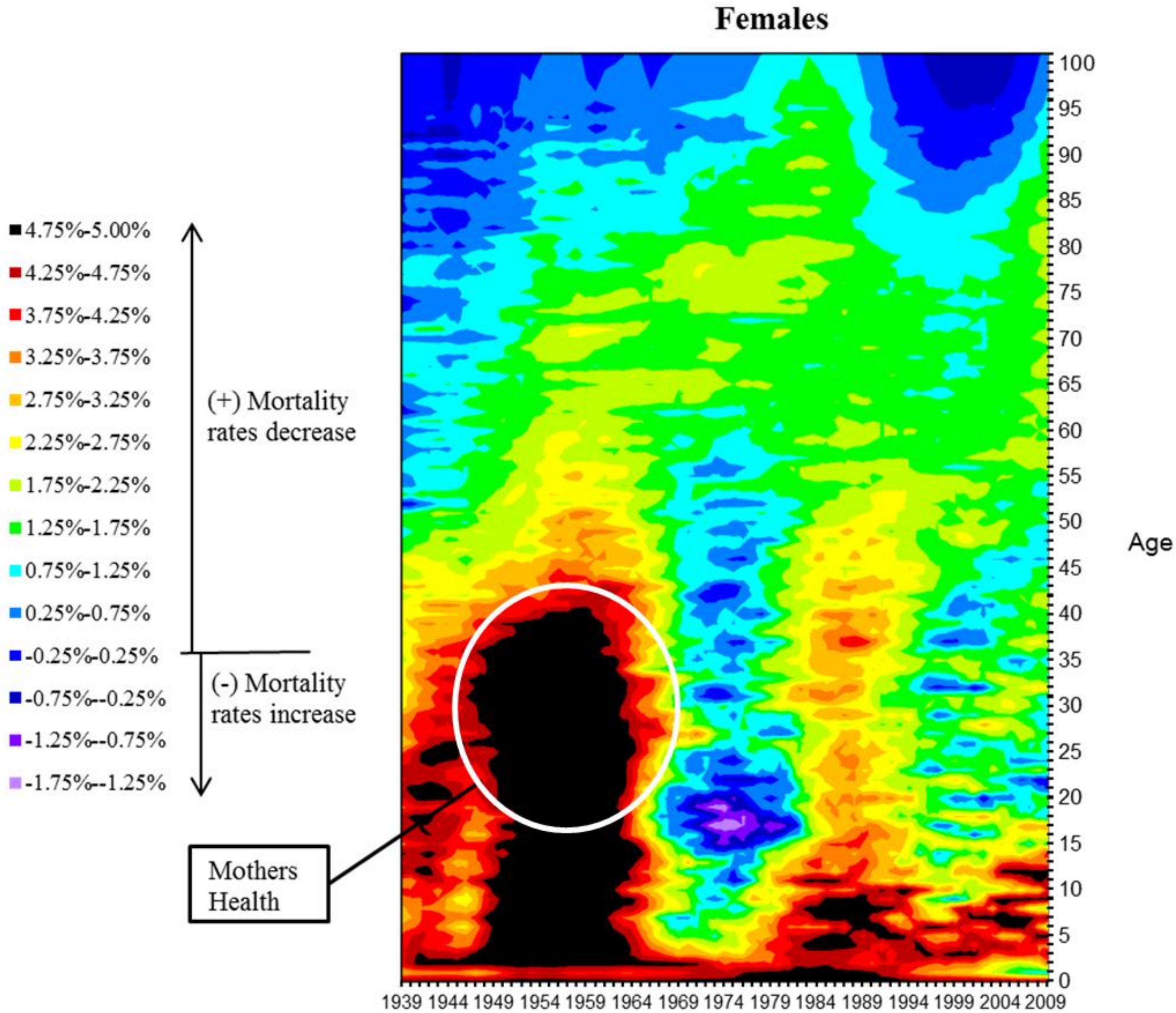
The methodology used to project future mortality rates involves making assumptions about future annual rates of mortality improvement by age, sex, and calendar year. Several future factors may affect mortality improvements including new medical techniques and discoveries, the level of pollutants, air quality, improvements in nutrition, amounts of physical activity, prevalence of obesity and diabetes, emergence of new forms of diseases, prevalence of smoking, health education, etc. As such, the projections of future mortality rates are developed by first examining past mortality trends and then applying judgment as to the magnitude of the impact these trends will have on future mortality improvement rates (MIRs).

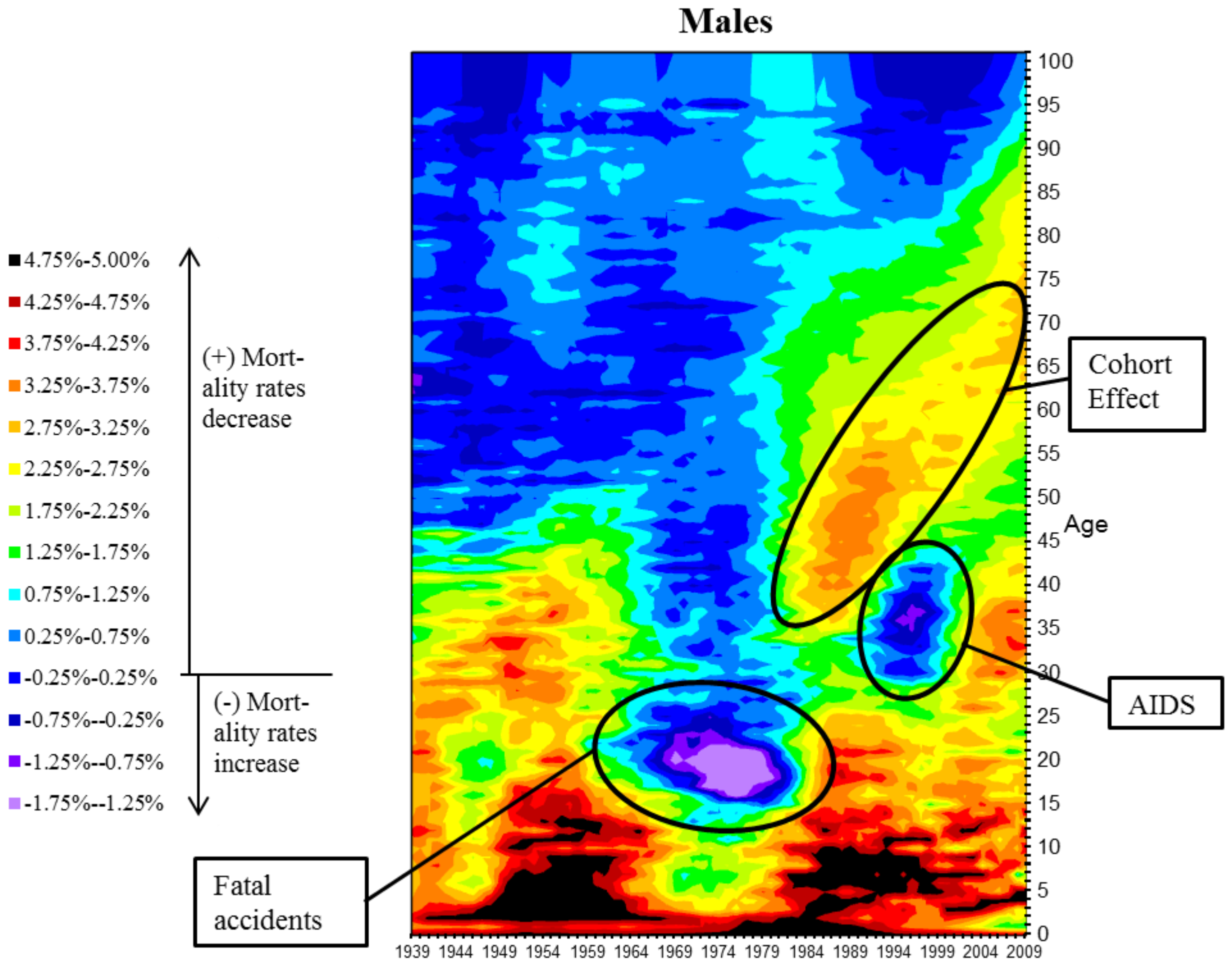
This section describes the setting of initial and ultimate MIRs assumptions. It also describes how the initial MIRs are assumed to converge to ultimate MIRs over a transition period, as well as the trends that were taken into consideration to develop the intermediate period assumptions.

For the purpose of the 26th CPP Actuarial Report, the OCA analysed Canadian experience using methodologies that were developed by the Continuous Mortality Investigation (CMI) group of the Institute and Faculty of Actuaries in the United Kingdom. In addition, in developing the intermediate period MIRs assumptions, the OCA used tools that were provided by the CMI. In particular, the cohort elements of the tools were incorporated into the OCA's model.

Heat maps of the historical MIRs used to analyse the Canadian experience and to develop assumptions for the transition period are shown in Chart 1. This chart shows 15-year moving averages of annual MIRs ending in the given years by age for Canadian males and females. The averaging period of 15 years was chosen since it provides both sufficient smoothness and the level of detail required for the projections. In addition, an averaging period of 10 years was used when significant recent trends were masked by averaging over a 15-year period. The heat maps were developed using the CHMD mortality rates.

Chart 1: Historical Annual MIRs (Canada)
(15-year Moving Average based on CHMD Mortality Rates)





Although there has been a substantial reduction in mortality rates over time, there have been periods with low or even negative mortality improvements (i.e. little change or increase in mortality), as shown in Chart 1. Furthermore, these periods have been more evident for males than females. The most recent deterioration in mortality rates was observed in the 1990s for males aged late 20s to early 40s, which was due to increasing mortality from AIDS.

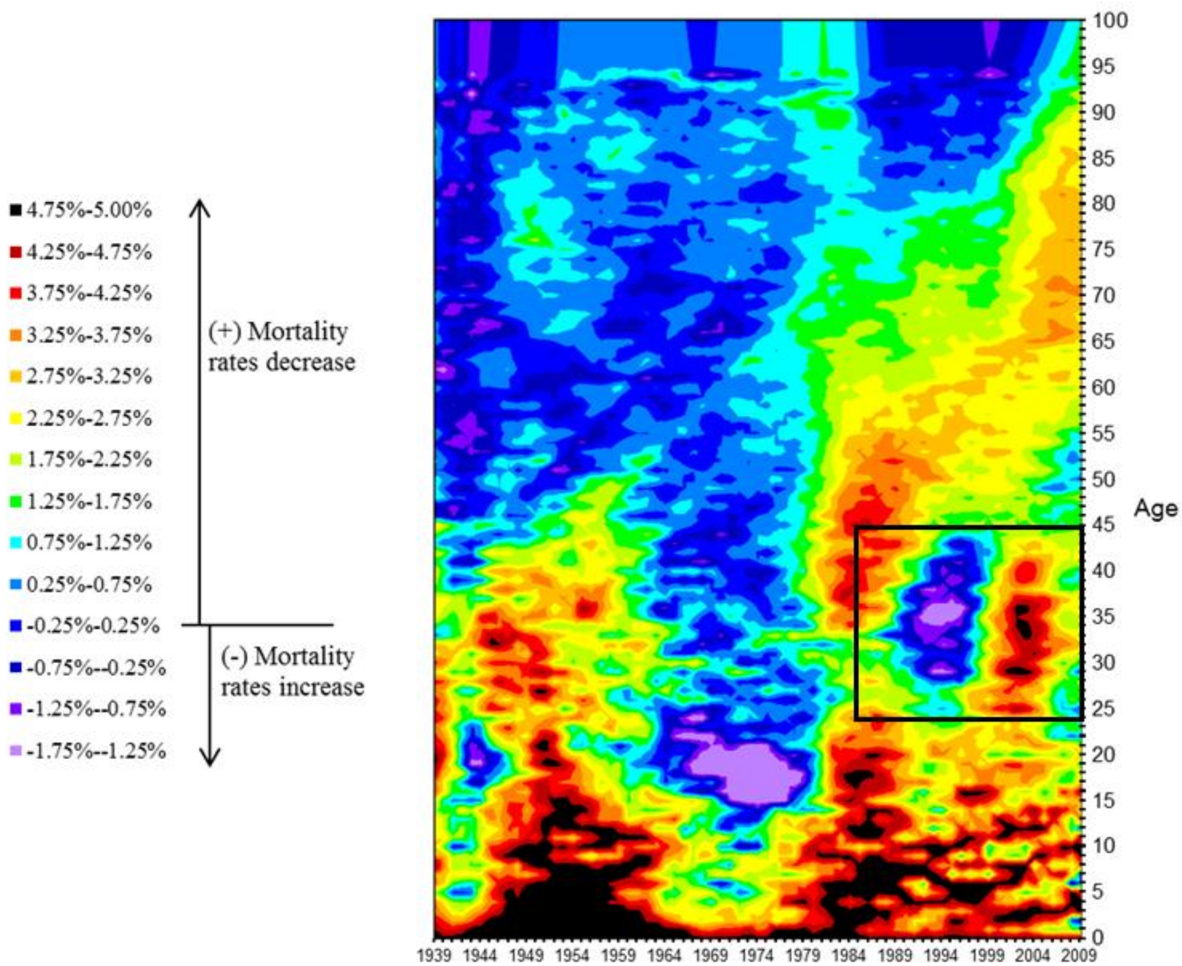
Mortality improvement rates for any given age, sex, and calendar year may be regarded as a combination of age, year, and cohort components or effects. Age effects are seen as horizontal bands or patterns on heat maps, calendar year effects as vertical patterns, and cohort effects as diagonal ones.

Looking at the heat maps of Chart 1, it can be seen that, for example, the age effect is present for both sexes at the very young ages. Improvements in mortality for these ages were very strong. A significant calendar year effect is seen for females aged less than 45 in the 1950s and early 1960s. This can be explained by the decline of deaths from pregnancy- and birth-related causes, referred to as the “Mothers Health” effect in Chart 1. These reductions were made possible by “dramatic improvement in maternity care, including improvements in sepsis control, the availability of blood transfusions, the introduction of antibiotics, access to safe cesarean sections and abortion services, and, where abortion is illegal and therefore unsafe, access to effective post abortion care”, as stated by Mavalankar and Rosenfield (2005). Mortality improvement rates during that decade were close to 5% per year.

There is no discernible cohort effect observed from the historical data for Canadian females. Therefore, no cohort component was assumed for the projections of the female MIRs for the 26th CPP Actuarial Report. Instead, the female MIRs were projected solely as a function of age and calendar year.

It could be argued that a cohort effect exists for males born between the 1930s and the 1940s. In addition, Chart 1 seems to indicate that another cohort effect is currently developing for males aged approximately 30 to 44 in 2009. However, an analysis of the heat map for males based on 10-year moving averages of annual improvement rates shows that high MIRs at these ages from the end of the 1990s to mid-2000s represent a recovery effect subsequent to the higher AIDS-related mortality around the mid-1990s (see black box in Chart 2). Moreover, this effect seems to be quickly disappearing.

Chart 2: Historical Male Annual MIRs (Canada)
(10-year Moving Average based on CHMD Mortality Rates)

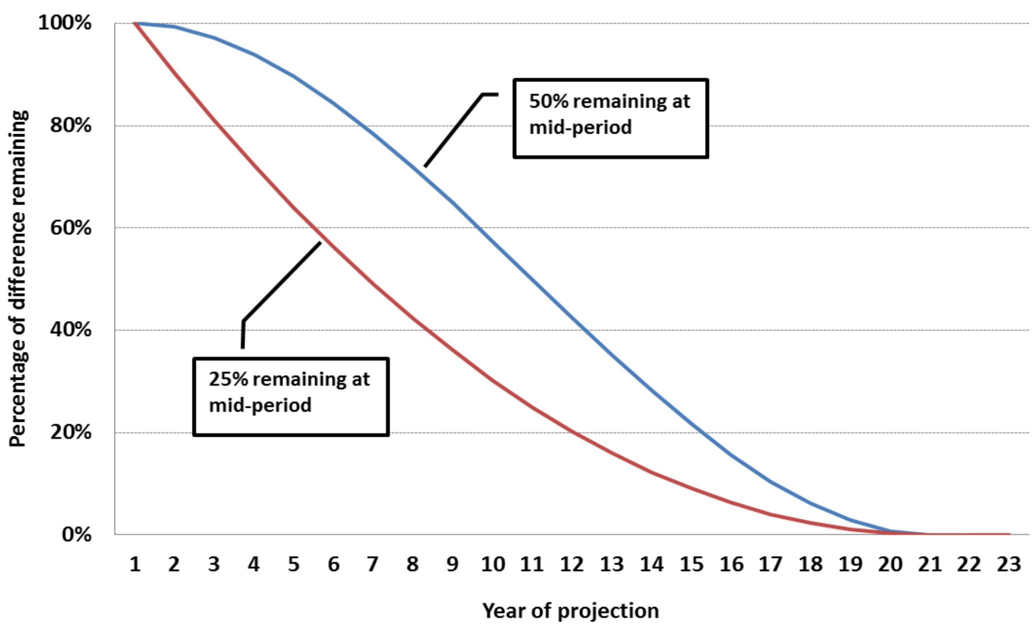


Thus, a cohort component together with a combined age and period component were incorporated into the projections for males aged 60 to 74 in 2010. It was assumed that the cohort component of the MIRs has a maximum value of 0.5% in 2010. Furthermore, it was assumed that the cohort component converges to zero over a period of 10 years, with 50% of the initial value remaining at the mid-period.

For the remaining ages, no cohort component was assumed for males, and the 26th CPP Actuarial Report male MIRs were projected solely as a function of age and calendar year.

The recent trends in mortality improvement rates were used to determine the pace of the transition from the initial to ultimate mortality improvement rates. Chart 3 presents two patterns of convergence that were used for the age and period components of the MIRs. These patterns show the proportions of the differences between initial and ultimate MIRs left at each year of the transition period. Each pattern included is defined by a fixed percentage of this difference left at the middle of the transition period, specifically 25% and 50%. It is clearly seen that the lower percentage of the difference remaining at the middle of the transition period results in a steeper decline in the MIRs and thus lower MIRs during the transition period.

Chart 3: Convergence algorithms



For females younger than age 60, Chart 4 shows that the mortality improvement rates were generally decreasing or have been relatively stable over recent years. For females in older age groups (60-74 and 75-89), Chart 5 shows that while an analysis based on 15-year moving average indicates an upward trend in the improvement rates since the late 1990s, analysis based on 10-year moving averages reveals that a stabilization in these rates has occurred more recently.

Chart 4: Female MIRs (15-59, Canada)
(15-year moving average)

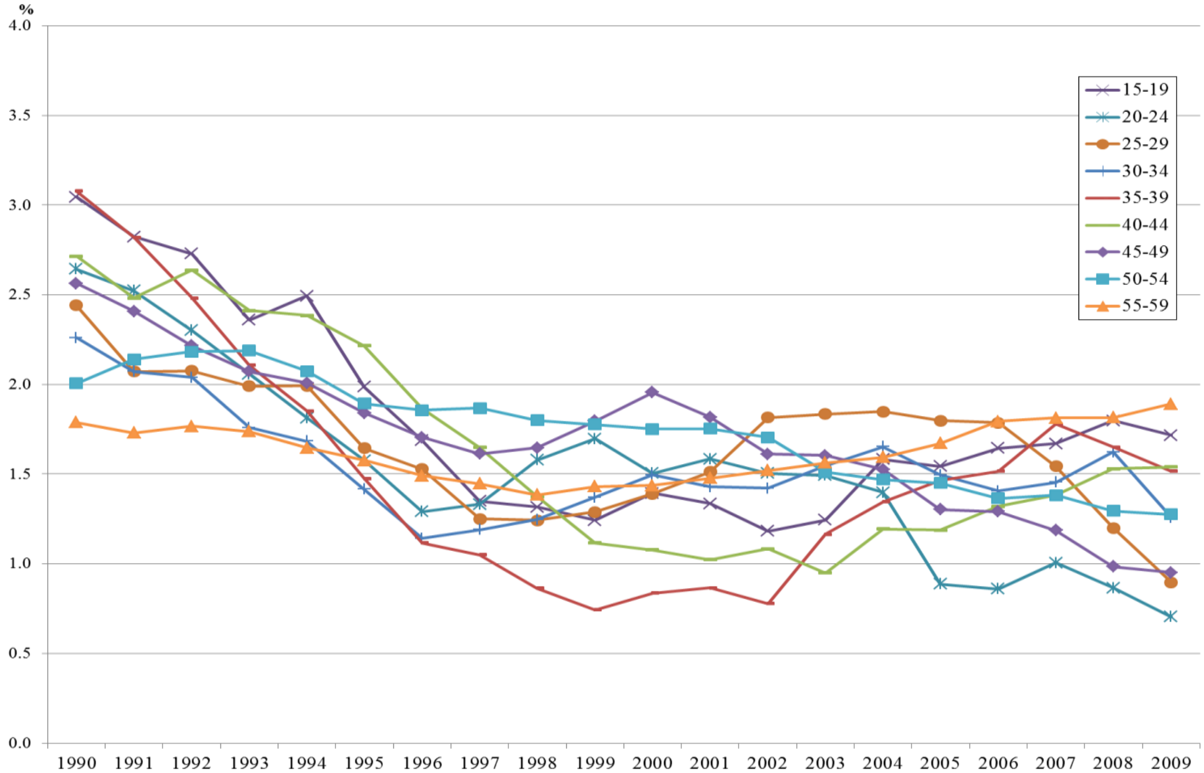
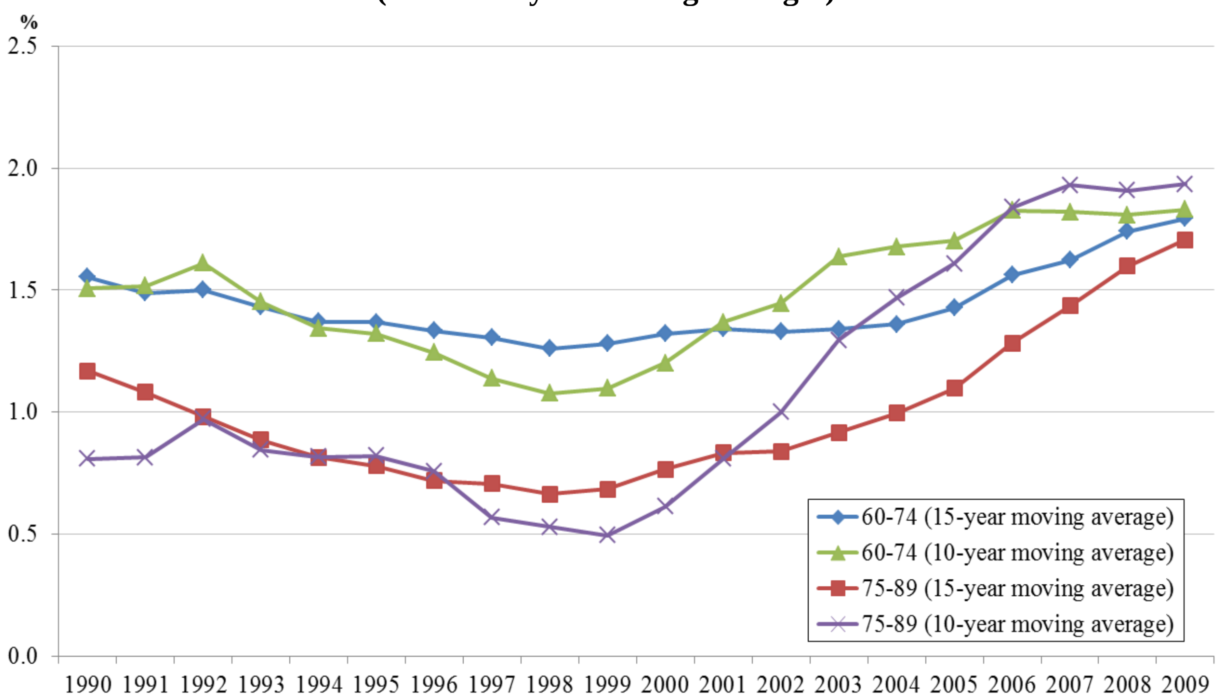


Chart 5: Female MIRs (60-89, Canada)
(10 and 15-year moving averages)



As a result, it was assumed that female MIRs will gradually decline and that the transition for all ages will follow the pattern shown in Chart 3 with 50% of the difference between the initial and ultimate rates remaining at the midpoint of the transition period (2020 for Canada).

For males younger than age 60, Chart 6 shows that the MIRs have been generally decreasing in recent years. In addition, as discussed earlier for ages 30 to 44, the pace of decrease has been quite significant. For male older age groups, Chart 7 shows that while the analysis based on 15-year moving averages indicates an upward trend in the improvement rates, analysis based on 10-year moving averages reveals a reversal of the upward trend more recently.

It was thus assumed for males aged 30 to 44 in 2010 that the MIRs will decline relatively quickly, and that the transition will follow the pattern shown in Chart 3 with 25% of the difference between the initial and ultimate rates remaining at the midpoint of the transition period. For the remaining age groups, the combined age and period component of the transition follows the other pattern shown in Chart 3 (with 50% of the difference remaining at the midpoint of the transition period).

Chart 6: Male MIRs (15-59, Canada)
(15-year moving average)

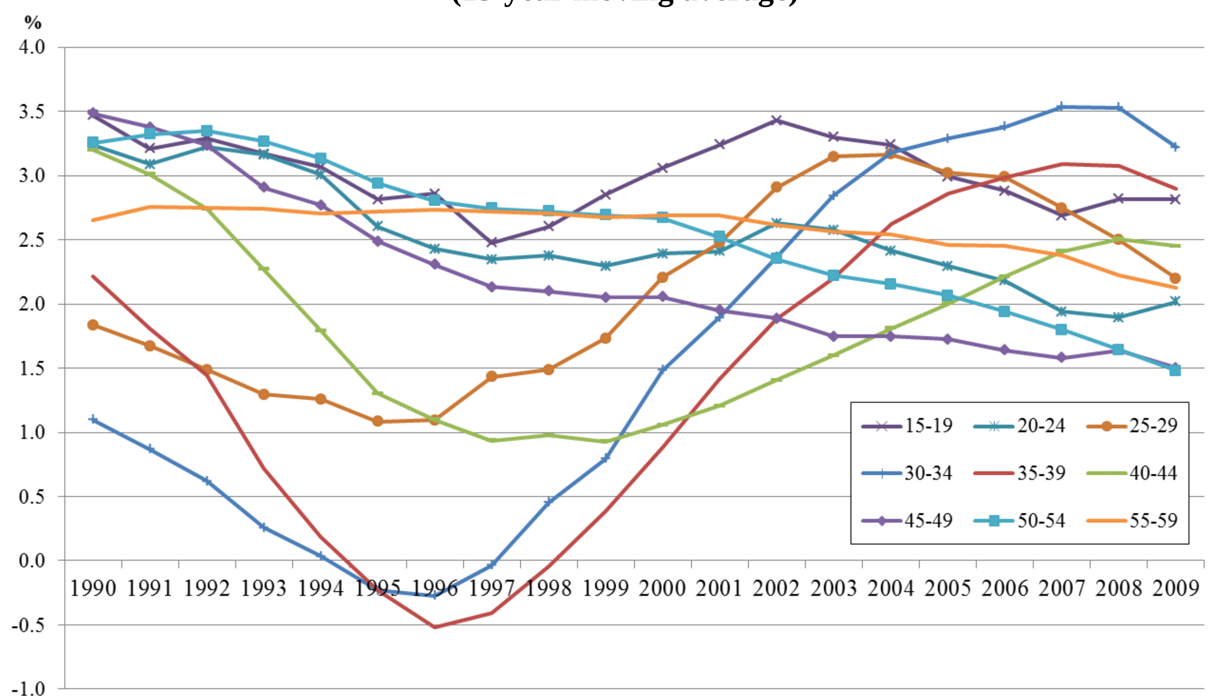
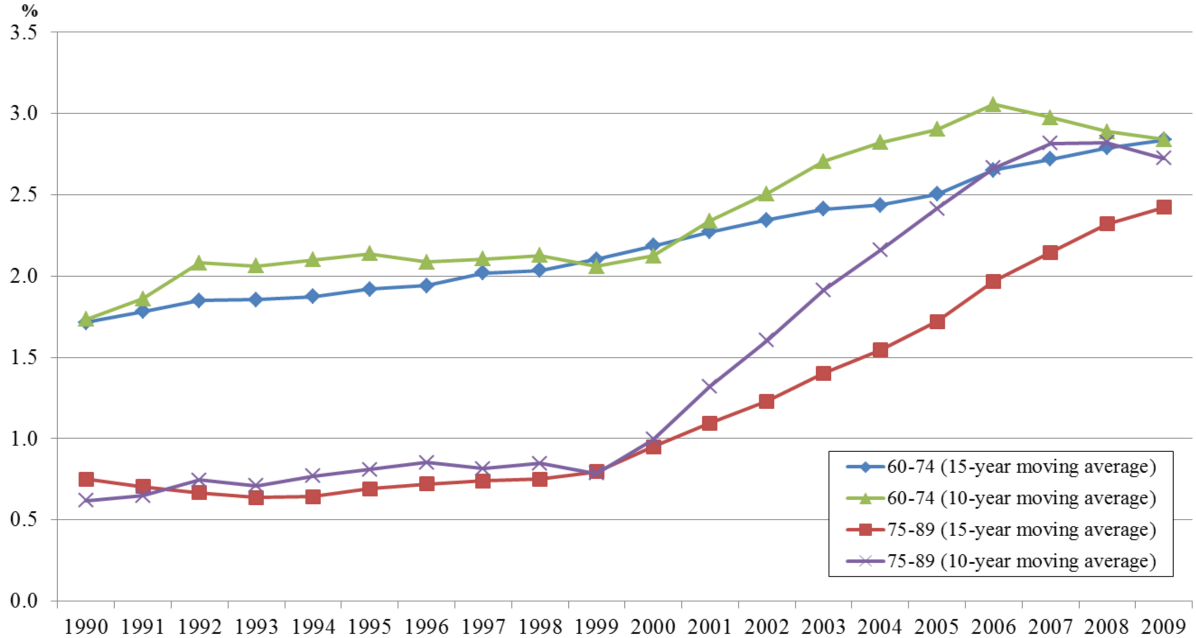


**Chart 7: Male MIRs (60-89, Canada)
(10 and 15-year moving average)**



Charts 8 and 9 present the heat maps of the historical and projected mortality improvement rates for males and females in Canada. It illustrates the projected smooth transition from recent historical mortality improvement rates to the assumed ultimate rates.

Chart 8: Historical and Projected Male MIRs (Canada)
(15-year moving average based on CHMD)

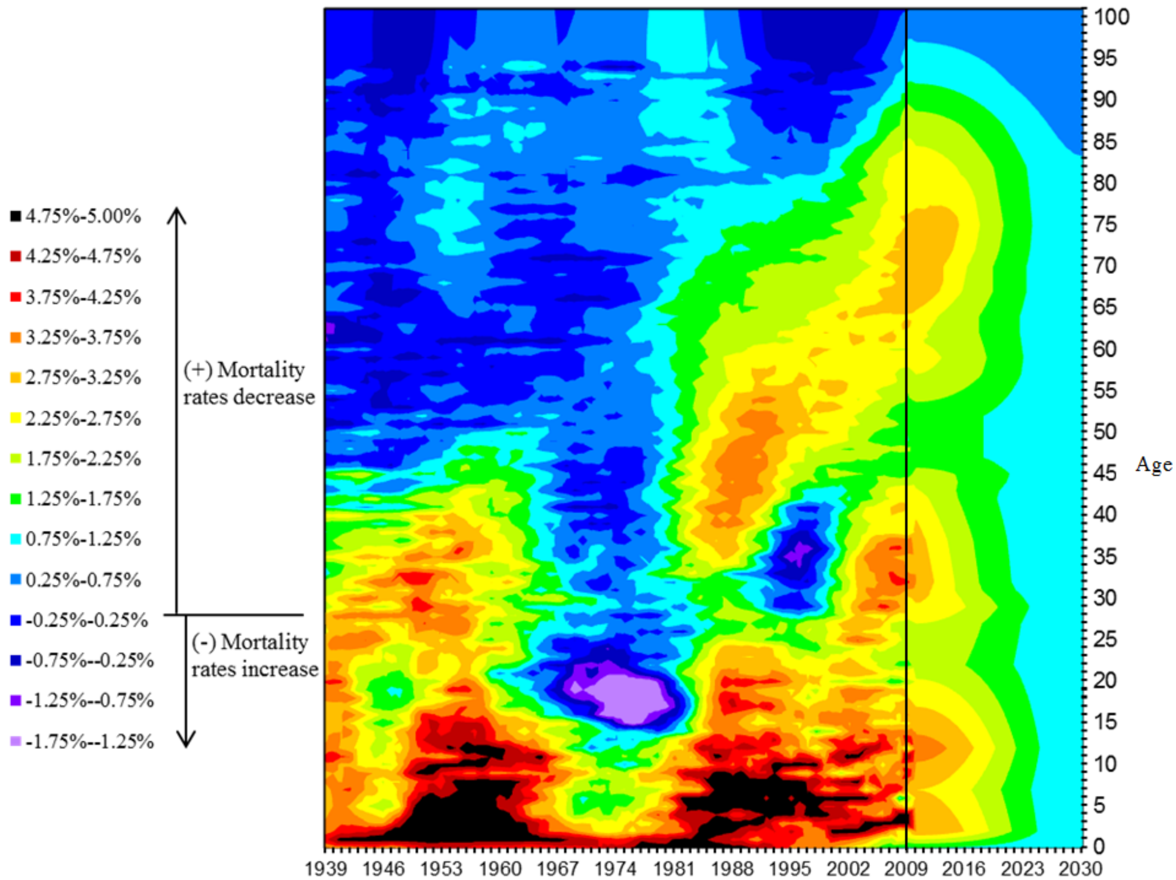
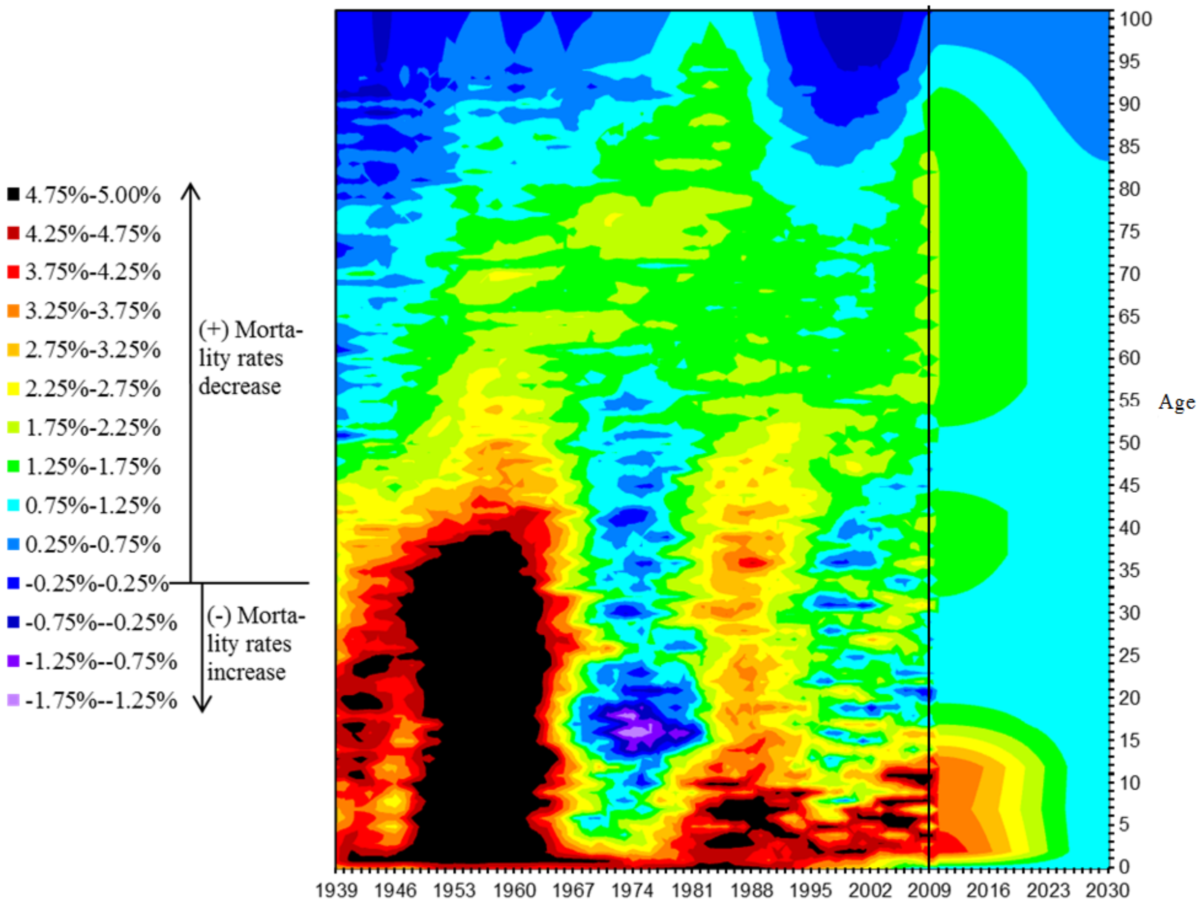
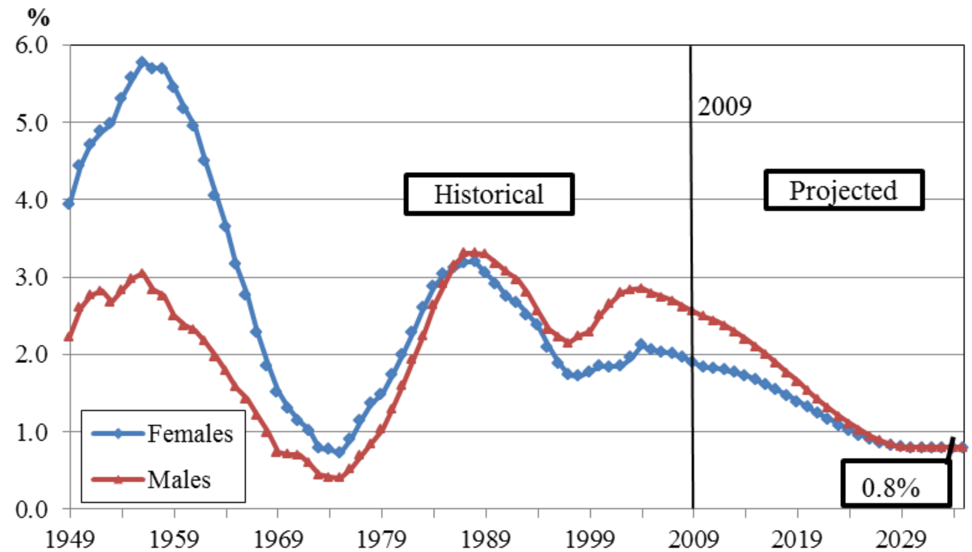


Chart 9: Historical and Projected Female MIRs (Canada)
(15-year moving average based on CHMD)



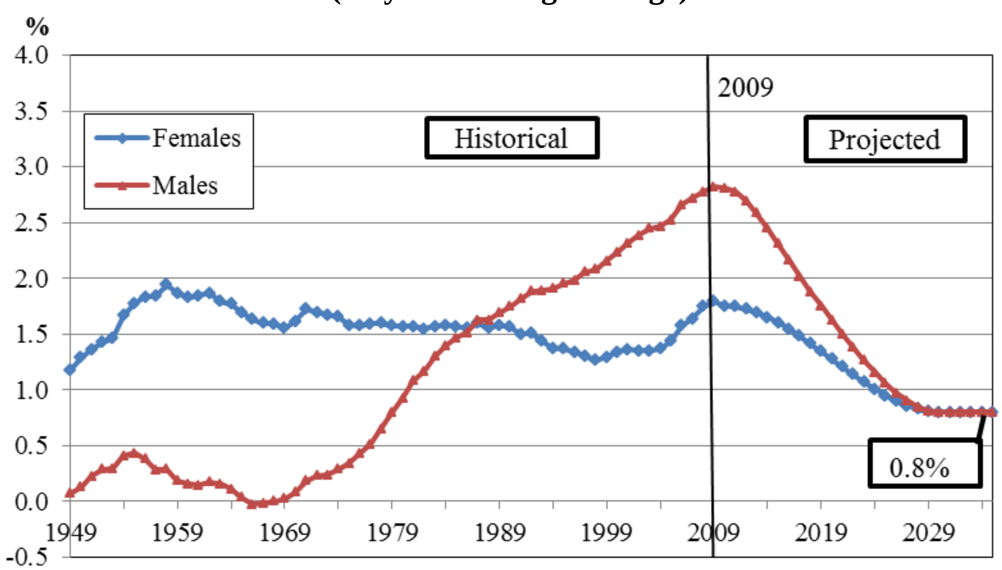
The following Charts 10 to 14 present historical MIRs (based on 15-year moving averages ending in the given years) and assumed future MIRs by age group for males and females. For the age group 0-59 (Chart 10), the most recent downward trend starting at the end of the 1990s is evident and is assumed to continue into the future. The ultimate MIR for years 2030 and thereafter for this age group, for both sexes, is assumed to be 0.8% per year.

Chart 10: Historical and Projected MIRs (0-59, Canada)
(15-year Moving Average)



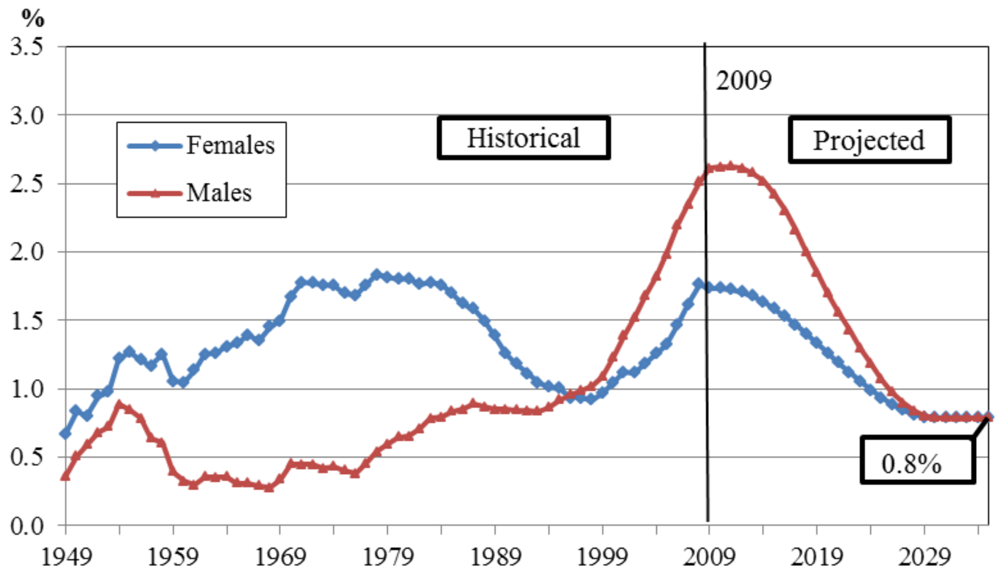
For ages 60-74 (see Chart 11), male improvement rates have been increasing for the last 40 years and are projected to continue to increase for a few more years due to the cohort effect. The MIRs for this age group are expected to reach an ultimate value of 0.8% in 2030. For females aged 60-74, improvement rates have been decreasing over the last 20 years. Although female MIRs have increased in recent years, they are expected to revert to their historical decreasing trend. The MIRs for both males and females are assumed to reach an ultimate level of 0.8% by 2030.

Chart 11: Historical and Projected MIRs (60-74, Canada)
(15-year Moving Average)



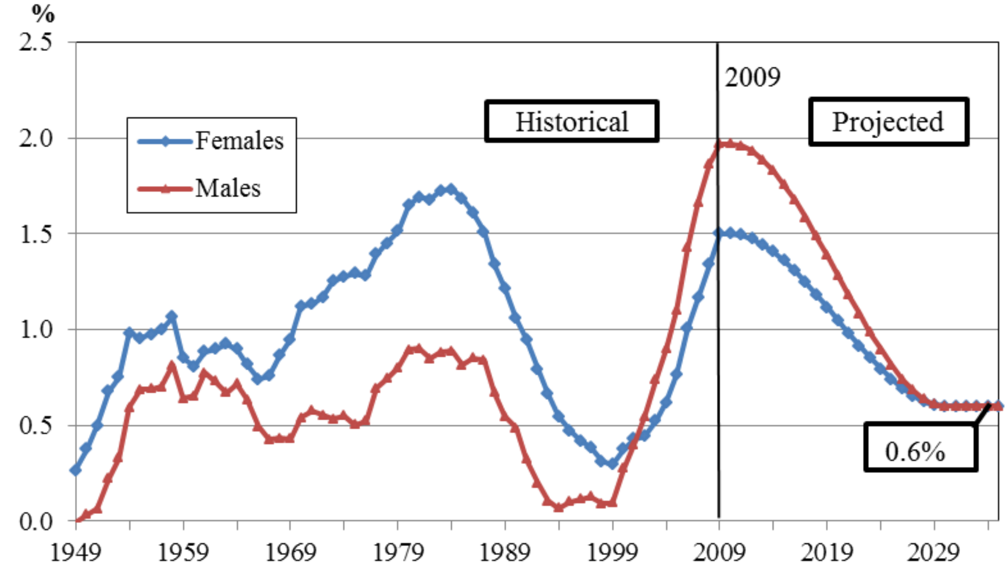
For the age group 75-84 (see Chart 12), both male and female MIRs have been steadily increasing over the last 10 years. However, as shown in Charts 5 and 7 (10-year averaging curves), older age group MIRs have started to stabilize for females and decrease for males. Therefore, it is assumed that MIRs for ages 75 to 84, for both sexes, will stabilize over the next few years before starting to decline to an ultimate value of 0.8% in 2030.

Chart 12: Historical and Projected MIRs (75-84, Canada)
(15-year Moving Average)



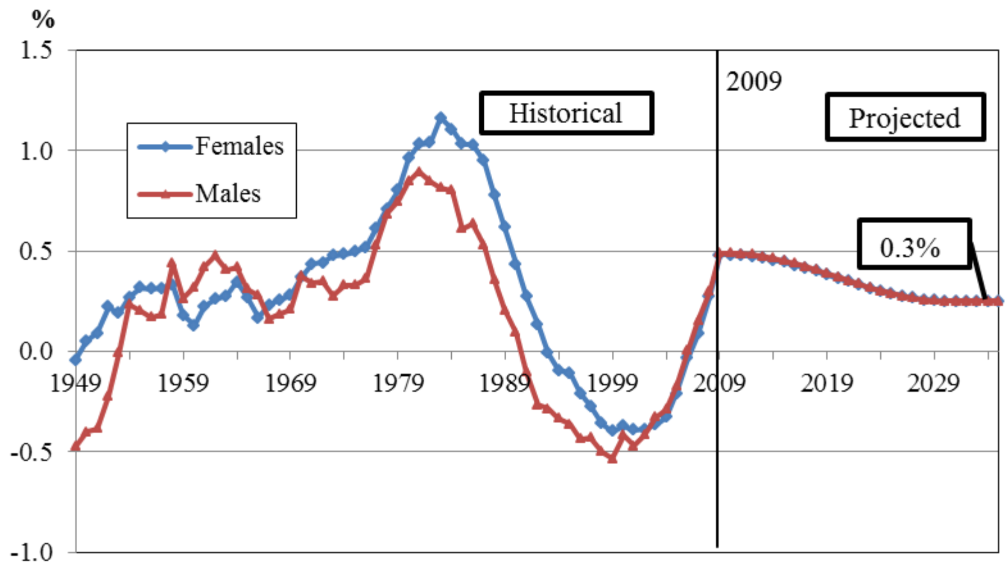
Historically, MIRs for ages 85-89 (see Chart 13) have shown a similar pattern as for ages 75-84, and this is expected to continue in the future. It was considered that at older ages it becomes more difficult to realize gains in mortality since death may result from simultaneous multiple medical conditions. Thus, although the MIRs for both males and females have steadily increased for the last 10 years, they are expected to stabilize and then decline to reach an ultimate value of 0.6% in 2030.

Chart 13: Historical and Projected MIRs (85-89, Canada)
(15-year Moving Average)



Finally, for ages 90 and above, Chart 14 shows that male and female MIRs have been very close for the past 10 years and are expected to remain so in the future. It is projected that the rates will decrease to reach an ultimate value of 0.3% in 2030.

Chart 14: Historical and Projected MIRs (90+, Canada)
(15-year Moving Average)



Thus, the initial 2010 annual mortality improvement rates are assumed to vary by age and sex and are set equal to the average annual MIRs experienced in Canada over the last 15 years (1994-2009). Table 4 shows the resulting rates by age and sex that are assumed to apply for the year 2010, the intermediate (transition) period (2011-2029) and ultimately (2030+). The initial annual MIRs are assumed to gradually reach their ultimate values over a period of 20 years (in 2030). The assumed ultimate MIRs are based on the historical experience of females only. Male improvement rates are currently higher than female rates, but are assumed to be the same as female rates for years 2030 and thereafter. Ultimate rates for males and females are set equal to half the value of the average experience for females over the 15 to 20-year periods ending in 2009. For years 2030 and thereafter, the ultimate annual MIRs vary by age only and not by sex or calendar year.

Table 4: Assumed Annual MIRs (Canada)

	Males			Females		
Age	**2010**	**2011-2029**	**2030+**	**2010**	**2011-2029**	**2030+**
	%	%	%	%	%	%
0	1.3	1.0	0.8	0.8	0.8	0.8
1-14	3.1	1.9	0.8	3.5	2.2	0.8
15-44	2.6	1.6	0.8	1.3	1.1	0.8
45-64	2.0	1.4	0.8	1.5	1.1	0.8
65-74	3.0	1.8	0.8	1.8	1.3	0.8
75-84	2.6	1.7	0.8	1.7	1.3	0.8
85-89	2.0	1.3	0.6	1.5	1.1	0.6
90-94	1.3	0.8	0.4	1.2	0.8	0.4
95+	0.4	0.3	0.2	0.4	0.3	0.2

2. Projection Results

This section presents the projected mortality rates by age and sex along with other resulting mortality measures. Table 5 shows that the projected mortality rates continuously decrease over the long term. For example, the mortality rate for a 65-year-old male is expected to decrease from 11.6 deaths per 1,000 people in 2013 to 6.4 deaths per 1,000 people in 2075. The gap between male and female mortality rates for a given age is also projected to decrease over the long term.

Table 5: Mortality Rates (Canada)
(annual deaths per 1,000 people)

	Males				Females			
Age	**2013**	**2025**	**2050**	**2075**	**2013**	**2025**	**2050**	**2075**
0	4.85	4.28	3.50	2.86	4.58	4.17	3.41	2.79
10	0.11	0.09	0.07	0.06	0.10	0.07	0.06	0.05
20	0.62	0.51	0.42	0.34	0.27	0.24	0.19	0.16
30	0.73	0.59	0.48	0.39	0.38	0.34	0.28	0.23
40	1.17	0.99	0.81	0.66	0.79	0.69	0.56	0.46
50	3.20	2.78	2.27	1.86	2.08	1.85	1.51	1.24
60	7.32	6.03	4.92	4.02	4.78	4.08	3.33	2.72
65	11.56	9.52	7.76	6.35	7.42	6.34	5.18	4.24
70	17.91	14.45	11.78	9.64	11.79	10.07	8.22	6.72
75	29.20	22.99	18.73	15.32	19.43	16.59	13.55	11.08
80	50.08	40.37	32.91	26.92	33.95	28.99	23.67	19.37
85	85.15	71.11	59.77	50.40	61.47	53.37	44.92	37.87
90	142.28	125.35	110.90	98.33	110.05	98.21	86.93	77.08
100	319.64	302.44	280.38	260.09	287.41	271.95	252.12	233.87

Life expectancies of Canadians are assumed to continue to grow, but at a slower rate than what was experienced in the 20th century. For the period 2013 to 2075, life expectancy for male newborns is projected to increase from 80.0 years to 85.7 years. For female newborns, the increase is projected to be from 84.0 years to 88.6 years. These life expectancies are referred to as period life expectancies since they are based on the mortality rates of the given year.

On the other hand, cohort life expectancies take into account future mortality improvements after the given year. The projected increases in cohort life expectancies at birth are from 86.1 years in 2013 to 90.1 years in 2075 for males and from 89.1 to 92.5 years for females over the same period. Given the continuing trend toward increasing longevity, cohort life expectancies are considered to be more realistic than period life expectancies.

Life expectancies have increased considerably over the last 30 years, and this is reflected in the projected growth in the near term. Thereafter, there is a projected slowdown in life expectancy growth consistent with the lower MIRs assumed for years 2030 and thereafter. It is also projected that the gap in life expectancies between females and males will continue to narrow over time. However, it is not anticipated that this gap will disappear altogether.

A comparison between period and cohort life expectancies is presented in Tables 6 and 7. Table 6 shows the projected period life expectancies at various ages for selected years, while Table 7 shows cohort life expectancies. Table 8 presents the median life expectancies, which correspond to the number years an individual a given age is expected to live with a 50% probability. Median life expectancy differs from cohort life expectancy in that the median represents the number of years lived before half the cohort has died, while cohort life expectancy represents the average number of years expected to be lived by the cohort. The historical and projected evolution of period and cohort life expectancies at birth for males and females is displayed in Chart 15, and a similar evolution at age 65 is displayed in Chart 16.

Mortality improvements have more of an impact on increasing expected lifetimes at younger ages than at older ages, since there is more time starting from the younger ages for improvements to have effect, and the improvement factors decrease with age. For instance, by 2075, mortality improvements lead to about a four-year increase in expected lifetimes for both male and female newborns, compared to those without such improvements (that is, 90.1 minus 85.7, or 4.4 years for males and 92.5 minus 88.6, or 3.9 years for females). At age 30, this difference decreases to 2.7 years for males and 2.5 years for females, and by age 85, it falls to 0.1 of a year for males and 0.2 of a year for females.

Table 6: Period Life Expectancies [(1)]

	Males				Females			
Age	**2013**	**2025**	**2050**	**2075**	**2013**	**2025**	**2050**	**2075**
0	80.0	82.0	83.9	85.7	84.0	85.4	87.1	88.6
10	70.5	72.4	74.3	76.0	74.5	75.8	77.4	78.9
20	60.7	62.6	64.4	66.1	64.6	65.9	67.5	69.0
30	51.1	52.9	54.7	56.4	54.8	56.1	57.6	59.1
40	41.5	43.3	45.0	46.6	45.0	46.3	47.8	49.3
50	32.2	33.9	35.5	37.1	35.5	36.8	38.2	39.6
60	23.5	25.1	26.5	27.9	26.5	27.6	29.0	30.2
65	19.4	20.9	22.3	23.5	22.2	23.2	24.5	25.7
70	15.6	17.0	18.2	19.3	18.1	19.0	20.2	21.3
75	12.1	13.3	14.3	15.3	14.2	15.1	16.1	17.1
80	9.1	10.0	10.8	11.6	10.7	11.5	12.3	13.1
85	6.6	7.2	7.8	8.4	7.8	8.3	8.9	9.5
90	4.6	5.0	5.4	5.8	5.4	5.8	6.2	6.6
100	2.3	2.5	2.7	2.9	2.6	2.7	2.9	3.1

(1) Period life expectancies are based on the mortality rates of the given attained year.

Table 7: Cohort Life Expectancies [(1)]

	Males				Females			
Age	**2013**	**2025**	**2050**	**2075**	**2013**	**2025**	**2050**	**2075**
0	86.1	86.9	88.6	90.1	89.1	89.9	91.3	92.5
10	75.9	76.7	78.4	79.9	79.0	79.7	81.1	82.4
20	65.3	66.2	67.9	69.4	68.5	69.2	70.7	72.0
30	55.0	55.8	57.5	59.1	58.1	58.8	60.3	61.6
40	44.7	45.5	47.2	48.7	47.7	48.4	49.9	51.3
50	34.7	35.5	37.1	38.6	37.6	38.3	39.8	41.1
60	25.3	26.1	27.5	28.9	27.9	28.6	30.0	31.2
65	20.9	21.7	23.0	24.3	23.3	24.0	25.3	26.5
70	16.7	17.5	18.7	19.9	19.0	19.6	20.8	21.9
75	12.9	13.6	14.7	15.7	14.9	15.5	16.5	17.5
80	9.5	10.2	11.0	11.9	11.2	11.7	12.5	13.4
85	6.8	7.3	7.9	8.5	8.0	8.4	9.1	9.7
90	4.7	5.0	5.4	5.8	5.5	5.8	6.3	6.7
100	2.4	2.5	2.7	2.9	2.6	2.7	2.9	3.1

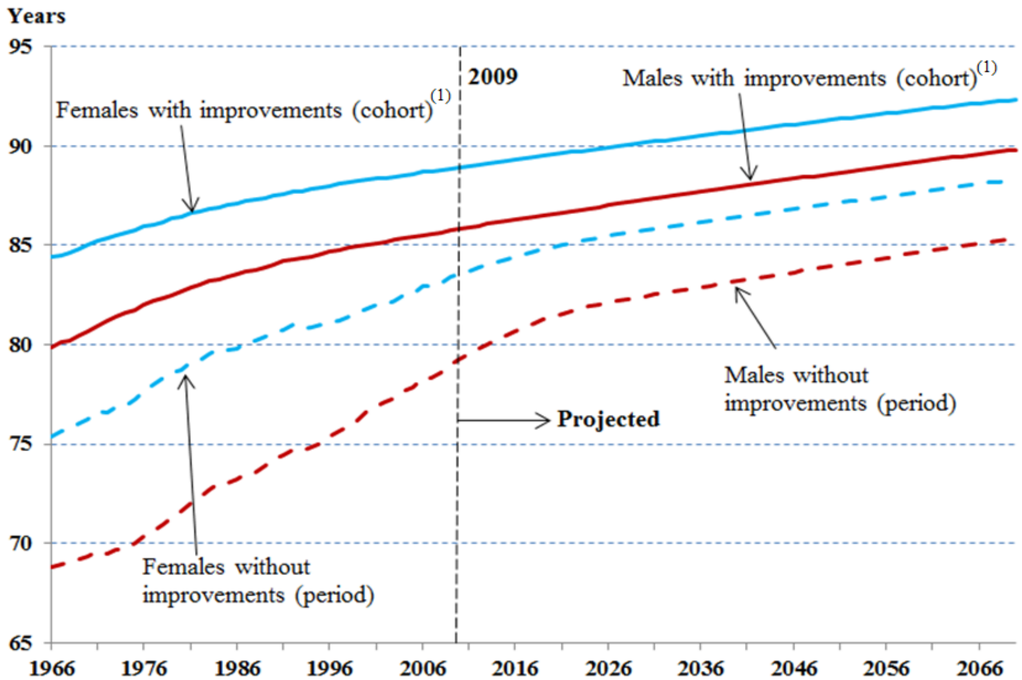
(1) Cohort life expectancies take into account assumed future improvements in mortality and therefore differ from period life expectancies, which are based on the mortality rates of the given attained year.

Table 8: Median Life Expectancies [(1)]

	Males				Females			
Age	**2013**	**2025**	**2050**	**2075**	**2013**	**2025**	**2050**	**2075**
0	88.8	89.5	90.9	92.0	91.3	91.8	93.0	94.0
10	78.2	79.0	80.4	81.6	80.8	81.4	82.6	83.6
20	67.6	68.4	69.9	71.2	70.3	70.9	72.1	73.2
30	57.0	57.8	59.4	60.7	59.8	60.4	61.7	62.8
40	46.4	47.2	48.8	50.3	49.2	49.9	51.3	52.4
50	35.9	36.8	38.4	39.8	38.8	39.5	40.9	42.1
60	25.7	26.6	28.2	29.6	28.5	29.2	30.6	31.8
65	20.8	21.7	23.2	24.6	23.5	24.2	25.6	26.7
70	16.2	17.1	18.5	19.8	18.7	19.4	20.6	21.8
75	11.8	12.7	14.0	15.1	14.1	14.8	15.9	17.0
80	8.1	8.9	9.9	10.8	10.0	10.6	11.5	12.4
85	5.1	5.7	6.3	7.0	6.5	7.0	7.7	8.3
90	2.9	3.3	3.7	4.1	3.8	4.2	4.6	5.1
100	0.8	0.9	1.0	1.2	1.0	1.1	1.3	1.5

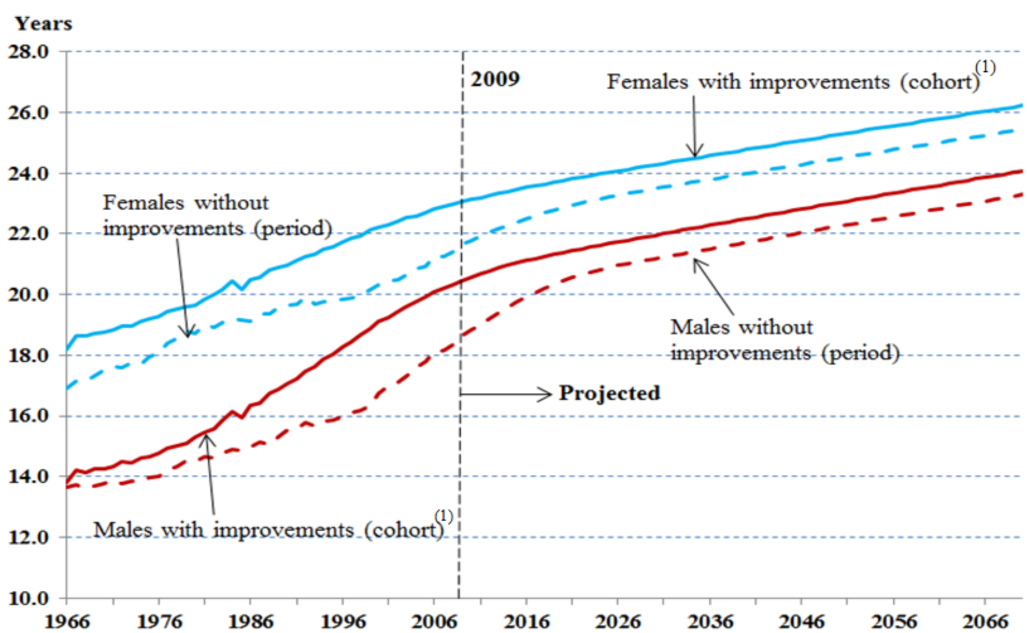
(1) With future mortality improvements after year shown. They represent the expected number of years lived by the cohort until half the cohort has died.

Chart 15: Male and Female Life Expectancies at Birth



(1) Cohort Life Expectancies at birth up to 2009 are calculated using both historical and projected mortality rates. For example, a newborn in 2000 would reach the maximum life span of 120 in 2120. To calculate the life expectancy at birth in 2000, historical mortality rates are used for years 2000 to 2009 and projected mortality rates for years 2010 to 2120.

Chart 16: Male and Female Life Expectancies at Age 65



(1) Cohort Life Expectancies at age 65 up to 2009 are calculated using both historical and projected mortality rates. For example, a person aged 65 in 2000 would reach the maximum life span of 120 in 2055. To calculate the life expectancy at age 65 in 2000, historical mortality rates are used for years 2000 to 2009 and projected mortality rates for years 2010 to 2055.

B. International Comparisons

1. Projected Mortality Improvement Rates

Table 9 summarizes the initial and ultimate MIR assumptions for Canada used for the 26th CPP Actuarial Report compared to the MIR assumptions of the United States Social Security Administration used in the 2012 OASDI Trustees Report (TR 2012) and the assumptions for the latest United Kingdom's Office for National Statistics (ONS) period and cohort life expectancy tables (2010-based).

Table 9: Assumed MIRs (Canada, U.S., UK)

	26th CPP Actuarial Report Initial (2010)		26th CPP Actuarial Report Ultimate (2030+)		U.S. SSA 2012 Trustees (2036+)		UK ONS 2010 Based (2035+)	
Age	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
0	1.25	0.75	0.8	0.8	1.6	1.6	1.2	1.2
1-4	3.25	4.00	0.8	0.8	1.6	1.6	1.7	0.9
5-9	2.75	3.50	0.8	0.8	1.6	1.6	1.1	1.1
10-14	3.50	3.75	0.8	0.8	1.6	1.6	1.0	0.8
15-19	2.75	1.75	0.8	0.8	0.9	0.9	1.2	1.5
20-24	2.00	0.75	0.8	0.8	0.9	0.9	1.3	1.1
25-29	2.25	1.00	0.8	0.8	0.9	0.9	1.2	1.1
30-34	3.25	1.25	0.8	0.8	0.9	0.9	1.2	1.1
35-39	3.00	1.50	0.8	0.8	0.9	0.9	1.2	1.3
40-44	2.50	1.50	0.8	0.8	0.9	0.9	1.2	1.2
45-49	1.50	1.00	0.8	0.8	0.9	0.9	1.2	1.2
50-54	1.50	1.25	0.8	0.8	1.1	1.1	1.2	1.2
55-59	2.25	1.75	0.8	0.8	1.1	1.1	1.2	1.2
60-64	2.40	1.75	0.8	0.8	1.1	1.1	1.2	1.3
65-69	3.00	1.75	0.8	0.8	0.8	0.7	1.2	1.2
70-74	3.10	1.75	0.8	0.8	0.8	0.7	1.2	1.2
75-79	2.75	1.75	0.8	0.8	0.8	0.7	1.2	1.2
80-84	2.50	1.75	0.8	0.8	0.8	0.7	1.2	1.2
85-89	2.00	1.50	0.6	0.6	0.5	0.5	1.1	1.2
90-94	1.25	1.25	0.4	0.4	0.5	0.5	1.1	1.2
95-99	0.75	0.75	0.3	0.3	0.5	0.5	1.1(1)	1.1(1)
100-104(2)	0.50	0.50	0.3	0.3	0.5	0.5	1.1(3)	1.1(4)
105-109	0.25	0.25	0.3	0.3	0.5	0.5	N/A	N/A
110-114	0.15	0.15	0.2	0.2	0.5	0.5	N/A	N/A
115-119	0.05	0.05	0.1	0.1	0.5	0.5	N/A	N/A
120	0.00	0.00	0.0	0.0	N/A	N/A	N/A	N/A

(1) Ultimate MIR reached in 2038.
(2) The UK table does not show mortality rates beyond age 100. Therefore, for UK, MIRs for the age group 100-104 refer to the MIRs at age 100.
(3) Ultimate MIR reached in 2039.
(4) Ultimate MIR reached in 2040.

For the U.S., the ultimate annual MIRs are assumed to be somewhat lower than the average rate during the period 1900-2007. For the UK, the assumptions used for the projections are that annual MIRs will converge to 1.2% per year for most ages in 2035 (the 25th year of the 2010-based projections), and remain constant at that level thereafter. The 1.2% ultimate rate assumed for most cohorts is broadly equivalent to the average annual rate of improvement over the whole of the 20th century for the UK. Care should be exercised when comparing the assumed MIRs in different countries in terms of the resulting life expectancies. Future life expectancies are determined not only by future mortality improvement rates, but also by the current mortality rates to which these improvements are applied. For example, while the assumed future MIRs shown in Table 9 are higher for the United States than for Canada, the current as well as projected life expectancies in the U.S. remain below the corresponding life expectancies in Canada.

The following sections compare the projected mortality rates by age group of the 26th CPP Actuarial Report with those included in the 2012 OASDI Trustees Report in the United States and those published by the United Kingdom's Office for National Statistics. The mortality rates for the United States were derived from the TR 2012 data provided by the Office of the Chief Actuary at the Social Security Administration.

2. Projected Mortality Rates

Tables 10 and 11 compare the current and projected mortality rates for males and females for Canada, the United States, and the United Kingdom for years 2010, 2030, and 2050.

**Table 10: Male Mortality Rates (Canada, U.S., UK)
(annual deaths per 1,000 people)**

	26th CPP Actuarial Report			U.S. SSA 2012 Trustees			UK ONS 2010 based		
Age	**2010**	**2030**	**2050**	**2010**	**2030**	**2050**	**2010**	**2030**	**2050**
0	5.04	4.11	3.50	7.05	5.27	3.78	4.64	3.47	2.72
10	0.13	0.09	0.07	0.08	0.05	0.03	0.09	0.06	0.05
20	0.66	0.49	0.42	1.29	1.15	0.99	0.54	0.37	0.29
30	0.79	0.57	0.48	1.42	1.28	1.09	0.89	0.67	0.52
40	1.26	0.95	0.81	2.30	1.89	1.57	1.62	1.52	1.19
50	3.35	2.67	2.27	5.77	5.12	4.18	3.37	2.35	1.84
60	7.84	5.78	4.92	10.94	8.38	6.51	8.66	6.12	4.79
65	12.48	9.12	7.76	15.64	11.77	9.66	13.23	9.73	7.63
70	19.56	13.83	11.78	23.97	18.22	15.31	21.59	14.98	11.74
75	32.04	22.00	18.73	38.47	30.22	25.49	35.59	23.67	18.55
80	54.11	38.64	32.91	61.83	48.35	39.98	60.42	38.25	30.14
85	90.90	68.51	59.77	102.15	86.10	76.46	103.18	63.55	50.15
90	148.95	122.10	110.90	173.26	153.36	138.11	164.38	98.37	77.95
100	325.37	297.75	280.38	375.32	343.07	305.95	332.02	242.04	183.03

Table 11: Female Mortality Rates (Canada, U.S., UK)
(annual deaths per 1,000 people)

	26th CPP Actuarial Report			U.S. SSA 2012 Trustees			UK ONS 2010 based		
Age	**2010**	**2030**	**2050**	**2010**	**2030**	**2050**	**2010**	**2030**	**2050**
0	4.68	4.01	3.41	5.77	4.30	3.09	4.05	2.98	2.33
10	0.11	0.07	0.06	0.09	0.06	0.04	0.08	0.06	0.04
20	0.28	0.23	0.19	0.45	0.40	0.34	0.24	0.16	0.13
30	0.40	0.33	0.28	0.63	0.55	0.46	0.45	0.34	0.27
40	0.83	0.66	0.56	1.44	1.24	1.02	0.91	0.77	0.61
50	2.15	1.77	1.51	3.34	2.97	2.41	2.20	1.62	1.26
60	5.03	3.91	3.33	6.79	5.19	4.03	5.52	3.97	3.09
65	7.82	6.08	5.18	10.32	8.10	6.74	8.34	6.27	4.89
70	12.42	9.65	8.22	16.86	13.77	11.72	14.23	9.85	7.67
75	20.47	15.91	13.55	27.63	23.39	19.98	23.17	16.13	12.60
80	35.76	27.80	23.67	45.31	37.64	31.36	42.07	27.27	21.43
85	64.46	51.49	44.92	79.21	71.63	64.09	77.21	47.51	37.31
90	114.53	95.71	86.93	139.09	128.49	116.33	144.53	82.89	65.24
100	292.56	267.73	252.12	320.78	294.06	263.00	314.49	231.41	173.54

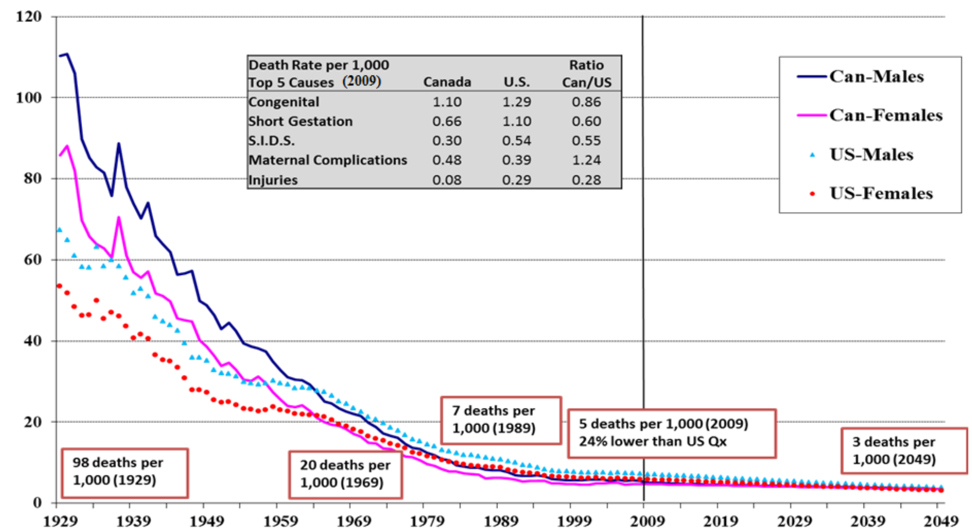
It can be seen that although the assumed mortality improvement rates for both males and females in the U.S. are higher than the assumptions of the 26th CPP Actuarial Report, the expected mortality rates in the U.S. continue to be higher than the projected mortality rates for Canada. This is mainly due to the fact that the current mortality rates in the U.S. are significantly higher than Canadian rates. Current mortality rates in Canada are slightly lower than in the UK, but the projected UK mortality rates are lower than the Canadian ones in both 2030 (after age 80) and 2050 (after age 45) due to the much stronger UK MIR assumptions.

a) <u>Mortality Rates for Ages less than 1</u>

As shown in Chart 17, infant mortality rates have continually decreased over the last 80 years in both Canada and the U.S. In Canada, the reduction was about 75% over the last 40 years ([20-5]/20) compared to 80% over the previous 40-year period ([98-20]/98). It is worth noting that infant mortality rates are now decreasing at a much slower pace: the rates declined by 29% in the last 20 years ([7-5]/7) while they had decreased by 65% in the previous 20-year period
([20-7]/20).

The Canadian infant mortality rate in 2009 was 24% lower than in U.S., with most infant deaths in both countries being due to congenital anomalies. Compared to the U.S. rates by cause, mortality is much lower in Canada in four of the top five causes, as shown in the shaded portion of Chart 17.

Chart 17: Projected Mortality Rates (Age less than 1)



Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

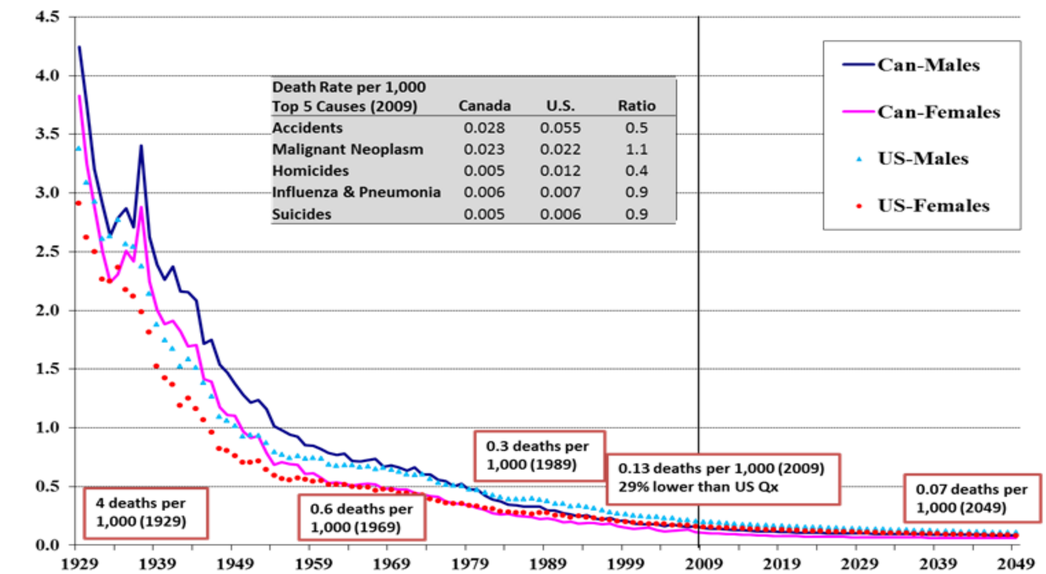
As shown in Table 9, it assumed for the 26th CPP Actuarial Report that the ultimate annual mortality improvement rate at age below 1 for both males and females is 0.8 percent, which results in a 40% reduction of the mortality rates by 2049. This improvement rate is lower than the assumed ultimate rate of 1.6 percent for both males and females under TR 2012. As a result, the gap between Canadian and U.S. infant mortality rates shrinks over the projection period, as shown in Chart 17.

b) Mortality Rates for Ages 1-14

In Canada, most deaths in the 1 to 14 age group occur due to accidents (unintentional injuries), and malignant neoplasms (Statistics Canada, 2009). For this age group (see Chart 18), Canadian and U.S. mortality levels have been close since 1970, but mortality in Canada has fallen somewhat faster. The reduction was about 78% over the last 40 years ([0.6-0.13]/0.6), a little less than the 85% over the previous 40-year period ([4-0.6]/4). However, it is worth noting that youth mortality rates are now decreasing at a slower pace: the rates decreased by 57% over the last 20 years ([0.3-0.13]/0.3). A further reduction of 46% is projected over the next 40 years.

In 2009, Canadian mortality rates for youths were 29% lower than U.S. youth mortality rates mainly due to lower mortality from accidents and homicides.

Chart 18: Projected Mortality Rates (Ages 1-14)



Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

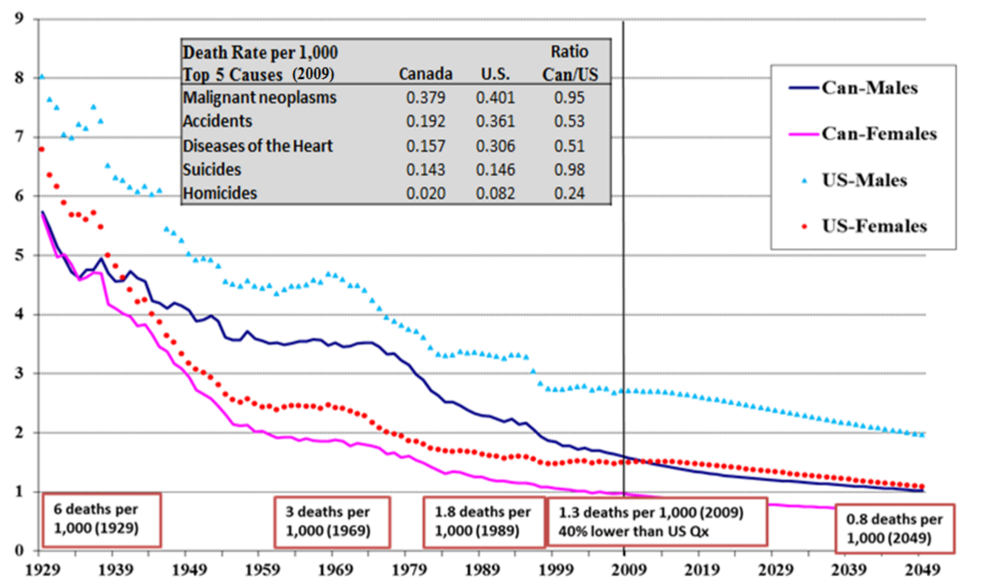
As shown in Table 9, it is assumed for the 26th CPP Actuarial Report that the ultimate annual MIR for youths for both males and females is 0.8 percent. This rate is lower than the assumed ultimate rate of 1.6 percent for both males and females under TR 2012. As a result, the gap between Canadian and U.S. youth mortality rates reduces over the projection period.

c) Mortality Rates for Ages 15-54

Nearly 30% of all male deaths in this age group are due to accidents and suicides (Statistics Canada 2009). The reduction was about 57% over the last 40 years ([3-1.3]/3) and 50% over the previous 40-year period ([6-3]/6). However, as for youths, mortality rates are now decreasing at a slower pace: the rates decreased by 28% over the last 20 years ([1.8-1.3]/1.8) compared to 40% over the previous 20 years ([3-1.8]/3). A further reduction of 38% is projected over the next 40 years. Current mortality for this age group is 40% lower than for U.S. mainly due to much lower mortality caused by homicides, accidents, and diseases of the heart.

It is assumed for the 26th CPP Actuarial Report that the ultimate annual MIR is 0.8 percent for both males and females for this age group. The assumption is 0.1 of a percentage point lower than the ultimate rate of 0.9 percent assumed under TR 2012 for ages 15 to 49 and 0.3 of a percentage point lower than the ultimate rate of 1.1 percent assumed under TR 2012 for the age group 50 to 54. As a result (see Chart 19), the gap between Canadian and U.S. mortality rates reduces over the projection period.

Chart 19: Projected Mortality Rates (Ages 15-54)



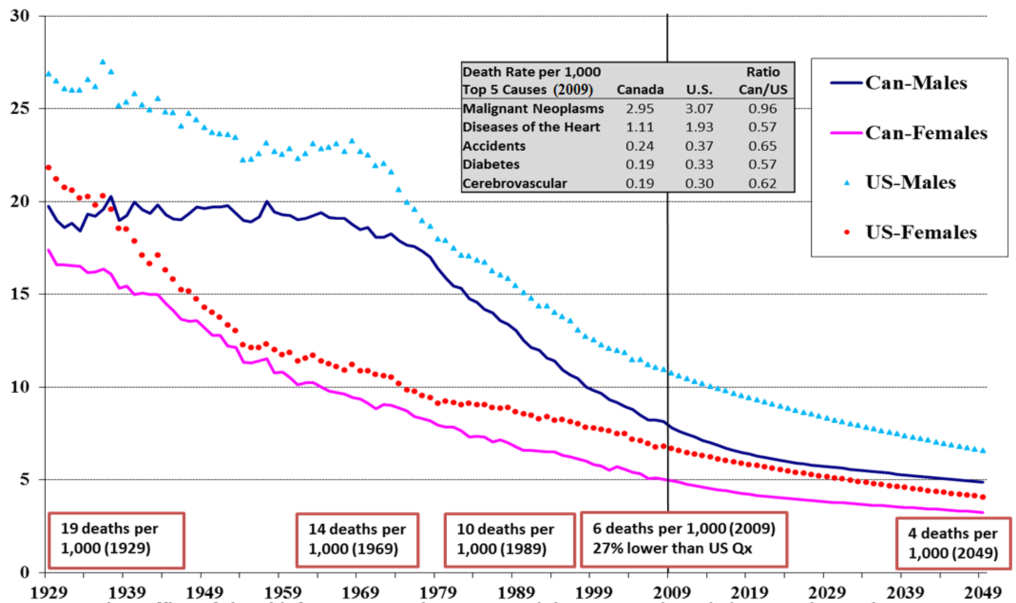
Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

d) Mortality Rates for Ages 55-64

As for the younger age groups, mortality rates have also continually decreased over the last 80 years for the 55 to 64 age group. The reduction was about 57% over the last 40 years ([14-6]/14) compared to only 26% over the previous 40-year period ([19-14]/19). Moreover, it has been observed that male mortality rates in this age group have been decreasing at a much faster pace over the last two decades than in previous decades. A further reduction of 33% is projected by 2049 ([6-4]/6). Mortality for this age group is 27% than in the U.S., and can be explained by lower mortality rates for diseases of the heart and diabetes.

It is assumed for the 26th CPP Actuarial Report that the ultimate annual MIR is 0.8 percent for both males and females. The assumption is 0.3 percentage points lower than the ultimate rate of 1.1 percent assumed under TR 2012. As a result (see Chart 20), the gap between Canadian and U.S. mortality rates reduces over the projection period.

Chart 20: Projected Mortality Rates (Ages 55-64)



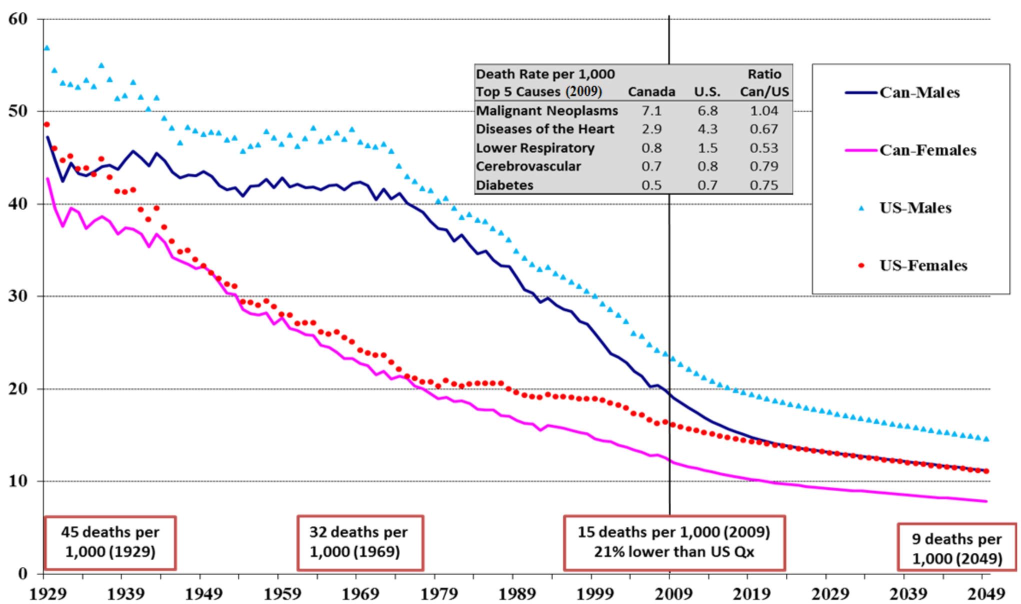
Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

e) Mortality Rates for Ages 65-74

For the age group 65 to 74, the reduction was about 53% over the last 40 years ([32-15]/32) compared to 29% over the previous 40-year period ([45-32]/45). A further reduction of 40% is projected ([15-9]/15). As illustrated in Chart 21, male mortality rates in this age group have been decreasing at a faster pace over the last two decades than in previous decades. Current mortality is 21% lower than in the U.S. mainly due to much lower mortality caused by diseases of the heart, lower respiratory diseases, and diabetes.

In this age group, malignant neoplasms are the leading cause of death in Canada for both sexes (Statistics Canada 2009). Therefore, future improvements may come mainly from medical breakthroughs. An ultimate improvement rate of 0.8 percent for both males and females is assumed in the 26th CPP Actuarial Report. The assumption for this age group is the same as the ultimate rate of 0.8 percent assumed for males and 0.1 of a percentage point higher than the 0.7 percent assumed for females under TR 2012. As a result, the gap between Canadian and U.S. mortality rates increases over the projection period.

Chart 21: Projected Mortality Rates (Ages 65-74)



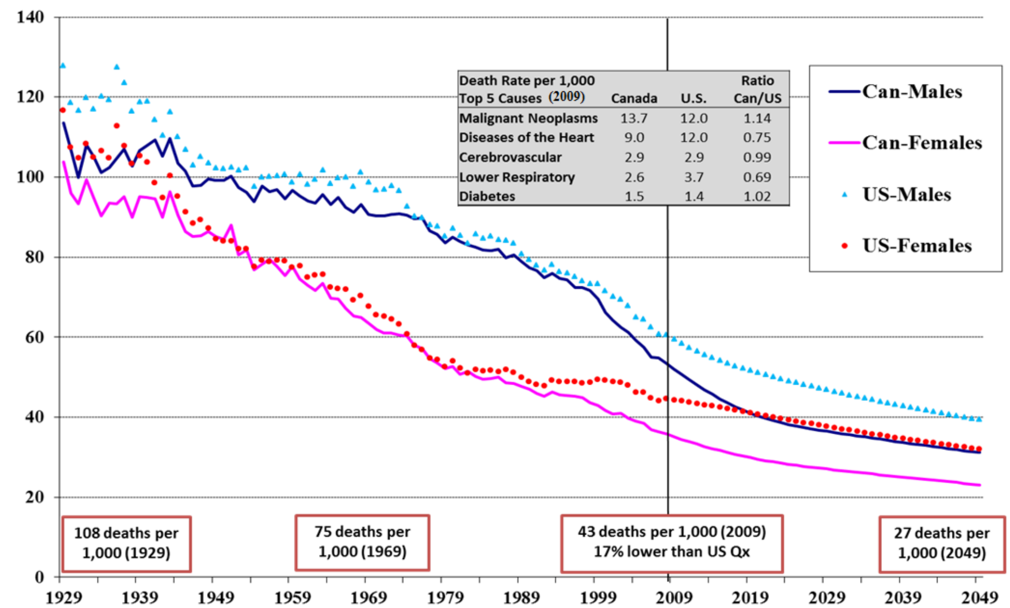
Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

f) Mortality Rates for Ages 75-84

For the age group 75 to 84, mortality rates have continually decreased over the last 80 years. The reduction was about 43% over the last 40 years ([75-43]/75) compared to only 31% over the previous 40-year period ([108-75]/108). A further reduction of 37% is projected by 2049 ([43-27]/43). It has been observed that mortality rates have been decreasing at a faster pace during the last decade. In fact, the rates decreased more in the last decade than in previous decades, especially for males. Current mortality is 17% lower than in U.S. mainly due to much lower mortality caused by chronic lower respiratory diseases and diseases of the heart.

For this age group, diseases of the heart and malignant neoplasms are the leading causes of death in Canada for both sexes (Statistics Canada 2009). Future improvements may come mainly from medical breakthroughs and lifestyle changes. The historical gap in mortality rates between Canada and the United States (Chart 22) depends on many factors, which may include historically lower accessibility to healthcare in the U.S. due to limited insurance coverage and the expensive costs of medical treatment. Assuming that male MIRs will eventually decrease to those of females given the most recent 30 years of experience, an ultimate improvement rate of 0.8 percent for both males and females is assumed for the 26th CPP Actuarial Report. The TR 2012 assumption is the same for males and 0.1 of a percentage point lower for females for this age group, which increases the gap between Canadian and U.S. mortality rates over time.

Chart 22: Projected Mortality Rates (Ages 75-84)



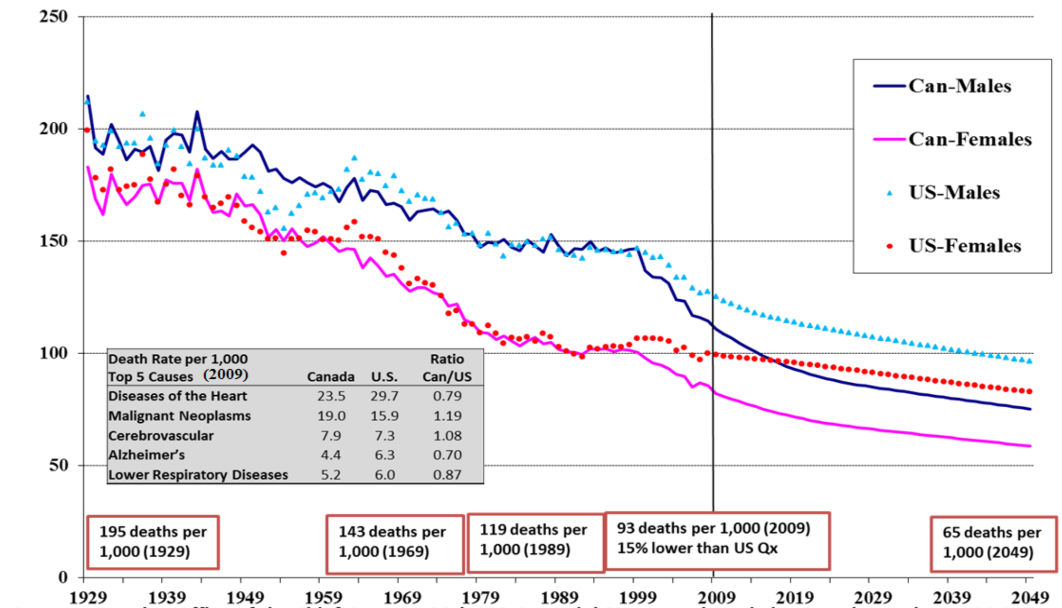
Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

g) Mortality Rates for Ages 85-89

Mortality rates of the 85 to 89 age group have shown considerable improvements over the last 80 years. The reduction was about 35% over the last 40 years ([143-93]/143) compared to 27% over the previous 40-year period ([195-143]/195). A further reduction of 30% is projected by 2049 ([93-65]/93). Canadian mortality rates have been decreasing much faster than U.S. rates since 1999, as shown in Chart 23. Current mortality is 15% lower than in the U.S. mainly due to much lower mortality caused by Alzheimer's and diseases of the heart.

Considering that mortality improvement rates tend to decrease with age, an ultimate improvement rate of 0.6 percent for both males and females has been assumed for the 26th CPP Actuarial Report. This rate is 0.1 of a percentage point higher than the 0.5 percent assumed for both sexes under TR 2012, which causes the gap between the Canadian and U.S. rates to increase over time.

Chart 23: Projected Mortality Rates (Ages 85-89)



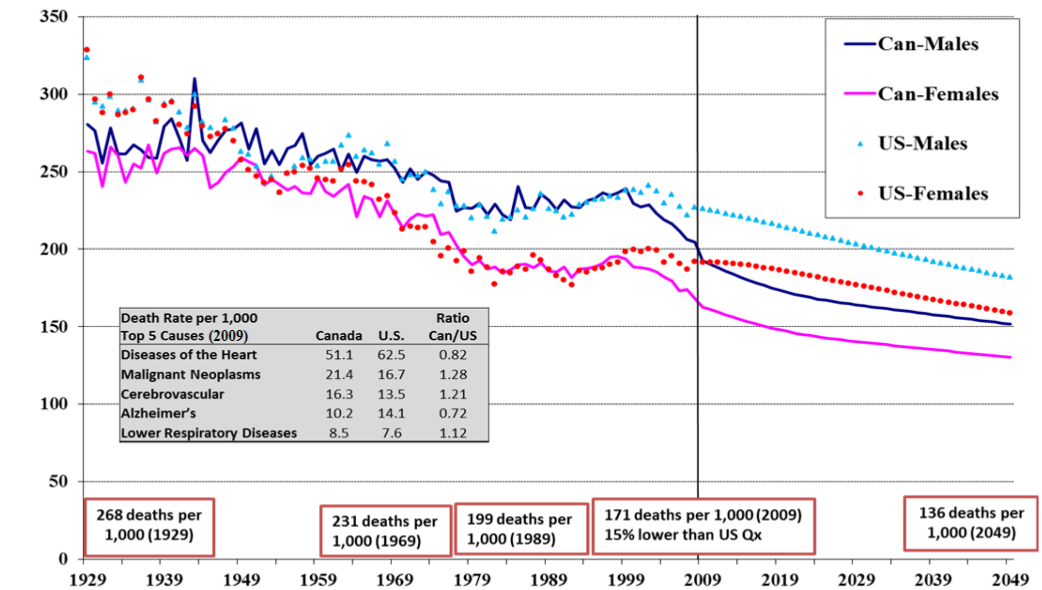
Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

h) <u>Mortality Rates for Ages 90 and Older</u>

For the mortality rates of the oldest age group, data quality is still a major concern and much uncertainty exists. However, the mortality rates for this age group have been decreasing over the last 80 years. A reduction of 26% ([231-171]/231) was experienced over the last 40 years, compared to a reduction of 14% over the previous 40-year period ([268-231]/268). As of 2009, Canadian mortality for this oldest age group is 15% lower than U.S. mortality, due to lower mortality caused by Alzheimer's and diseases of the heart.

For the 26th CPP Actuarial Report, it was assumed that mortality for both sexes in this age group would improve at an annual rate of 0.3 percent. This improvement rate corresponds to the MIR that females aged 90 and older have experienced over the last 15 years. This rate is 0.2 of a percentage point lower than what is assumed for both sexes in the TR 2012 for this age group. This leads to a reduction in the Canada-U.S. mortality rates gap over time (Chart 24).

Chart 24: Projected Mortality Rates (Ages 90+)

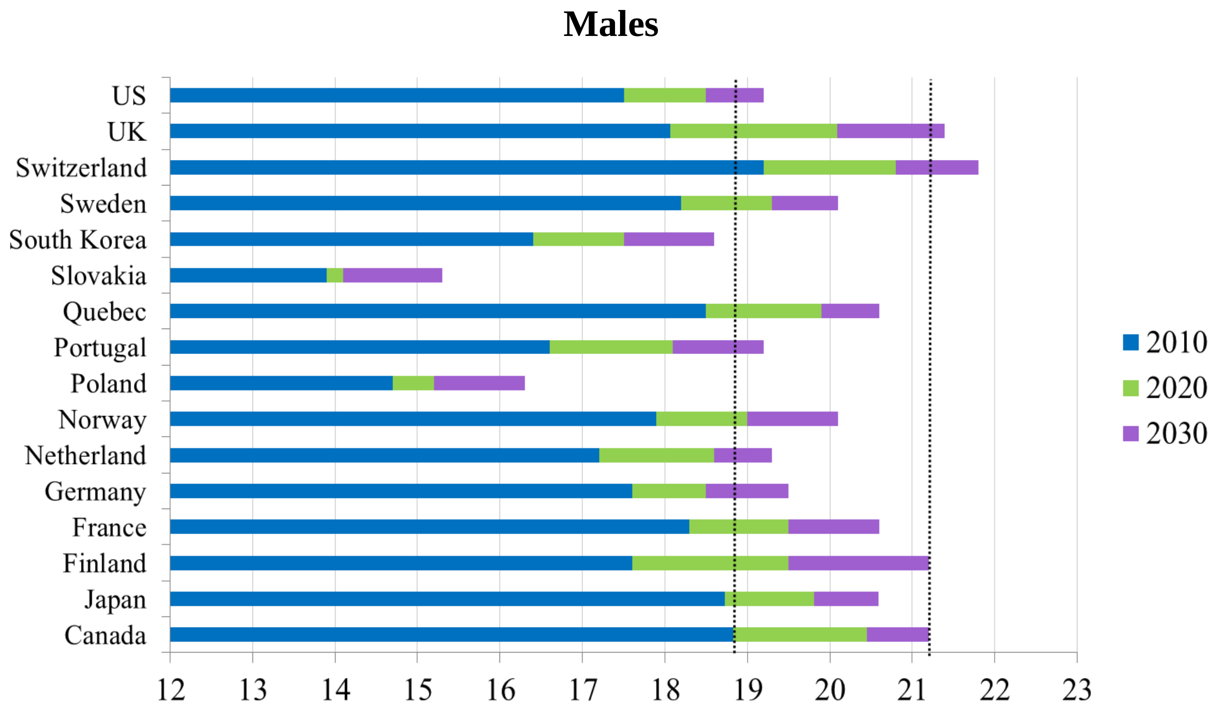


Source : Canada : Office of the Chief Actuary, 26th CPP Actuarial Report and Statistics Canada catalogue 84-215-x
U.S. : 2012 OASDI Trustees Report and U.S. National Vital Statistics Report, Volume 60 No.3
All rates are standardized using the 2012 Canadian population

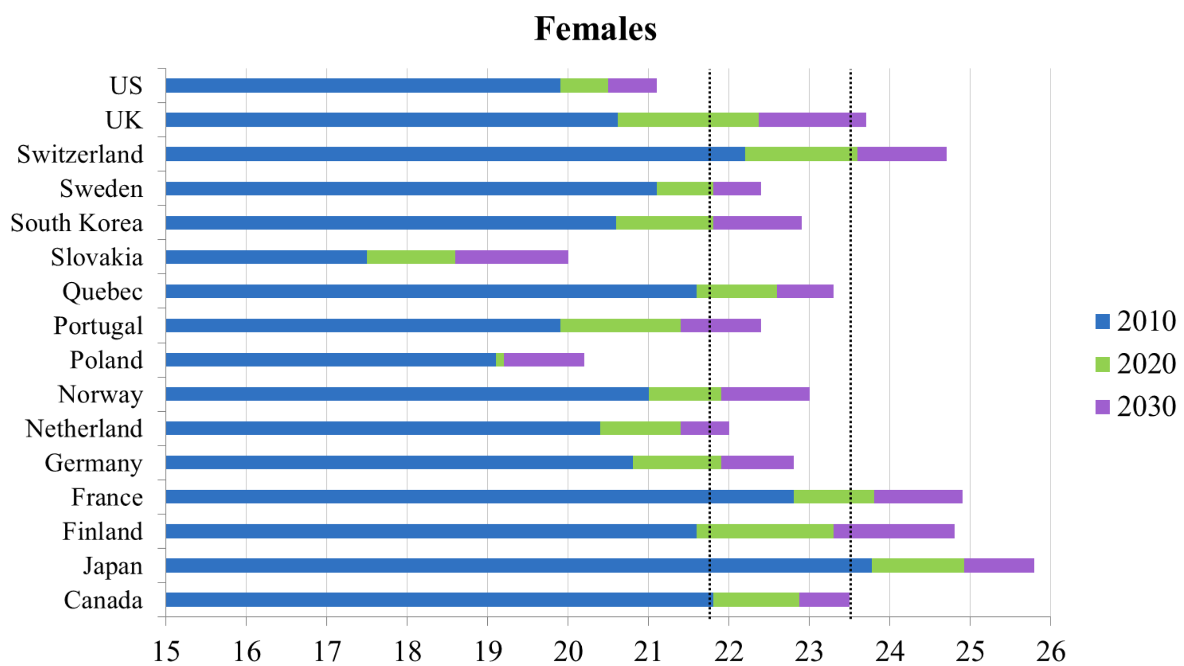
3. Life Expectancies

Chart 25 provides a comparison of life expectancies at age 65 without future mortality improvements in Canada and other countries. The projections of life expectancies for Canada are based on the assumptions of the 26th CPP Actuarial Report, while the projections for Québec are based on the assumptions used for the Québec Pension Plan (QPP) Actuarial Report as at 31 December 2009, and the projections for the remaining countries are based on the assumptions of the social security actuaries responsible for assessing the financial status of the countries' social security programs. As shown, it is projected that by 2030, British and Swiss men are expected to live longer than Canadian men at age 65. It is also shown that by 2030, British, Swiss, French, Finnish, and Japanese women are all projected to live longer than Canadian women at age 65.

Chart 25: International Comparison of Life Expectancies at Age 65 (without future mortality improvements)



* Source: Presentations and reports given at the 17th International Conference of Social Security Actuaries and Statisticians and Dept. of Population Dynamics Research, National Institute of Population and Social Security Research, Japan



* Source: Presentations and reports given at the 17th International Conference of Social Security Actuaries and Statisticians and Dept. of Population Dynamics Research, National Institute of Population and Social Security Research, Japan

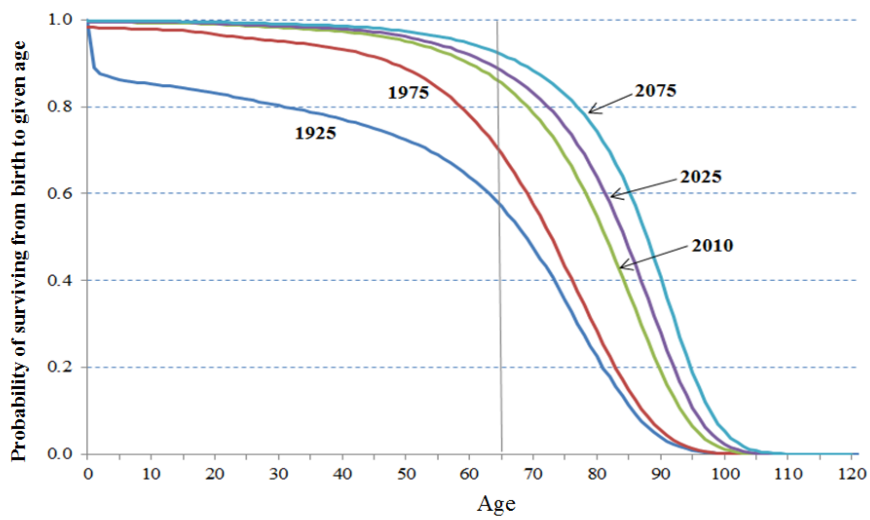
IV. Living to Advanced Ages

A. Survival Curves

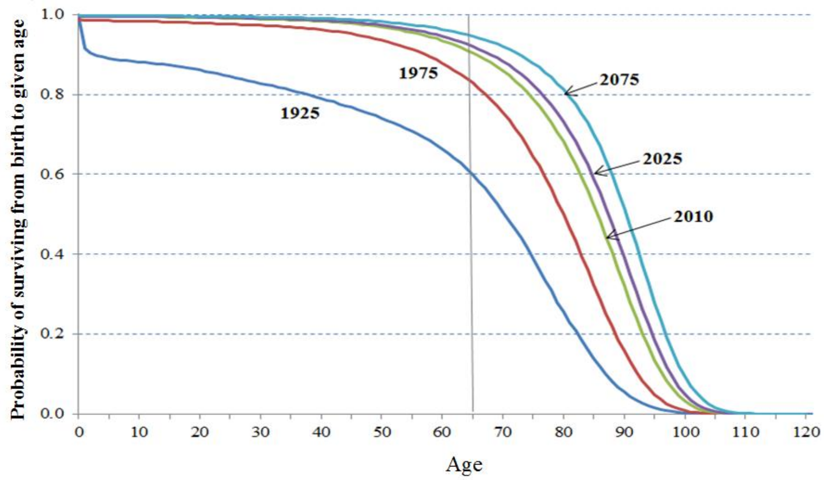
The survival curves at birth presented in Chart 26 illustrate that the probabilities of a newborn reaching a very advanced age are very low. A survival curve at birth shows the probability of a newborn reaching a given age. The "squaring" of the survival curves over time from 1925 to 2075 occurred since gains in life expectancy have been greater at the younger ages than at the older ages, while the maximum age that can be attained has remained at about 120 years. The assumed maximum life span of 120 years is consistent with the fact that only a few individuals have ever lived beyond age 110, and that the highest age at death ever verified was for Jeanne Calment (from France) who died at the age of 122 in 1997. The oldest verified Canadian on record is Marie-Louise Meilleur, who died at the age of 117 in 1998 (see: http://en.wikipedia.org/wiki/Oldest_people). Chart 26 clearly illustrates that the probability of surviving from birth to ages beyond 110 is practically zero, based on the 26th CPP Actuarial Report assumptions.

As indicated in the graphs by the intersection of the vertical lines at age 65 with the survival curves, the probability of reaching age 65 has substantially increased over time. Based on the period life tables of 1925, males had a probability of 57 percent of reaching age 65. By 2010, this figure had increased to 87 percent, and by 2075 it is projected to reach 93 percent. For females, the probability of reaching age 65 was 60 percent in 1925, increased to 91 percent by 2010, and is projected to reach 95 percent by 2075. Overall, probabilities of surviving to older ages have increased over the last century, and this trend is expected to continue in the future but at a slower pace.

Chart 26: Survival Curves at Birth
Males (based on period life tables)



Females (based on period life tables)



Although life expectancies are projected to increase in the future, it is plausible that health and environmental factors may counteract the degree of this increase. The rising incidence of obesity in both children and adults and the ensuing risk of related complications, such as diabetes and diseases of the heart, could act to reduce future projected gains in life expectancy (Olshansky et al. 2005). The threat of worldwide pandemics resulting from more virulent forms of infectious diseases is also a reality that could affect longevity.

B. Distribution of Ages at Death

Another perspective on viewing the aging of the population is to consider the median age at death and the proportion of deaths at different ages over time (see Tables 12 and 13). It is projected that deaths resulting from those aged 85 and older will eventually constitute the largest proportion of all deaths compared to the younger age groups shown, as the number of elderly increases. By 2075, over 65 percent of all deaths will result from those aged 85 and older. Correspondingly, the median age at death for both sexes is projected to increase above age 85 by 2050.

Table 12: Median Age at Death

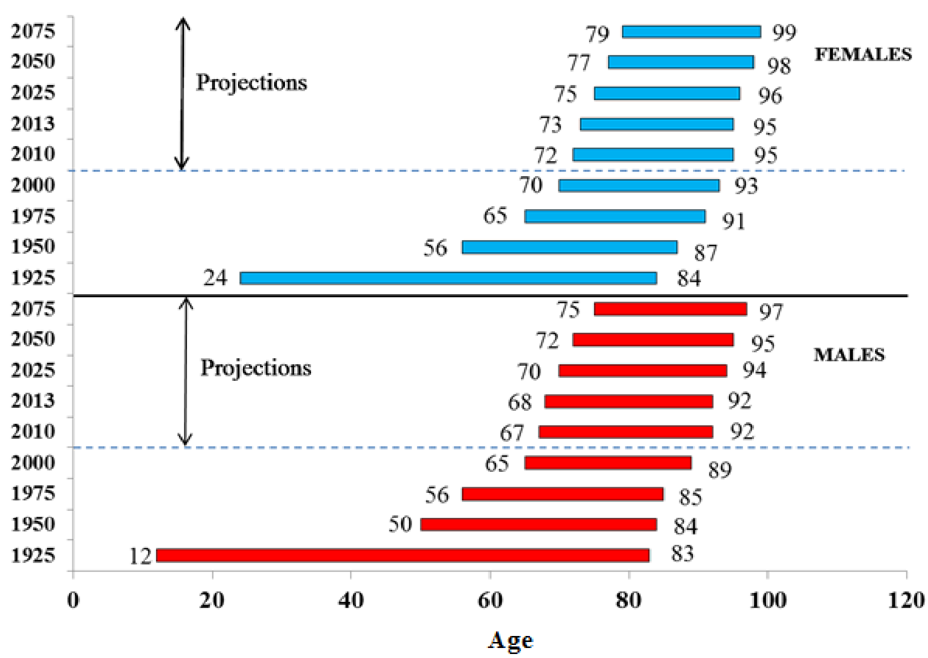
Year of Death	Males	Females
1925	44	45
1950	65	68
1975	68	74
2000	74	80
2010	76	82
2013	77	83
2025	79	84
2050	86	89
2075	87	90

Table 13: Distribution of Deaths, Number and Proportion

Year of Death	Number of Deaths (in thousands)					Proportion of Deaths (%)				
	0-64	65-74	75-84	85+	Total	0-64	65-74	75-84	85+	Total
1925	67	14	13	5	99	68	14	13	5	100
1950	58	28	26	11	124	47	23	21	9	100
1975	61	38	41	27	167	37	22	25	16	100
2000	49	43	66	60	218	22	20	30	28	100
2010	55	40	70	75	240	23	17	29	31	100
2013	53	42	67	92	253	21	17	26	36	100
2025	48	53	86	126	314	15	17	28	40	100
2050	44	49	107	311	511	9	9	21	61	100
2075	40	43	111	368	562	7	8	20	65	100

It is also interesting to consider over time the range of ages in which a given percentage of deaths are expected to occur. For instance, Chart 27 shows the progression of the age range over time in which 70 percent of deaths are expected to occur, where both 15% of the oldest deaths and 15% of the youngest deaths are excluded. The historical large gains in life expectancy can be seen from this table. Based on period life tables of 1925, about 70 percent of males could expect to die between the ages of 12 and 83; that is, 15 percent of males died prematurely before age 12, while 15 percent who were the strongest died after age 83. By 2013, the age range in which 70 percent of deaths occur is expected to both move forward and narrow to an age range of 68 to 92. A similar shift and narrowing in range can be seen for females. Again, this trend is expected to continue in the future, but at a slower pace compared to the past.

Chart 27: Evolution of the Distribution of the Age at Death (15th to 85th percentile)



C. Probabilities of Surviving to Ages 90 and 100

Table 14 shows the probabilities of living to 90 for those aged 20, 50, and 80 in 2012 in Canada, the U.S., and UK. Canadian males aged 80 in 2012 are projected to have a 44% chance of living another 10 years to age 90 (55% for Canadian females). The corresponding probabilities for the other two countries are 37% for American males (45% for American females) and 43% for British males (53% for British females).

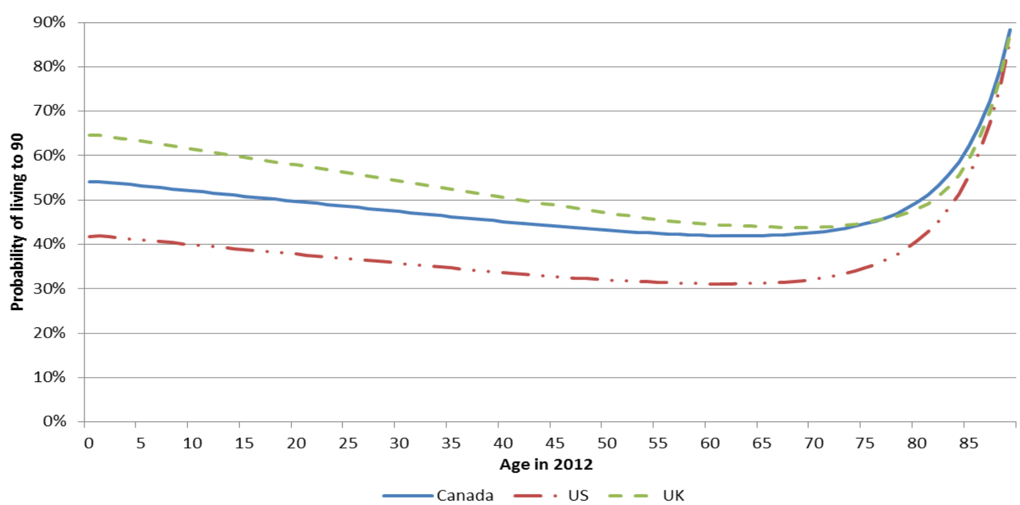
Table 14: Probability of Living to 90 (1)

	Canada		U.S.		UK	
Age in 2012	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
20	44.2%	55.1%	33.4%	42.2%	52.4%	63.3%
50	37.5%	48.8%	27.6%	36.4%	41.3%	53.0%
80	44.0%	54.9%	36.8%	44.8%	43.3%	52.6%

(1) Source: 26th CPP Actuarial Report, 2012 OASDI Trustees Report, and UK Office for National Statistics (ONS) assumptions.

Chart 28 shows that people aged between 60 and 65 in 2012 have the lowest probability of reaching age 90 (on average for both sexes). This probability is higher for younger ages due to the projected decreases in mortality rates. On the other hand, for older age groups the probabilities of living to 90 increase, since only individuals who have already reached older ages are considered.

Chart 28: Probability of living to 90 for Canada, U.S., and UK(1)



(1) Source: 26th CPP Actuarial Report, 2012 OASDI Trustees Report, and UK Office for National Statistics (ONS) assumptions.

Table 15 shows the probabilities of living to 90 for the same age cohorts as given in Table 14, but from birth. Those aged 20, 50 and 80 in 2012 were born respectively in 1992, 1962, and 1932. A Canadian male born in 1992 (aged 20 in 2012) had a 44% chance at birth of reaching age 90, which is 1.3 times higher than for a male newborn in 1962 and 2.3 times higher than for a male newborn in 1932. In comparison, a Canadian female born in 1992 had a 55% chance at birth of reaching age 90, which is 1.2 times higher than for a female newborn in 1962 and 1.7 times higher than for a female newborn in 1932.

An American male born in 1992 had a 33% chance at birth of reaching age 90, which is 1.3 times higher than one born in 1962, and 2.3 times higher than one born in 1932. A British male born in 1992 had a 52% chance at birth of reaching age 90, which is 1.4 times higher than one born in 1962, and 2.9 times higher than one born in 1932.

Table 15: Probability of Newborn Living to 90(1)

	Canada		U.S.		UK	
Year of birth	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
1992	43.7%	54.7%	32.8%	41.7%	51.8%	62.8%
1962	34.1%	46.1%	24.5%	33.9%	38.0%	50.3%
1932	19.1%	32.8%	14.5%	24.5%	17.9%	29.6%

(1) Source: 26th CPP Actuarial Report, 2012 OASDI Trustees Report, and UK Office for National Statistics (ONS) assumptions.

Table 16 shows the probabilities of living to 100 for those aged 20, 50 and 80 in 2012 in Canada, the U.S., and UK. The probabilities of living to 100 are significantly lower than the probabilities of living to 90 due to both the longer required period of survival and the higher mortality rates between ages 90 and 100. Canadian males aged 80 in 2012 are projected to have about a 5% chance of living to age 100 (9% for Canadian females). The corresponding probabilities for the U.S. and UK are 2% for American males (4.5% for American females) and 7.5% for British males (10% for British females).

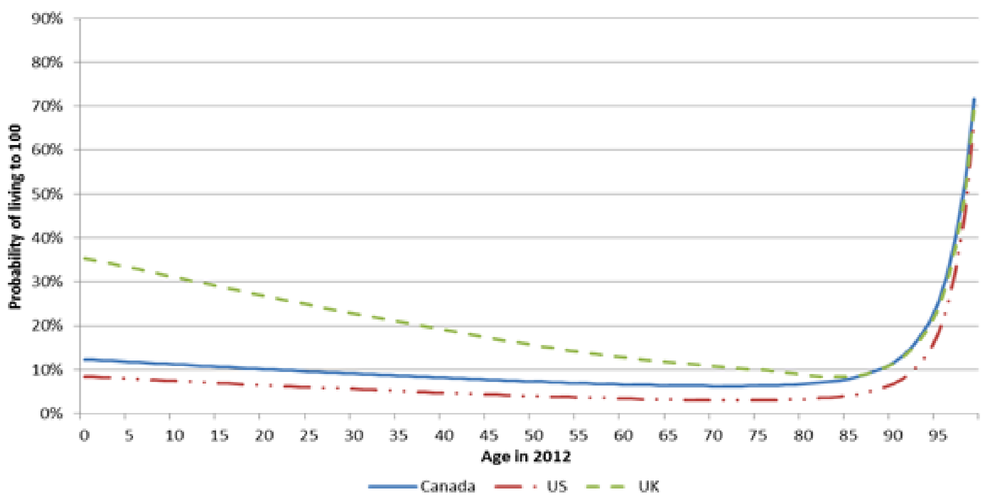
Table 16: Probability of Living to 100 (1)

	Canada		U.S.		UK	
Age in 2012	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
20	7.5%	12.8%	4.7%	8.2%	23.4%	30.2%
50	5.1%	9.5%	2.7%	5.3%	13.0%	18.2%
80	4.7%	8.8%	2.2%	4.5%	7.5%	10.2%

(1) Source: 26th CPP Actuarial Report, 2012 OASDI Trustees Report, and UK Office for National Statistics (ONS) assumptions.

In Chart 29 it is shown that the probability of surviving to age 100 is higher at the younger ages (on average for both sexes). In Canada, a male aged 20 in 2012 is 60% more likely to reach age 100 than a male aged 80 (45% more likely for a female). In comparison, American and British citizens aged 20 in 2012 are much more likely than their 80-year old counterparts to reach age 100: American men by 2.1 times (1.8 times for females) and British men by 3.1 times (3.0 times for females).

Chart 29: Probability of Living to 100 for Canada, the U.S., and UK(1)



(1) Source: 26th CPP Actuarial Report, 2012 OASDI Trustees Report and UK Office for National Statistics (ONS) assumptions.

Table 17 shows the probabilities of living to 100 from birth for the same age cohorts as in the previous tables. A Canadian male born in 1992 (aged 20 in 2012) had about a 7% chance at birth of reaching age 100, which is 1.6 times higher than a male born in 1962, and 3.7 times higher than one born in 1932. In comparison, a Canadian female born in 1992 had about a 13% chance at birth of reaching age 100, which is 1.4 times higher than a female born in 1962, and 2.4 times higher than one born in 1932.

An American male born in 1992 had about a 5% chance at birth of reaching age 100, which is about twice as high compared to one born in 1962, and over 5 times higher than one born in 1932. A British male born in 1992 had about a 23% chance at birth of reaching age 100, which is about twice as high compared to one born in 1962, and 7.5 times higher than one born in 1932. A British male born in 1992 was 3.1 times more likely to reach age 100 than a Canadian male, and 5.0 times more likely than an American male. The corresponding figures for British females relative to Canadian and American females are 2.4 and 3.7, respectively.

Table 17: Probability of Newborn Living to 100 (1)

	Canada		U.S.		UK	
Year of birth	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
1992	7.4%	12.6%	4.6%	8.1%	23.1%	29.9%
1962	4.7%	9.0%	2.4%	5.0%	11.9%	17.3%
1932	2.0%	5.2%	0.9%	2.4%	3.1%	5.7%

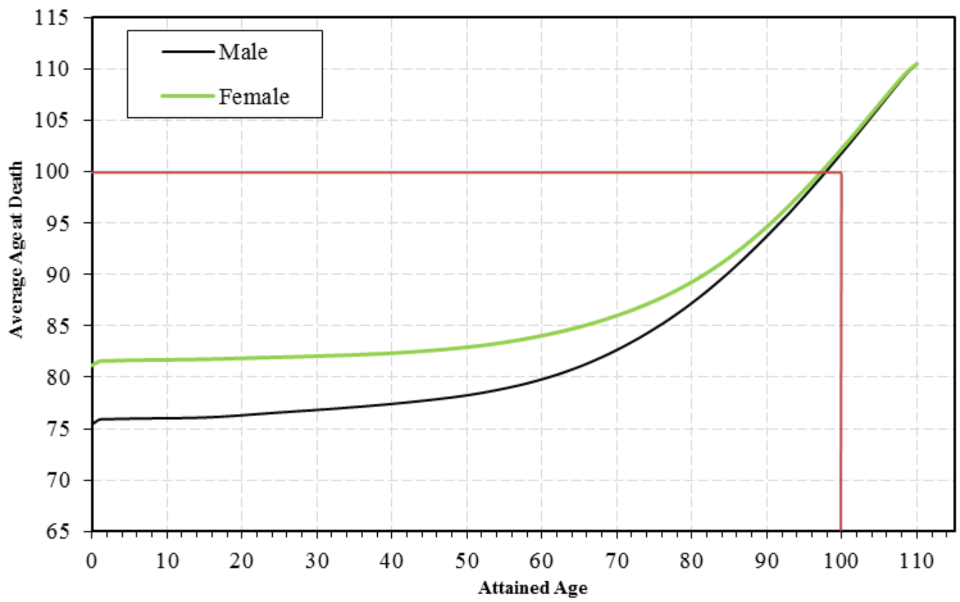
(1) Source: 26th CPP Actuarial Report, 2012 OASDI Trustees Report, and UK Office for National Statistics (ONS) assumptions.

D. Reaching a Life Expectancy of 100

The combination of improved mortality, genetic research, and further advances made in medical science raises the question as to whether a life expectancy at birth of 100 years in

Canada is possible in the near future. The purpose of this section is to examine the extent to which current mortality rates in Canada would need to be reduced in order to obtain a life expectancy at birth of 100 years, using simple mathematical models applied to the 2009 CHMD mortality rates. The life expectancy for an individual at a given age determines the expected age at death. Chart 30, which is based on the 2009 CHMD, confirms that the expected age at death is a non-decreasing function of attained age. It follows that the expected age at death for a newborn is the lowest of all. It is interesting to note that, based on year 2009 mortality rates, an expected age at death of 100 is only reached when a woman attains the age of 97 and when a man reaches age 98.

Chart 30: Expected Age at Death by Attained Age (2009)
(without mortality improvements)



A simple test can be conducted to see at what age the expected age at death becomes 100 when improvements to the 2009 CHMD mortality rates are applied. If there were no mortality from birth up to a specific age, then the expected age at death for all ages from birth up to the specific age would equal the expected age at death for the specific age. For example, all else being equal, if all mortality rates in 2009 were assumed to be zero up to age 97, as shown in Chart 31, then the expected age at death of any female aged 0 to 96 would become 100, the same as for age 97.

Chart 31: Expected Age at Death if no Mortality up to Age 97, Females (2009)

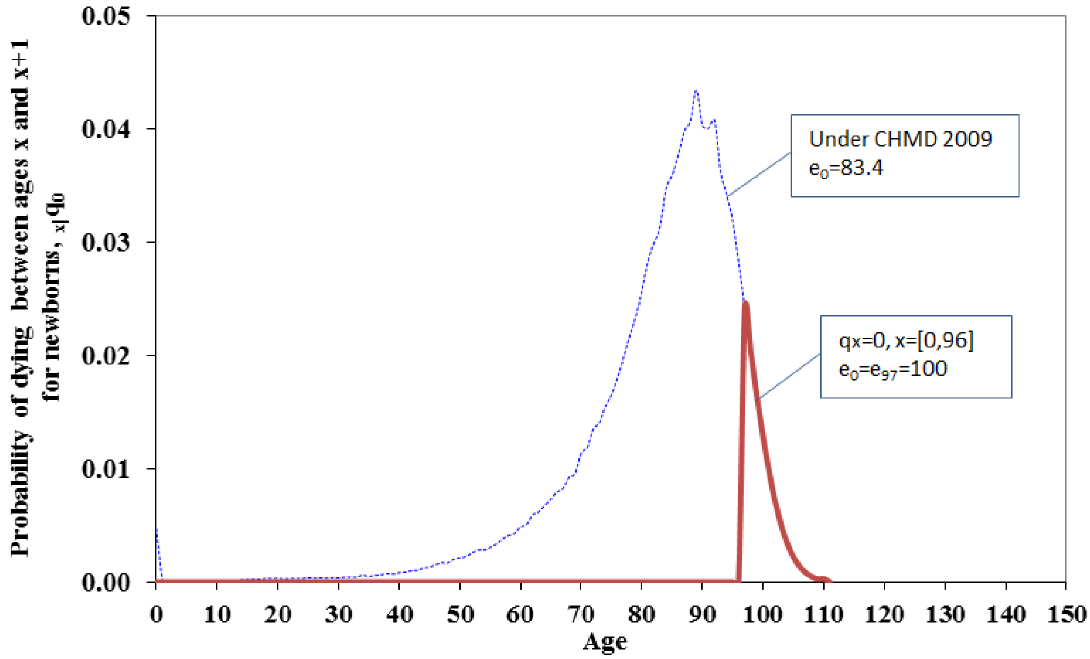


Table 18 presents the percentage reductions in the year 2009 mortality rates that would be required to attain an expected age at death of 100 for various given ages. These percentages are applied to all ages between the attained age in 2009 to age 109 (limit age in the CHMD). For example, mortality reductions of 87% for males and 82% for females would be required at each age between 0 and 109 to produce an expected age at death of 100 for a newborn. For someone age 65, the reductions would be 85% for males and 80% for females at each age from 65 to 109. The required reductions are about 2.7 to 4.0 times higher than what has been experienced over the last 15 years (1994-2009).

Table 18: Reductions in Mortality Rates Required to Reach a Life Expectancy of 100

	Expected Age at Death in 2009				Reductions in 2009 Mortality Required to Increase the Expected Age at Death to 100			
Attained Age	Age At Death		Cumulative Reduction in Mortality Rates for All Ages Above Attained Age Over the Last 15 Years(1)		Required Reduction in Mortality Rates for All Ages Above Attained Age		Required Mortality Reduction Relative to Last 15 Years' Experience	
	Males	Females	Males	Females	Males	Females	Males	Females
0	79	83	30%	21%	87%	82%	2.9 times	3.9 times
50	81	85	30%	21%	86%	81%	2.9 times	3.9 times
65	84	87	31%	21%	85%	80%	2.7 times	3.8 times
80	89	90	26%	19%	80%	75%	3.1 times	4.0 times
95	98	99	11%	9%	41%	32%	3.7 times	3.6 times

(1) Estimated using the slope method with mortality rates from the 2009 CHMD over the period 1994 to 2009.

The levels of mortality reductions can be put in perspective by analyzing the time it would take to reach a life expectancy of 100 years. As shown in Table 19, if mortality continues to improve at the average annual rates experienced during the last 15 years (2.35% for males and 1.54% for females), a life expectancy at birth of 100 could be reached in 85 years for males and 112 years for females (year 2009 being the starting point). Under the scenario where mortality improves at half the rates experienced during the last 15 years, it would take double the time to reach a life expectancy of 100 (170 years for males and 225 years for females). If, inversely, mortality improves at twice the rates experienced over 1994 to 2009, a life expectancy of 100 would be reached in half the time (i.e. 42 years for males and 56 years for females).

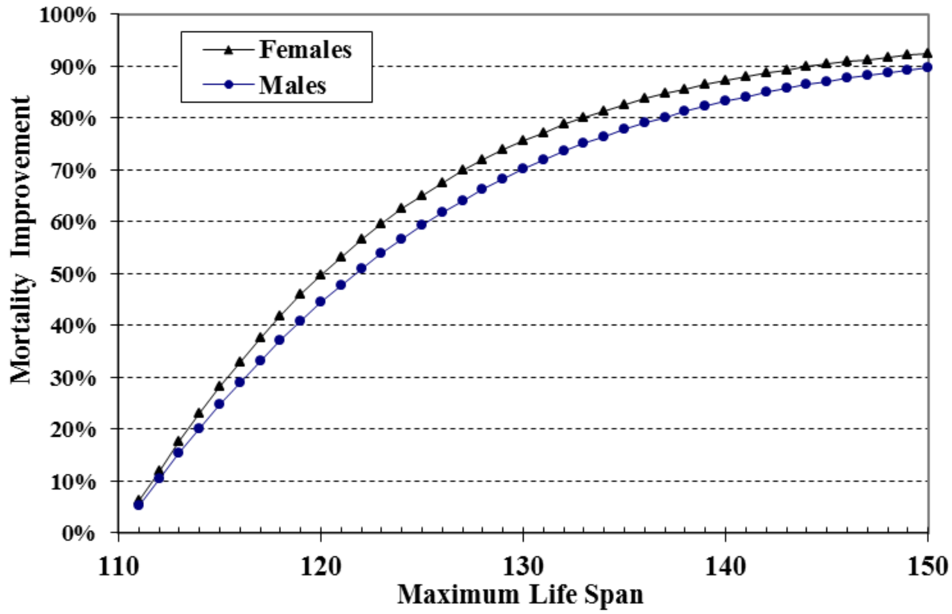
Table 19: Years Required to Reach an Expected Age at Death of 100 based on Varying MIRs

Attained Age in 2009	If Mortality for Males Improves at:			If Mortality for Females Improves at:		
	Half the Rate of the Last 15 Years	the Rate of the Last 15 Years	Twice the Rate of the Last 15 Years	Half the Rate of the Last 15 Years	the Rate of the Last 15 Years	Twice the Rate of the Last 15 Years
0	(1.18% / Year) 170 years	(2.35% / Year) 85 years	(4.70% / Year) 42 years	(0.77% / Year) 225 years	(1.54% / Year) 112 years	(3.08% / Year) 56 years

It should be noted that the mathematical models used so far have assumed a maximum life span of 110, which could be considered to be unrealistic, since significant mortality improvement at older ages should result in an increase in the maximum life span. This suggests a second test: measuring the effect of mortality improvements at older ages through an increase in the maximum life span, the ultimate age to which a human being can live.

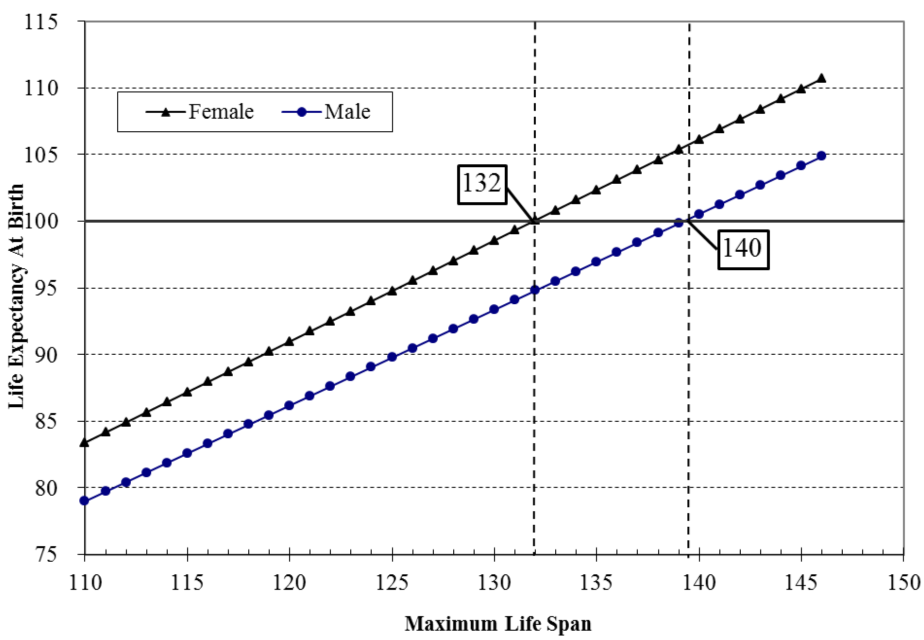
The simplest way to implement an increase in the maximum life span using the 2009 CHMD is to map the current 110 mortality rates (from ages 0 to 109) to "new" ages from 0 to 110+n. The new ages are derived from the current ages by increasing each of the current ages by a factor of 1+n/110. With this approach, for example, if the mortality rates are applied to a new table ending at age 121, i.e. 110 × (1 + 10%), an increase of n=11 ages or 10% (=11/110) from the current one, then the mortality rate currently applicable to age 60 would be applied to age 66, [60 × (1 + 10%)], and so forth. Consequently, the new mortality rate for a male age 66 would be 8.25 per thousand, the mortality rate of someone currently age 60, instead of 14.08 per thousand, which is the current mortality rate of someone age 66. This represents a decrease of 41% in the mortality rate at age 66. Because mortality rates generally rise with age, lower mortality rates are being applied to a given age with this technique. Therefore, the difference between this approach and the previous model is the way mortality rates are distributed by age. Chart 32 shows the resulting average mortality improvement for the ages 0 to 109 by the number of years in the maximum life span.

Chart 32: Mortality Improvement Needed to Increase Maximum Life Span



The effect of an increase in the maximum life span on life expectancy at birth is next examined. Chart 33 presents this information for both males and females. It shows that if the shape of the mortality curve is kept similar to the 2009 CHMD with the age mapping technique as described above, males would need a maximum life span of 140 years to have a life expectancy at birth of 100 years, while the comparable figure for females is 132 years.

Chart 33: Life Expectancy at Birth as a Function of Maximum Life Span



For males, increasing the maximum life span by 30 years to age 140 is equivalent to a reduction in mortality rates of 83% (see Chart 32), which slightly differs from the 87% reduction in mortality shown to be necessary in the previous model (see Table 18). For females, the corresponding reduction shown in Chart 31 is 80%, which is also lower than the 82% reduction shown in Table 18.

The fact that the oldest verified living person in the world is currently (as of March 5, 2014) 116 years old and that the oldest ever verified supercentenarian died at the age of 122 (Jeanne Calment of France, see: http://en.wikipedia.org/wiki/Oldest_people) clearly highlight how difficult it may be to reach maximum life spans of 140 years for males and 132 years for females.

Finally, Charts 34 and 35 compare the survival curves for each sex for the two mortality improvement models that result in a life expectancy at birth of 100 years with the actual CHMD survival curves of 2009. Chart 34 shows the male survival curves where mortality rates are reduced by 87% at each age between ages 0 to 109 and where the maximum life span is increased to age 140. For females, the mortality improvement model survival curves are shown in Chart 35, with corresponding figures of an 82% mortality rate reduction and a maximum life span of 132. The two charts compare the probability of surviving from birth to different attained ages according to the CHMD and the two mortality models.

Chart 34: Comparison of Survival Curves for Males using Different Methodologies

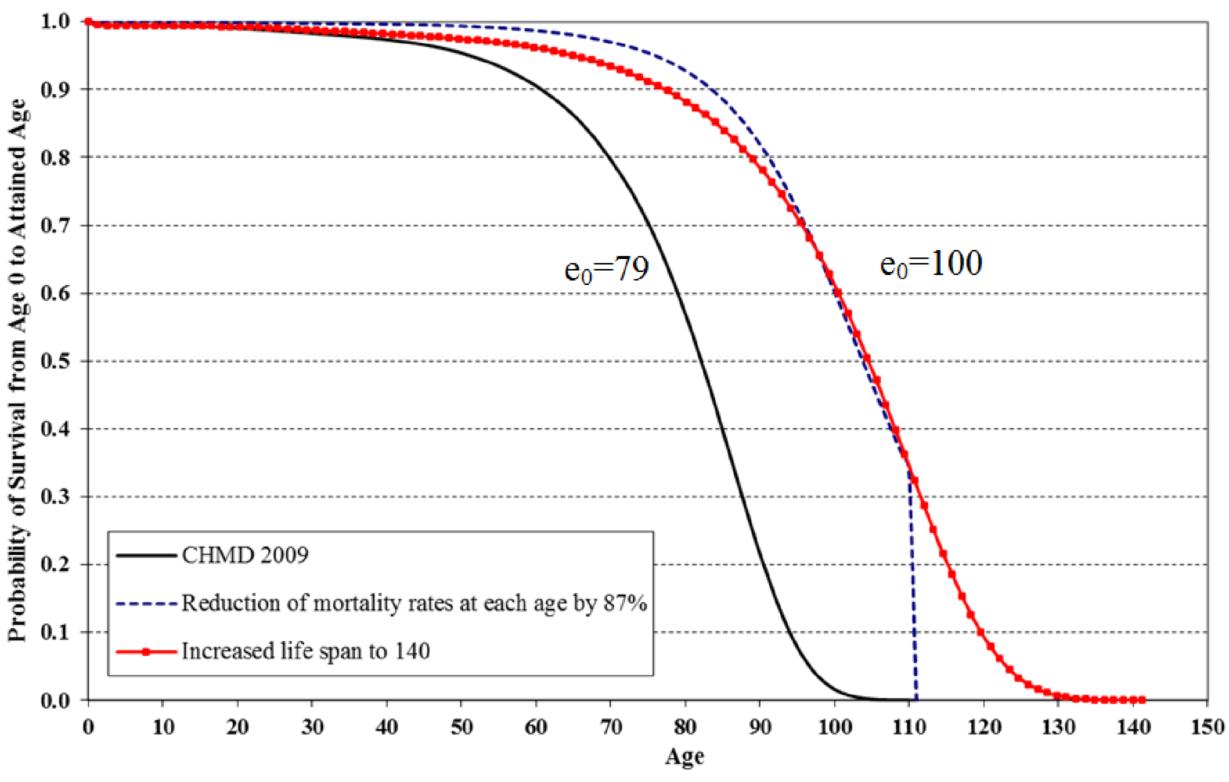
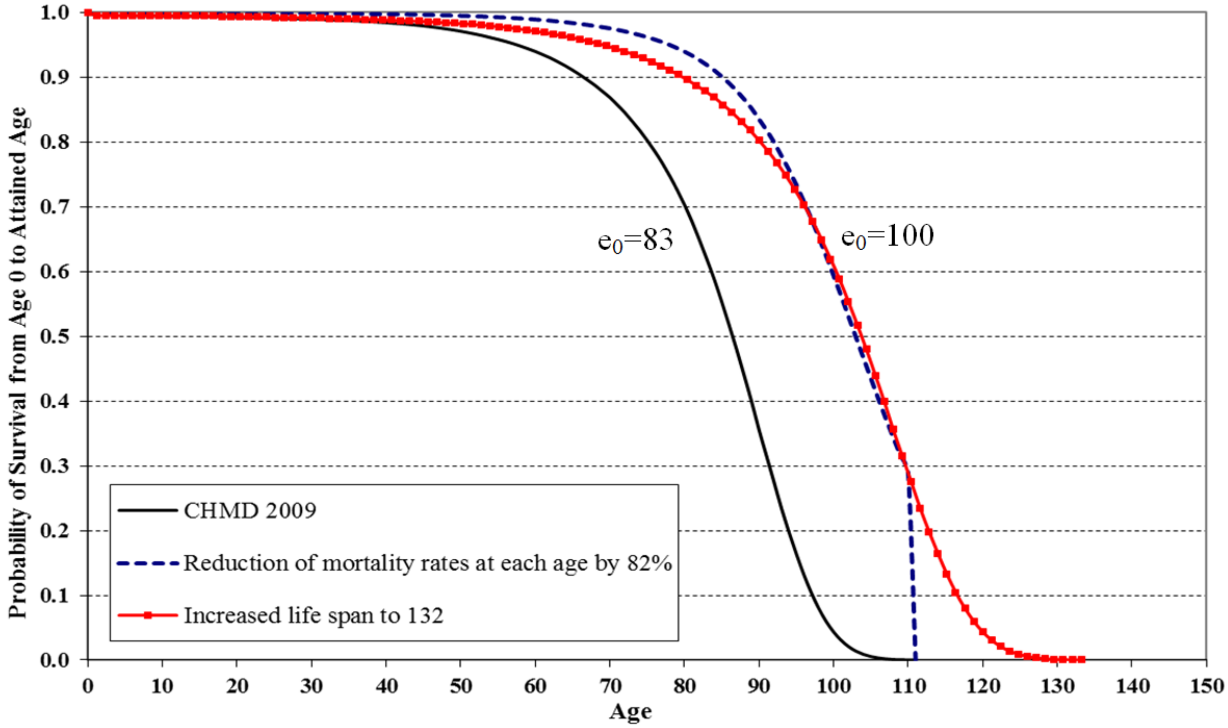


Chart 35: Comparison of Survival Curves for Females using Different Methodologies



V. Mortality and Causes of Death

A. Distribution of Deaths by Cause

A three-stage theory of epidemiological transitions addresses trends in causes of death, as put forth originally in the article "The Epidemiologic Transition: A Theory of the Epidemiology of Population Change", by Omran in 1971. According to this theory, mortality was primarily driven by unpredictable pestilence and famine before the 19th century, the abatement of pandemics and infectious diseases from the middle of the 19th century to the early 20th century, and by chronic diseases such as diseases of the heart and malignant neoplasms in the latter half of the 20th century. The end of the 20th century has been marked by declines in death rates from chronic, degenerative, and man-made diseases. In Canada, for both sexes in 2009, malignant neoplasms ranked higher than diseases of the heart as being the leading cause of death (responsible for about 30% of deaths in Canada), followed by diseases of the heart (responsible for about 21% of deaths), and cerebrovascular diseases (about 6%). Respiratory diseases and accidents caused about 4.5% and 4% of deaths, respectively.

From 1979 to 2009, the number of deaths due to diseases of the heart fell sharply, while deaths due to malignant neoplasms rose, as shown in Table 20. Over the same period, the sex ratio for deaths due to diseases of the heart also decreased sharply, from 140 to 111 males per 100 females. During the same period, the sex ratio for deaths due to malignant neoplasms also declined but more gradually, from 126 to 111 males per 100 females. The narrowing of the gap between the number of overall male deaths and overall female deaths may thus be partially explained by the narrowing of the gap between the numbers of deaths for each sex due to the two main causes of death: malignant neoplasms and diseases of the heart.

Table 20: Distribution of Deaths by Major Causes (1979 and 2009)[1]

Males - 1979

Age group	Malignant neoplasms		Diseases of the Heart		Cerebro-vascular diseases		Chronic lower respiratory diseases		Accidents		Others		Total	
0 to 14	158	4%	38	1%	11	0%	12	0%	784	22%	2,584	72%	3,587	100%
15 to 24	163	4%	50	1%	24	1%	17	0%	2,533	65%	1,129	29%	3,916	100%
25 to 44	808	13%	973	15%	168	3%	37	1%	2,157	34%	2,245	35%	6,388	100%
45 to 64	6,962	28%	9,517	38%	1,092	4%	627	3%	1,582	6%	4,995	20%	24,775	100%
65 +	13,416	23%	23,183	40%	5,590	10%	2,855	5%	1,346	2%	11,476	20%	57,866	100%
Total	21,507	22%	33,761	35%	6,885	7%	3,548	4%	8,402	9%	22,429	23%	96,532	100%

Males - 2009

Age group	Malignant neoplasms		Diseases of the Heart		Cerebro-vascular diseases		Chronic lower respiratory diseases		Accidents		Others		Total	
0 to 14	69	5%	25	2%	11	1%	5	0%	108	8%	1,164	84%	1,382	100%
15 to 24	100	7%	43	3%	6	0%	4	0%	614	41%	715	48%	1,482	100%
25 to 44	688	14%	528	10%	77	2%	9	0%	1,226	24%	2,517	50%	5,045	100%
45 to 64	9,093	37%	5,179	21%	616	3%	450	2%	1,632	7%	7,492	31%	24,462	100%
65 +	27,498	31%	20,166	23%	5,110	6%	5,055	6%	2,460	3%	27,650	31%	87,939	100%
Total	37,448	31%	25,941	22%	5,820	5%	5,523	4%	6,040	5%	39,538	33%	120,310	100%

Females - 1979

Age group	Malignant neoplasms		Diseases of the Heart		Cerebro-vascular diseases		Chronic lower respiratory diseases		Accidents		Others		Total	
0 to 14	119	5%	27	1%	8	0%	11	0%	420	17%	1,961	77%	2,546	100%
15 to 24	134	11%	31	2%	22	2%	4	0%	598	48%	468	37%	1,257	100%
25 to 44	998	32%	257	8%	165	5%	31	1%	566	18%	1,148	36%	3,165	100%
45 to 64	5,767	44%	2,942	22%	841	6%	290	2%	568	4%	2,731	21%	13,139	100%
65 +	10,058	19%	20,819	40%	7,244	14%	843	2%	1,311	3%	11,266	22%	51,541	100%
Total	17,076	24%	24,076	34%	8,280	12%	1,179	1%	3,463	5%	17,574	24%	71,648	100%

Females - 2009

Age group	Malignant neoplasms		Diseases of the Heart		Cerebro-vascular diseases		Chronic lower respiratory diseases		Accidents		Others		Total	
0 to 14	60	5%	23	2%	5	0%	1	0%	67	6%	997	86%	1,153	100%
15 to 24	65	11%	22	4%	3	0%	2	0%	207	34%	315	51%	614	100%
25 to 44	947	32%	194	7%	65	2%	12	0%	412	14%	1,289	44%	2,919	100%
45 to 64	8,558	54%	1,617	10%	483	3%	450	3%	593	4%	4,280	27%	15,981	100%
65 +	24,037	25%	21,459	22%	7,723	8%	4,869	5%	2,924	3%	36,429	37%	97,441	100%
Total	33,667	29%	23,315	20%	8,279	7%	5,334	4%	4,203	3%	43,310	37%	118,108	100%

(1) Source: Statistics Canada, Health Statistics Division.

Year 2009 data from Statistics Canada (publication “Deaths 2009 Catalogue no. 84F0211X”, Table 6.1) by age group have characteristics as described in the following section (see also Charts 36 and 37).

For the first year of life, neonatal deaths (deaths during the first 27 days) accounted for about 75% of infant mortality (deaths of children less than one year of age) in 2009. Table 21 shows how infant deaths are distributed by age.

Table 21: Distribution of Infant Deaths by Age (Canada)

Cumulative proportions of deaths occurring in the first year of life	Males	Females
3 months	0.85	0.87
6 months	0.94	0.94
9 months	0.98	0.97

From birth to age 14, accidents were one of the leading causes of death for both boys (22% of deaths) and girls (17%) in 1979. The proportions of deaths caused by accidents decreased significantly between 1979 and 2009 (8% for boys and 6% for girls), as shown in Table 20 and in Charts 36 and 37. It is worth noting that, in 2009, about 74% of deaths between the ages 0 and 14 occurred before the age of one.

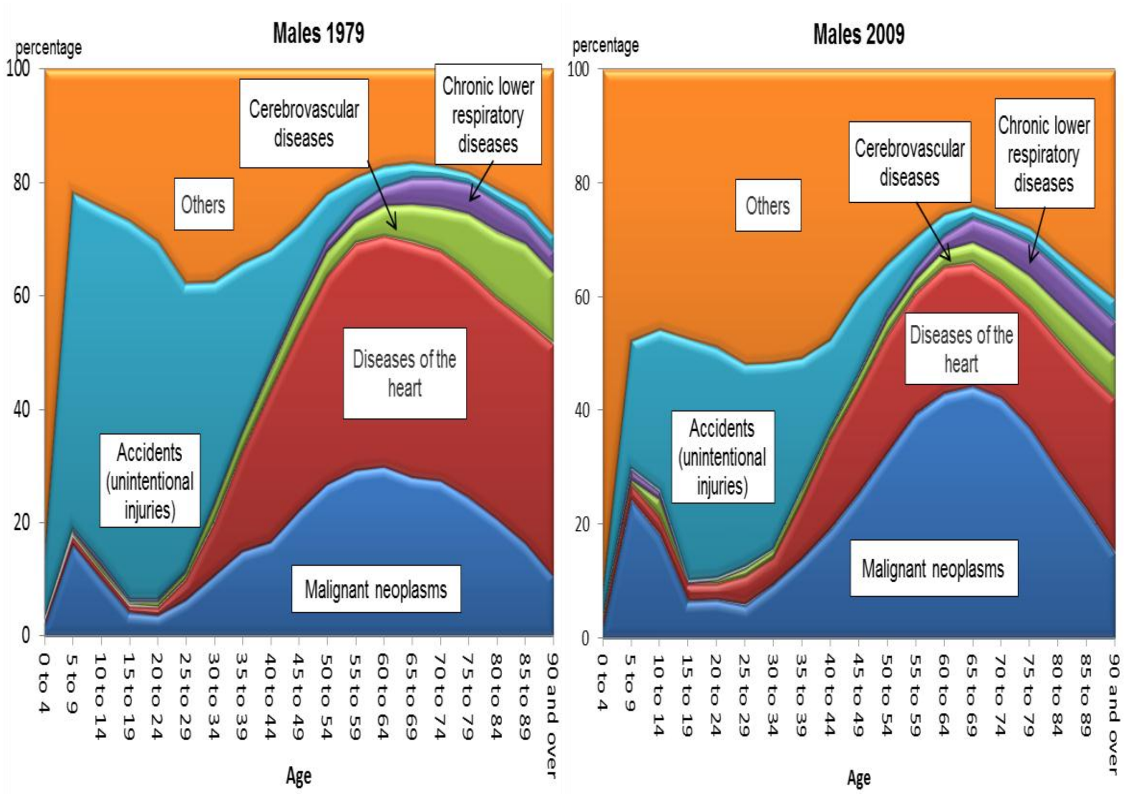
For ages 15-24, accidents were the cause of a particularly high proportion of deaths in 1979 (65% for males and 48% for females). Although the proportions of deaths caused by accidents decreased over the period from 1979 to 2009, accidents still represented a significant proportion of fatalities in 2009 (41% for males and 34% for females). In 2009, suicide was the second leading cause of death (24% for males and 21% for females). In 1979, males accounted for 76% of all deaths in this age group, while this percentage decreased to 71% in 2009.

For ages 25-44, accidents and malignant neoplasms were the leading causes of death in 1979 and in 2009. The proportions of deaths due to malignant neoplasms have been stable over the period 1979 to 2009 for this age group. The proportion of deaths caused by malignant neoplasms for females (32%) is more than twice that for males (14%). The proportions of deaths caused by accidents decreased for this age group, going from 18% to 14% for females and from 34% to 24% for males.

For ages 45-64, malignant neoplasms became the most common cause of death for males between 1979 and 2009, while it was already the most common cause of death for females in 1979. The proportions of deaths caused by malignant neoplasms went from 44% to 54% for females and from 28% to 37% for males over the given period. Prevalence of deaths caused by diseases of the heart decreased in this age group, with the proportions of deaths going from 22% to 10% for females, and from 38% to 21% for males.

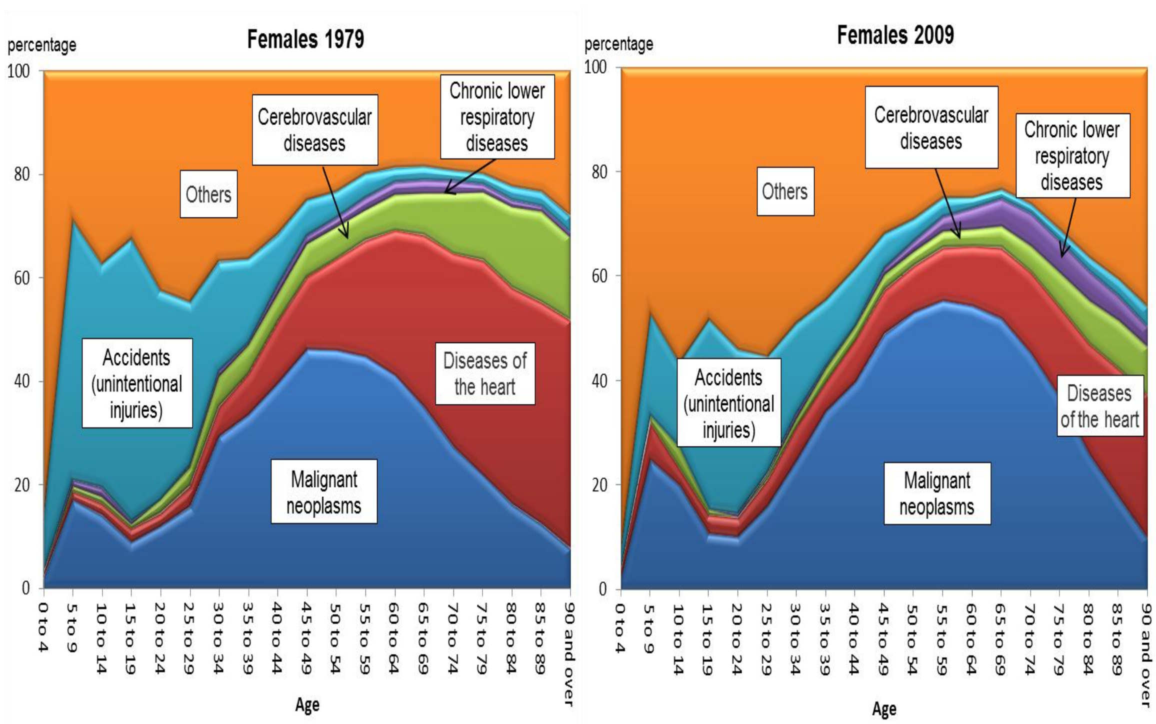
For ages 65 and older, the leading cause of death became malignant neoplasms over the period 1979 to 2009, supplanting diseases of the heart, which fell to second place. For this age group, malignant neoplasms went from causing 21% of deaths in 1979 to 28% in 2009, while diseases of the heart caused 40% of deaths in 1979 compared to 22% of deaths in 2009. Cerebrovascular diseases are now responsible for a smaller proportion of deaths for both sexes in this age group. Chronic lower respiratory diseases are also a significant cause of death among the elderly, with the proportion of deaths due to these diseases increasing since 1979.

Chart 36: Distribution of Male Deaths by Cause(1)



(1) Source: Statistics Canada, Health Statistics Division.

Chart 37: Distribution of Female Deaths by Cause(1)



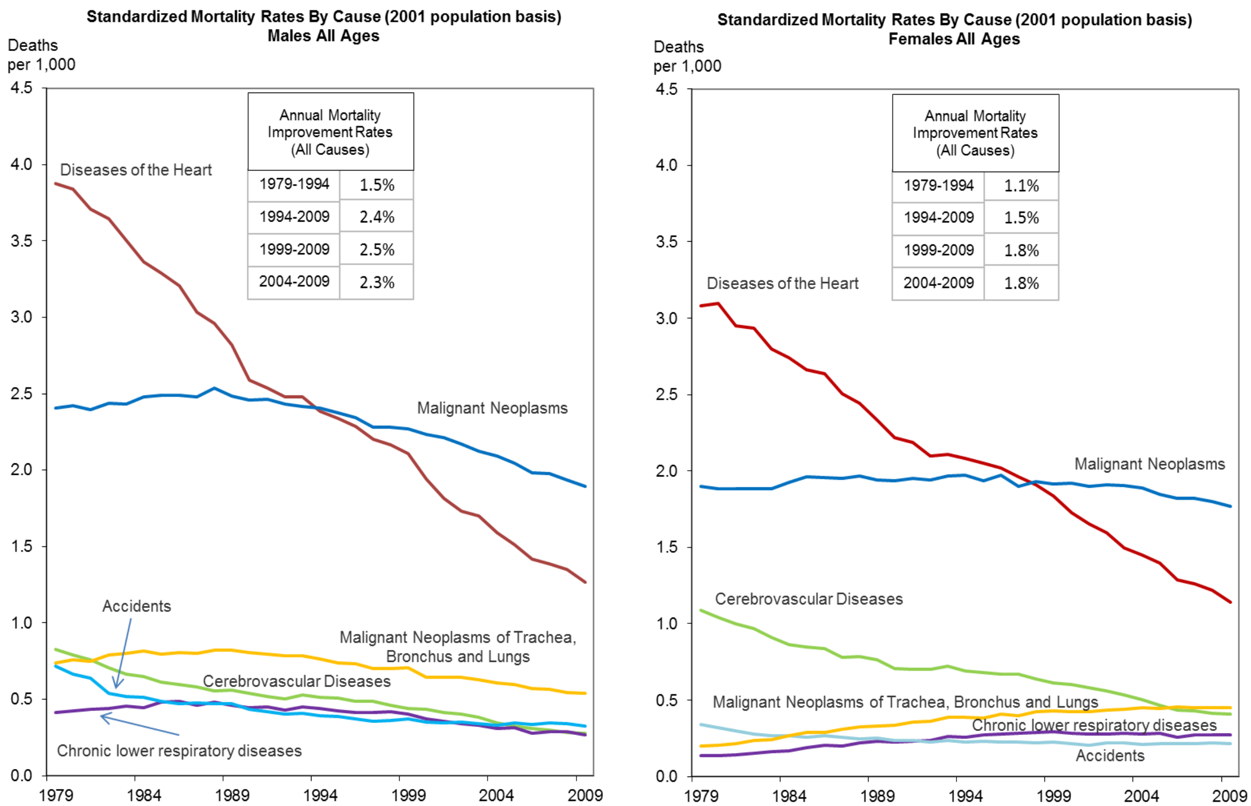
(1) Source: Statistics Canada, Health Statistics Division.

B. Mortality Rates by Cause

In Canada, the overall mortality rate declined significantly between 1979 and 2009. The overall standardized[1] rate for males declined by over 40%, from 10.6 to 6.0 deaths per thousand men over the period, while female overall mortality declined by 30%, from 8.6 to 6.0 deaths per thousand women. As shown in Chart 38, the average annual reduction in mortality for both sexes was more rapid over the 15-year period 1994 to 2009 (2.4% for males, 1.5% for females) than over the previous 15-year period (1979-1994) (1.5% for males, 1.1% for females).

This decrease in overall mortality within the Canadian population in recent decades is largely due to the drop in mortality from diseases of the heart that, between 1979 and 2009, went from 3.9 to just less than 1.3 deaths per thousand for males and from 3.1 to 1.1 deaths per thousand for females, representing an average decline for both sexes of about 67% over that period. During the same period, the mortality rate for external causes (accidents, suicides, and homicides) and cerebrovascular diseases fell by half for both males and females. Since 1991, mortality caused by malignant neoplasms for Canadian males gradually declined from 2.5 deaths per thousand to
1.9 deaths per thousand by 2009. For females, mortality caused by malignant neoplasms remained relatively stable at 1.9 deaths per thousand from 1979 to 2004, with a recent decrease to 1.8 deaths per thousand in 2009.

Chart 38: Mortality by Cause (1979-2009)(1)



(1) Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.

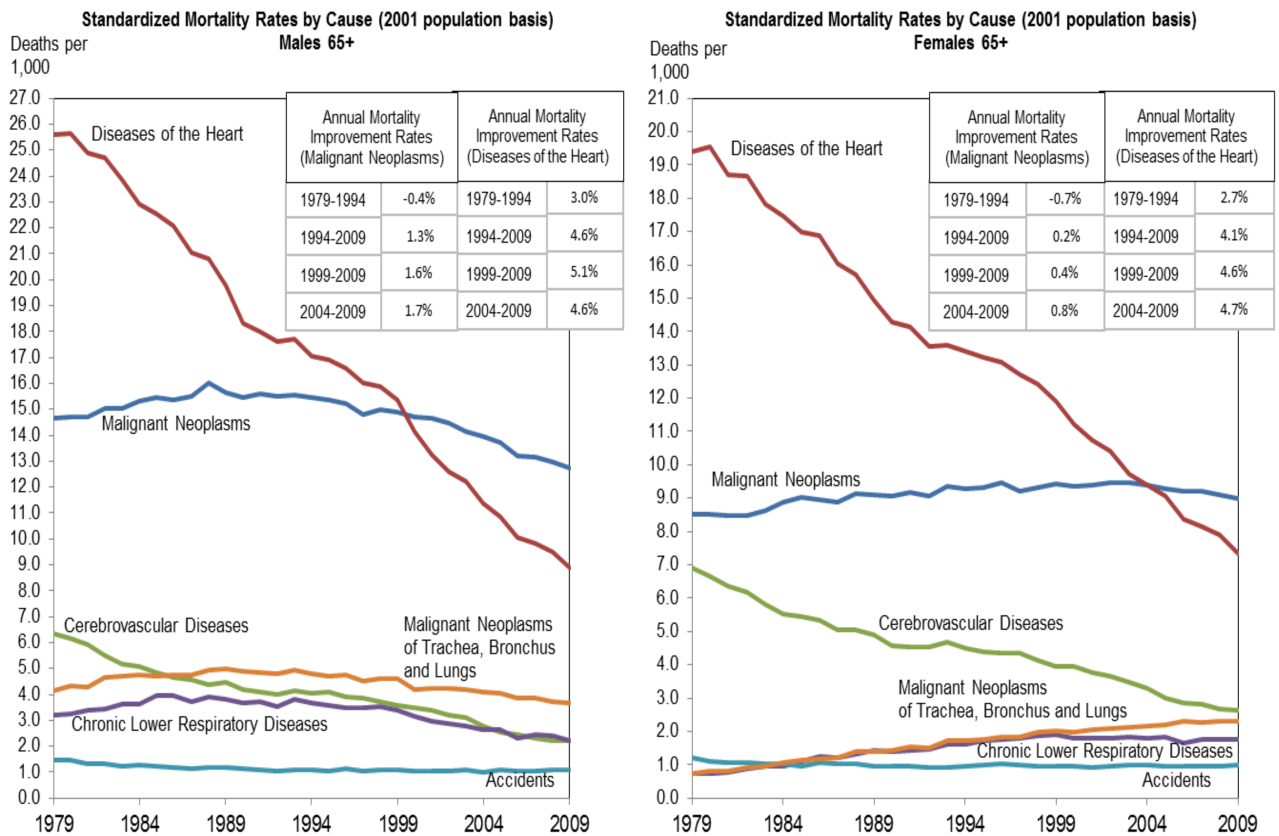
[1] All rates are adjusted to a year 2001 population basis.

C. Mortality Rates by Cause and Age

Taking a closer look at mortality rates by cause and age, especially at ages 65 and over, reveals that between 1979 and 2009, mortality rates related to diseases of the heart dropped significantly for both sexes. Moreover, over the same period, malignant neoplasms topped diseases of the heart as the most common cause of death. This resulted from the combination of mortality caused by malignant neoplasms being somewhat stable and significant decreases in mortality caused by diseases of the heart.

As previously stated, more recent increases in life expectancy have been largely due to improvements in mortality after age 65. Furthermore, as the difference between female and male life expectancies at age 65 has narrowed recently (from 4.2 years in 1980 to 3.1 years in 2009), mortality improvements have been greater for males than for females, as shown in Chart 39 and Table 22. More charts of mortality rates by cause for different age groups are included in the appendices.

Chart 39: Mortality by Cause for Ages 65 and Older (1979-2009)[1]



Males 65+

Annual Mortality Improvement Rates (Malignant Neoplasms)		Annual Mortality Improvement Rates (Diseases of the Heart)	
1979-1994	-0.4%	1979-1994	3.0%
1994-2009	1.3%	1994-2009	4.6%
1999-2009	1.6%	1999-2009	5.1%
2004-2009	1.7%	2004-2009	4.6%

Females 65+

Annual Mortality Improvement Rates (Malignant Neoplasms)		Annual Mortality Improvement Rates (Diseases of the Heart)	
1979-1994	-0.7%	1979-1994	2.7%
1994-2009	0.2%	1994-2009	4.1%
1999-2009	0.4%	1999-2009	4.6%
2004-2009	0.8%	2004-2009	4.7%

(1) Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.

Table 22: Annual Mortality Improvement Rates by Cause [(1)]

Age group	1979-1994	1994-2009	1999-2009	2004-2009	1979-2009
Males					
			Malignant Neoplasms		
65-69	-0.2%	2.1%	2.1%	2.1%	1.0%
70-74	-0.2%	1.6%	2.0%	2.1%	0.7%
75-79	-0.2%	1.1%	1.6%	1.6%	0.5%
80-84	-0.6%	0.9%	1.1%	1.2%	0.2%
85-89	-1.1%	0.8%	1.1%	1.5%	-0.1%
90+	-1.3%	0.0%	1.2%	1.4%	-0.8%
65+	***-0.4%***	***1.3%***	***1.6%***	***1.7%***	***0.5%***
			Diseases of the Heart		
65-69	4.2%	5.2%	5.1%	2.9%	4.6%
70-74	3.7%	5.5%	5.8%	5.2%	4.4%
75-79	2.9%	5.3%	5.7%	4.7%	3.8%
80-84	2.4%	4.7%	5.3%	4.8%	3.1%
85-89	2.2%	3.5%	4.7%	5.6%	2.3%
90+	2.0%	2.4%	3.5%	3.6%	1.6%
65+	***3.0%***	***4.6%***	***5.1%***	***4.6%***	***3.4%***
Females					
Age group	**1979-1994**	**1994-2009**	**1999-2009**	**2004-2009**	**1979-2009**
			Malignant Neoplasms		
65-69	-0.5%	0.8%	1.0%	1.4%	0.2%
70-74	-0.9%	0.4%	0.4%	0.9%	-0.2%
75-79	-0.9%	0.0%	0.3%	0.8%	-0.5%
80-84	-0.5%	-0.1%	0.2%	0.7%	-0.4%
85-89	-0.2%	-0.2%	0.3%	0.2%	-0.4%
90+	-0.8%	-0.1%	0.8%	1.0%	-0.5%
65+	***-0.7%***	***0.2%***	***0.4%***	***0.8%***	***-0.3%***
			Diseases of the Heart		
65-69	4.3%	5.7%	5.9%	4.6%	4.7%
70-74	4.3%	5.5%	5.3%	4.6%	4.4%
75-79	3.4%	5.4%	5.8%	6.0%	4.1%
80-84	2.8%	4.7%	4.9%	4.7%	3.4%
85-89	2.4%	3.7%	4.4%	4.7%	2.6%
90+	1.4%	2.7%	3.5%	4.0%	1.6%
65+	***2.7%***	***4.1%***	***4.6%***	***4.7%***	***3.1%***

(1) Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.

Between 1979 and 2009, mortality rates linked to diseases of the heart experienced the greatest declines by age group and sex. The 65 to 69 age group had the biggest reduction in mortality rates among the age groups over 65, going from 13.0 to 5.4 deaths per thousand for males (annual improvement of 4.6%) and from 5.2 to 1.3 deaths per thousand for females (annual improvement of 4.7%). More recently, female mortality rates for the age group 65 to 69 showed the largest decrease among female mortality rates for ages over 65, going from 2.3 deaths per thousand in 1999 to 1.3 deaths per thousand in 2009, representing an annual improvement rate of 5.9%. The most recent significant improvement in male mortality rates belongs to the age group 70 to 74, where mortality rates went from 9.7 per thousand to 5.0 per thousand over the period 1999 to 2009, representing an annual improvement rate of 5.8%. As previously stated, the magnitude of mortality improvements decreases as age advances. The 90 and older age group had the lowest improvement rates for both sexes compared to other age groups over 65.

Mortality rates associated with malignant neoplasms were relatively stable for ages above 65 over the period 1979 to 2009. Over the first half of that period, from 1979 to 1994, negative improvement rates ranging between -0.2% and -1.3% were observed for mortality caused by malignant neoplasms, for all age groups and both sexes combined. More lately, the malignant neoplasms related mortality rates have shown slight improvements for both sexes, although annual MIRs for males have been higher than those for females (between 1.2% and 2.1% for males and between 0.2% and 1.0% for females between 1999 and 2009).

While male mortality rates linked to malignant neoplasms of the trachea, bronchus, and lungs have been declining since 1994, the rates for females have been constantly increasing since 1979, with the most significant increases occurring before 1994. For both sexes, recent experience for these diseases shows that as age advances, annual MIRs decrease.

Mortality rates related to chronic lower respiratory diseases show an upward trend for females since 1979 and a downward trend for males since 1999. Male improvement rates are positive for all age groups above age 65 since 1999, ranging from 2.9% to 4.3% over the 1999 to 2009 period. Similar to improvement rates linked to malignant neoplasms of the trachea, bronchus and lungs, annual MIRs for chronic lower respiratory diseases decrease with advancing age.

Cerebrovascular diseases are one of the causes of death that had constant declining mortality rates over the period 1979 to 2009, going from 6.4 to 2.2 deaths per thousand for males and from 6.9 to 2.6 deaths per thousand for females, for ages over 65. Mortality rates associated with accidents have been relatively stable for each age group and sex since 1979.

Except for cerebrovascular and chronic lower respiratory diseases, mortality rates for all other major causes of death are higher for males than females as of 2009, all ages combined.

D. Impact of Causes of Death on Life Expectancy

In this section, life expectancy is put into perspective by considering the major causes of death. Based on the 26th CPP Actuarial Report, it is projected that cohort life expectancy (i.e. including future mortality improvements) at birth for males will increase over the period 2010 to 2075 from 85.8 to 90.1 years at birth and from 20.6 to 24.3 years at age 65. For females, the increases are from 88.9 to 92.5 years at birth and 23.1 to 26.5 years at age 65.

Using data from Statistics Canada for deaths by cause and age for the year 2009, it is possible to derive new cohort life expectancies at age 65 if future mortality improvements are set to vary by cause of death. Two scenarios are examined under which future mortality improvement rates are set to vary between causes related to malignant neoplasms and diseases of the heart, and all other causes.

Table 23 shows the proportions of deaths caused by malignant neoplasms and diseases of the heart by age group and sex for 2009. Table 23 reveals that above age 65, as age advances, fewer females die from malignant neoplasms and more from cardiovascular diseases. The same pattern is observed for males, but the magnitude of the variation is smaller than for females. Malignant neoplasms and diseases of the heart are responsible for two thirds of the deaths in the 65 to 69 age group. This proportion decreases as age advances.

Table 23: Proportion of Deaths by Cause (diseases of the heart, neoplasms) (2009)(1)

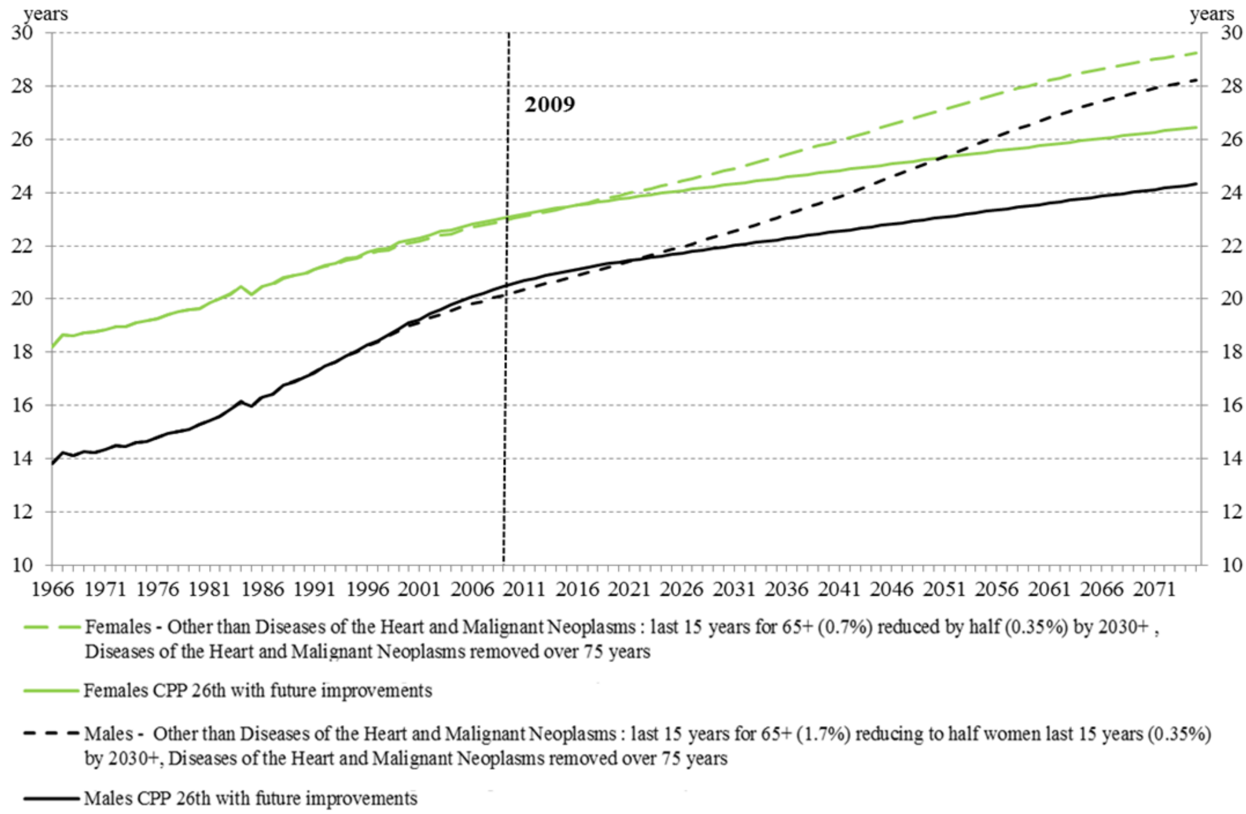
	Males			Females		
Age	**Diseases of the Heart**	**Malignant Neoplasms**	**Diseases of the Heart + Malignant Neoplasms(2)**	**Diseases of the Heart**	**Malignant Neoplasms**	**Diseases of the Heart + Malignant Neoplasms(2)**
Under 45	8%	11%	18%	5%	23%	28%
45 to 64	21%	37%	58%	10%	54%	64%
65 to 69	22%	44%	66%	13%	52%	65%
70 to 74	20%	42%	63%	15%	45%	61%
75 to 79	21%	37%	58%	17%	37%	54%
80 to 84	23%	29%	52%	21%	26%	47%
85 to 89	24%	23%	47%	25%	18%	42%
90 and over	27%	15%	42%	27%	10%	37%
All Ages	22%	31%	53%	20%	29%	48%

(1) Source: Data from Statistics Canada, Health Statistics Division.
(2) Component percentages may not sum to totals due to rounding.

The first scenario assumes that mortality related to diseases of the heart and malignant neoplasms is gradually eliminated over the next 75 years (see Appendices), while mortality from all other causes is initially improved at the rate observed over the last 15 years but gradually reduced by 2030 to half the rate observed for females from all other causes over the same period. This results in improvement rates for other than malignant neoplasms and diseases of the heart of 0.7% per year in 2010, reducing to 0.35% per year in 2030 and thereafter for females and 1.7% per year in 2010 to 0.35% per year in 2030 and thereafter for males. The assumption for other than malignant neoplasms and diseases of the heart is consistent with the approach that was used to develop the assumed improvement rates of the 26th CPP Actuarial Report. As discussed earlier, under that report, future mortality improvements rates are initially set equal to the all causes of death improvement rate observed over the last 15 years, but then gradually reduced by 2030 to about half the rate observed from all causes for females. One has to keep in mind that this scenario is strictly for illustrative purposes, as it assumes that individuals who would have died from certain causes (diseases of the heart or malignant neoplasms) will instead gradually die of other causes over their remaining lifetimes, and that each cause of death is independent. Despite its limitations, the obtained results enable the projected life expectancies under the 26th CPP Actuarial Report to be put into some perspective.

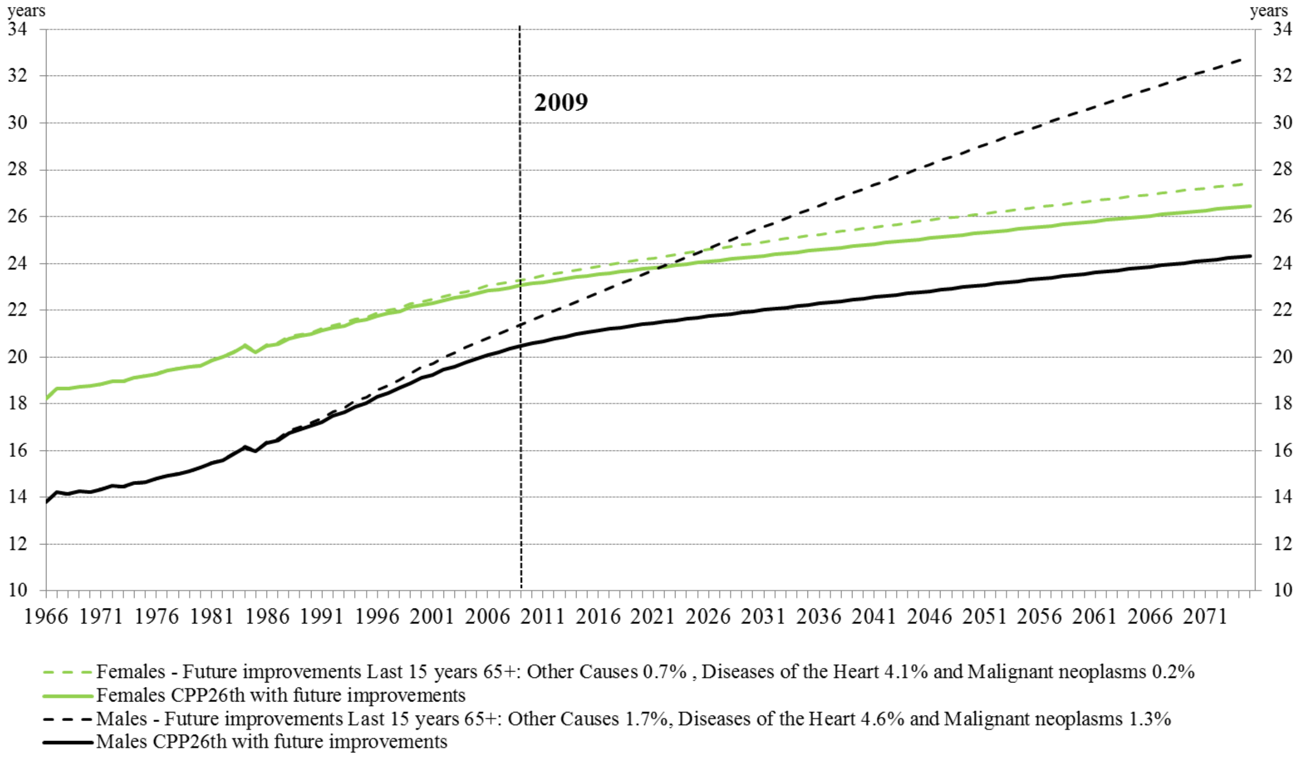
Chart 40 shows a comparison of the cohort life expectancies at age 65 between the 26th CPP Actuarial Report and those obtained under the scenario described above. The scenario results in cohort life expectancies at age 65 that eventually surpass those projected under the 26th CPP Actuarial Report, starting in 2017 for females and 2024 for males. Gradually removing the effect of mortality from diseases of the heart and malignant neoplasms over 75 years and applying lower improvement rates for other causes has a greater impact on life expectancies than the MIRs assumed in the 26th CPP Actuarial Report. By 2075, under the given scenario, cohort life expectancies are 2.7 years higher for females and 3.9 years higher for males than under the 26th CPP Actuarial Report.

Chart 40: Impact of Varying Improvement Rates by Cause on Life Expectancies at Age 65



Another scenario that can be tested is if the annual MIRs of the last 15 years (1994-2009) by cause (diseases of the heart, malignant neoplasms, and all other causes) are assumed to remain constant over the entire projection period. Chart 41 presents the resulting cohort life expectancies at age 65 under such a scenario. This scenario leads to a narrowing of the gap between female and male life expectancies at age 65 over the next 15 years and a higher life expectancy for males than for females by 2026 and thereafter. Under this scenario, in 2075, life expectancy at age 65 for males would surpass that for females by 5.4 years (32.8 years vs. 27.4 years). This results from the fact that MIRs for males have been greater than for females during the last 15 years. This highlights the need to be careful and fully cognizant of the choice of assumed future improvements and that, in particular, strictly restricting one's choice to recent experience may lead to unintended results.

Chart 41: Cohort Life Expectancies at Age 65
(MIRs of last 15 years)



VI. Old Age Security Program Beneficiaries Mortality Experience

Historically, the level and age trajectory of mortality rates at advanced ages in Canada have not been readily and precisely measurable due to problems concerning the reliability of data on deaths and on population counts beyond a certain point in official vital statistics. As the OAS Program provides the payment of old age basic benefits to almost all Canadians aged 65 and over, the availability of an administrative OAS beneficiaries database allows the more accurate measurement of the level and trend in mortality experienced by the oldest portion of the Canadian population.

A comparison of the mortality rates between those with middle to high retirement incomes and all OAS beneficiaries is shown in Table 24 (Office of Chief Actuary 2012). Retirement income includes but is not limited to CPP or QPP benefits, pension income, and Registered Retirement Income Fund withdrawals during a year. A beneficiary is considered in the middle to high retirement income class if he or she is not in receipt of a GIS pension, which is an income-tested benefit paid in addition to the basic OAS pension in cases where there is low income. Those with middle to high retirement incomes experience lower mortality compared to all OAS beneficiaries collectively, as shown in the table by the relative mortality ratios being below one. However, the middle to high income group mortality rates approach the overall rates as age increases, as seen by the convergence of the mortality ratios to levels near 1.00 for both males and females. The mortality rates and ratios of those OAS beneficiaries who have low retirement incomes are shown in Table 25. This group experiences higher mortality compared to all OAS beneficiaries, as shown by the relative mortality ratios exceeding one. For each sex, mortality rates converge to the overall OAS rates at the advanced ages. Chart 42 illustrates the difference in mortality between those with middle to high retirement incomes and those with low incomes.

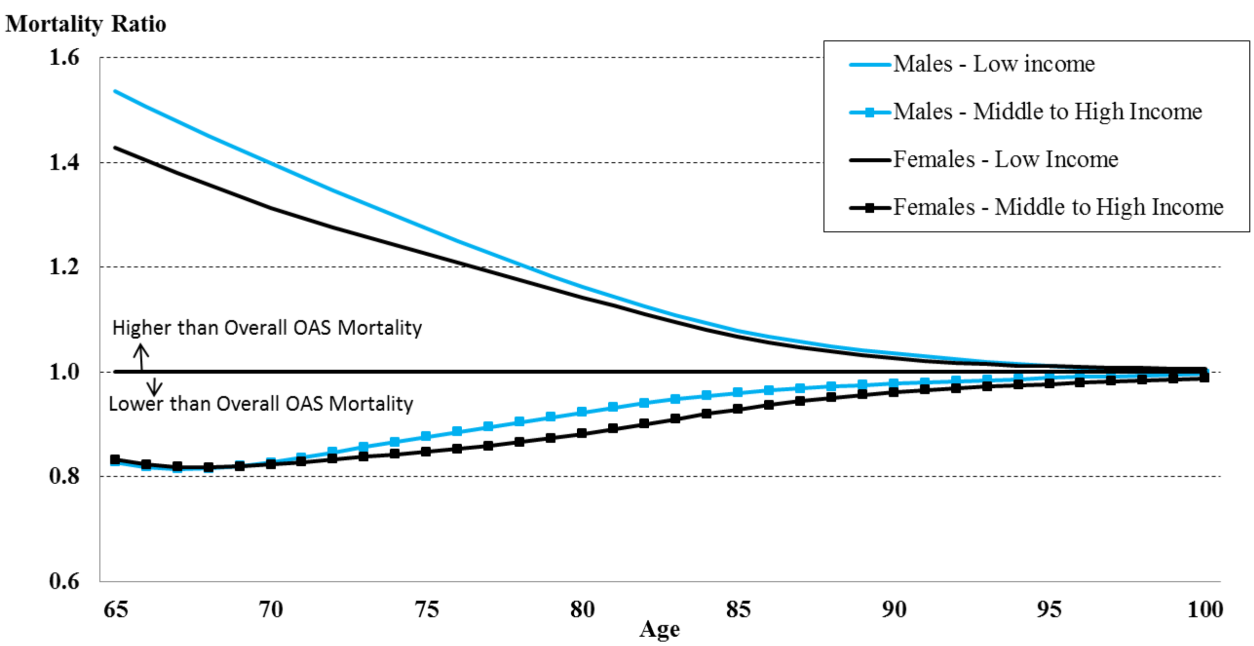
Table 24: Mortality Rates of OAS Beneficiaries (with Middle to High Retirement Incomes, 2007)
(deaths per thousand)

Age Group	Males			Females		
	Middle to High Income	Overall OAS	Ratio Middle to High Income to Overall OAS	Middle to High Income	Overall OAS	Ratio Middle to High Income to Overall OAS
65-69	13.8	16.9	0.82	8.6	10.5	0.82
70-74	22.9	27.1	0.85	14.2	17.1	0.83
75-79	39.8	44.5	0.89	24.4	28.4	0.86
80-84	69.9	74.4	0.94	44.4	49.5	0.90
85-89	119.0	123.5	0.96	82.1	87.9	0.93
90-94	192.9	197.5	0.98	146.1	152.1	0.96
95-99	282.7	286.7	0.99	232.2	238.1	0.98
100+	392.5	394.6	0.99	343.4	349.5	0.98

Table 25: Mortality Rates of OAS Beneficiaries (with Low Retirement Incomes, 2007)
(deaths per thousand)

	Males			Females		
Age Group	Low Income	Overall OAS	Ratio Low Income to Overall OAS	Low Income	Overall OAS	Ratio Low Income to Overall OAS
65-69	25.2	16.9	1.49	14.6	10.5	1.39
70-74	36.4	27.1	1.34	21.8	17.1	1.27
75-79	54.6	44.5	1.23	34.0	28.4	1.20
80-84	83.8	74.4	1.13	55.2	49.5	1.12
85-89	131.9	123.5	1.07	92.9	87.9	1.06
90-94	203.8	197.5	1.03	155.7	152.1	1.02
95-99	290.0	286.7	1.01	240.9	238.1	1.01
100+	394.0	394.6	1.00	352.3	349.5	1.01

Chart 42: Mortality Ratios: OAS Beneficiaries by Level of Income (2007)



OAS mortality rates are also dependent on whether beneficiaries were born in Canada or are immigrants (Office of Chief Actuary, 2012). OAS mortality rates are thus affected by the level of immigration to Canada, which historically has been volatile. As the total fertility rate in Canada has fallen significantly since the late 1950s to below replacement level, immigration has represented an increasing portion of the growth of the population.

As shown in Table 26, immigrants experience lower mortality than those born in Canada. As such, immigrants have contributed to increasing life expectancies in Canada. The greater life expectancies of immigrants as well as their relative better health compared to those born in Canada may be explained by a "healthy immigrant effect" as referred to by Chen, Wilkins and Ng (1996). The authors describe this effect as resulting from several factors.

First, people in poor health are less likely to migrate to another country. In addition, all potential immigrants to Canada are subject to medical screening. Moreover, immigrants to Canada are partially selected on the basis of employability, which would imply a certain status of health. As new immigrants tend to be healthy, they could experience greater life expectancies than those who had immigrated years earlier. Lastly, cultural and lifestyle characteristics of immigrants may also contribute to their relative better health and increased longevities.

Table 26: OAS Beneficiaries Mortality Rates by Place of Birth (2007)
(deaths per thousand)

	Males				
Age Group	**Born in Canada**	**Ratio Born in Canada to Overall OAS**	**Born Outside of Canada**	**Ratio Born Outside of Canada to Overall OAS**	**Overall OAS**
65-69	18.6	1.10	12.8	0.76	16.9
70-74	29.4	1.09	21.6	0.80	27.1
75-79	47.5	1.07	37.8	0.85	44.5
80-84	78.2	1.05	66.2	0.89	74.4
85-89	128.4	1.04	111.5	0.90	123.5
90-94	202.3	1.02	185.3	0.94	197.5
95-99	291.0	1.01	278.6	0.97	286.7
100+	402.9	1.02	386.7	0.98	394.6
	Females				
Age Group	**Born in Canada**	**Ratio Born in Canada to Overall OAS**	**Born Outside of Canada**	**Ratio Born Outside of Canada to Overall OAS**	**Overall OAS**
65-69	11.7	1.11	7.4	0.71	10.5
70-74	18.8	1.10	12.8	0.75	17.1
75-79	30.2	1.06	23.9	0.84	28.4
80-84	51.4	1.04	44.9	0.91	49.5
85-89	90.1	1.02	81.6	0.93	87.9
90-94	153.6	1.01	147.7	0.97	152.1
95-99	235.5	0.99	241.1	1.01	238.1
100+	347.6	0.99	352.7	1.01	349.5

A comparison of life expectancies at age 65 between various subgroups of OAS beneficiaries is presented in Table 27. The life expectancies shown do not include assumed future mortality improvements.

OAS beneficiaries born outside of Canada have greater life expectancies than beneficiaries born in Canada. The differential for males is 1.8 years and for females 1.5 years. For those born in Canada, the gap between female and male life expectancies is 3.3 years, which is higher than the corresponding differential of 3.0 years for those born outside of Canada.

An analysis of the differentials in life expectancies at age 65 by level of income shows that males experience a wider range in life expectancies at age 65 between wealthier and poorer OAS beneficiaries compared to females. The differential in life expectancies at age 65 between those with the middle to high retirement income and those with the lowest income is 2.4 years for males and 2.1 years for females. Moreover, the gap in life expectancies at age 65 between the two sexes decreases at a higher income level, from 3.6 years for those with low income to 3.3 years for those with middle to high income.

The results presented in Table 27 also confirm that both males and females who are married experience lower mortality than their single counterparts. The positive effect of being married on mortality is more pronounced for males, with a married-single differential in life expectancies for males that is almost twice the differential for females (3.3 years compared to 1.7 years). For both sexes, individuals who are married with middle to high retirement incomes experience the lowest mortality.

Table 27: OAS Beneficiaries Life Expectancies at Age 65 (2007)

	Males	Females	Female – Male Differential
All Income Levels	17.8	21.0	3.2
-Married	18.8	21.9	3.1
-Single	15.5	20.2	4.7
Low Income	16.2	19.8	3.6
-Married	17.6	20.7	3.1
-Single	14.1	19.4	5.3
Middle to High Income	18.6	21.9	3.3
-Married	19.3	22.5	3.2
-Single	16.7	21.1	4.4
Born in Canada	17.3	20.6	3.3
Born outside of Canada (immigrants)	19.1	22.1	3.0
Differential between Middle to High and Low Income	2.4	2.1	
Differential between Immigrants and those Born in Canada	1.8	1.5	
Differential Between Married and Single	3.3	1.7	

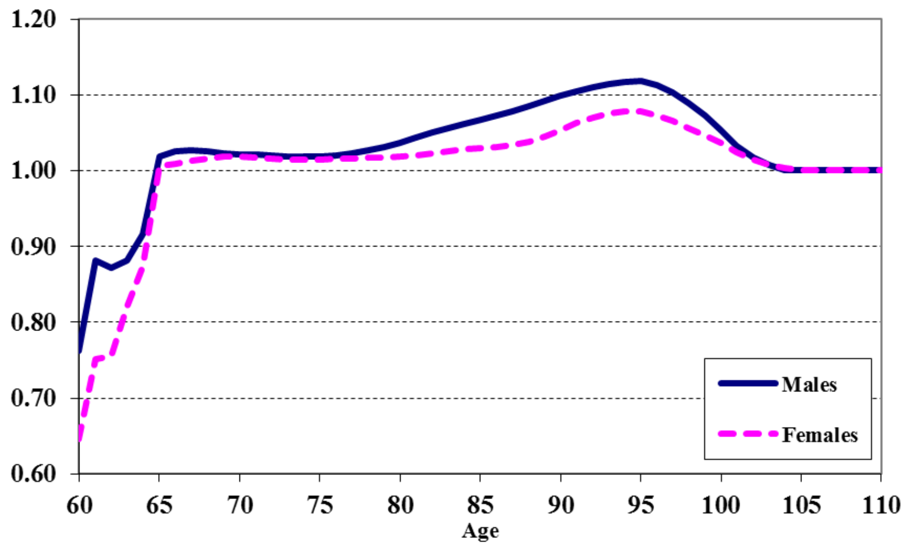
VII. Canada Pension Plan Beneficiaries Mortality Experience

This section reviews the recent mortality experience[1] of beneficiaries for the three main types of benefits that are provided by the CPP, i.e. retirement, survivor, and disability benefits.

A. Retirement Beneficiaries

The mortality experience of CPP retirement beneficiaries for the year 2009 is shown in Chart 43 in terms of mortality ratios relative to the general population (i.e. the CHMD Canada less Québec mortality rates for that year).

Chart 43: Mortality Ratios: CPP – Retirement – 2009 (Relative to General Population)



At ages 60 to 64, retirement beneficiary mortality rates for both sexes are significantly lower than for the general population. This is because retirement beneficiaries between the ages of 60 and 64 do not include CPP disability beneficiaries, who experience a much higher level of mortality (discussed in section C). At ages 65 and older, male and female CPP retirement beneficiaries experience higher mortality rates than the general population. The mortality difference increases at ages 80 and over and is greater for males than females. One important reason that may explain the difference is that CHMD mortality is based on a survey, while CPP retirement beneficiaries mortality is based on an administrative database.

An analysis of the mortality experienced by CPP retirement beneficiaries was also done by pension level, where four pension levels were defined by the following ranges of percentages of the maximum retirement benefit: less than 37.5%, 37.5% to less than 75%, 75% to less than 100%, and 100%. Charts 44 and 45 present the CPP retirement beneficiaries to the general population mortality ratios by level of retirement pension for males and females.

[1] The mortality experience presented for retirement and survivor benefits is based on data that were used in the preparation of the 26th CPP Actuarial Report (as at 31 December 2012). The mortality experience presented for disability benefits is based on data that were used in the preparation of OCA Actuarial Study No. 9 (September 2011).

In general, higher mortality differentials are experienced at the younger CPP retirement ages; however, at all pension levels, both sexes exhibit expected patterns of convergence to the general population mortality as age increases. There is a noticeable increase in the mortality ratios at age 65, which is attributable to the automatic conversion of disability beneficiaries to retirement beneficiaries at that age.

Charts 44 and 45 also show that for both sexes, the level of retirement pension is inversely related to the mortality ratios, with the effect reducing with age. CPP retirement beneficiaries with higher retirement pensions experience lower mortality ratios, compared to those beneficiaries with lower pensions who experience greater mortality ratios.

Chart 44: Mortality Ratios: CPP – Retirement – Level – Male – 2009

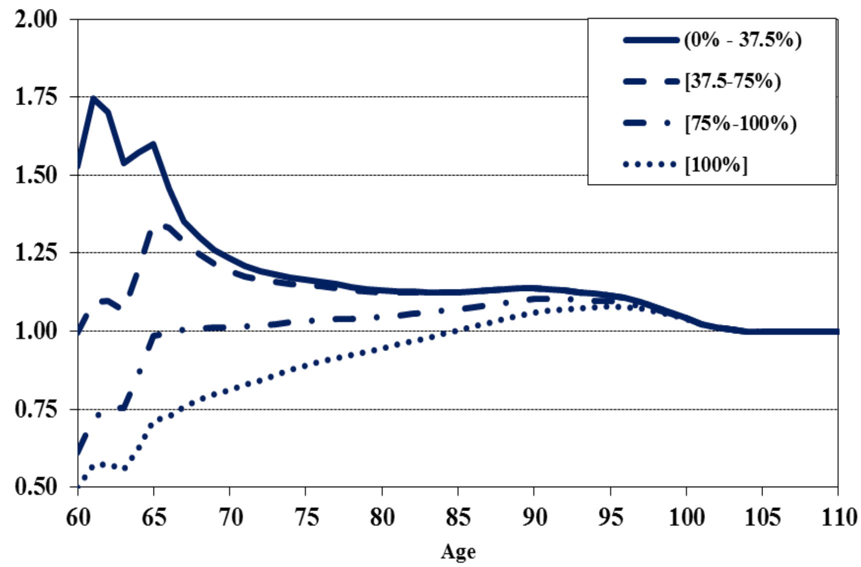
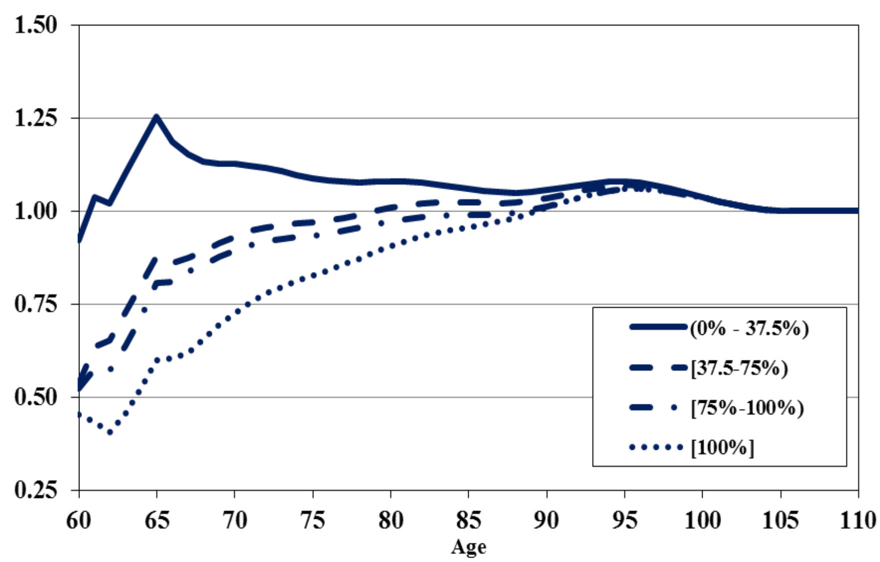


Chart 45: Mortality Ratios: CPP – Retirement – Level – Female – 2009

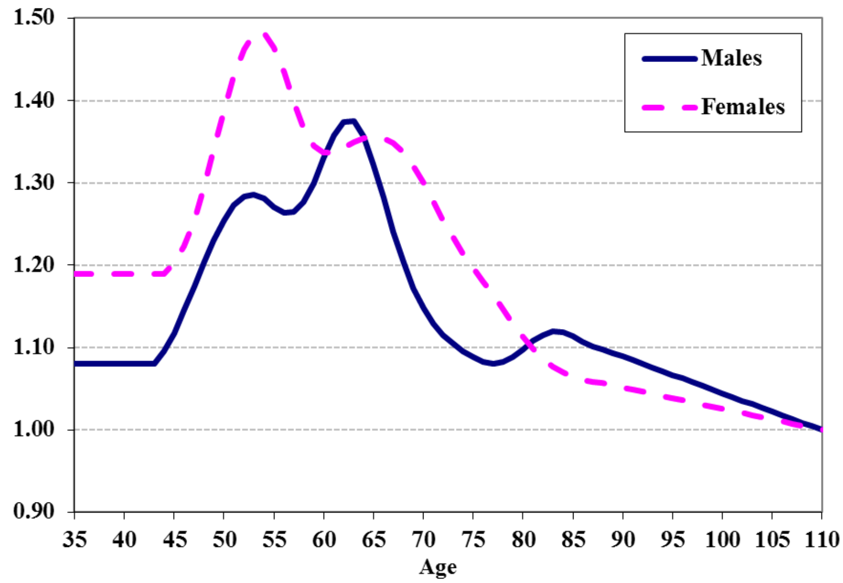


B. Survivor Beneficiaries

Similar to retirement beneficiaries mortality, survivor beneficiaries mortality experience based on the year 2009 shows a divergence from the general population mortality (i.e. CHMD Canada less Québec).

Chart 46 shows CPP survivor mortality rates relative to the rates for the general population. CPP survivor beneficiary mortality is seen to be significantly higher than that of the general population. One reason might be that survivors are deeply affected by the loss of their spouse, especially at the older ages where the survivor may already be in a weakened condition. Also, it could be assumed in some cases that losing part of the primary source of income adds stress to the survivors.

Chart 46: Mortality Ratios: CPP – Survivor – 2009
(Relative to General Population)

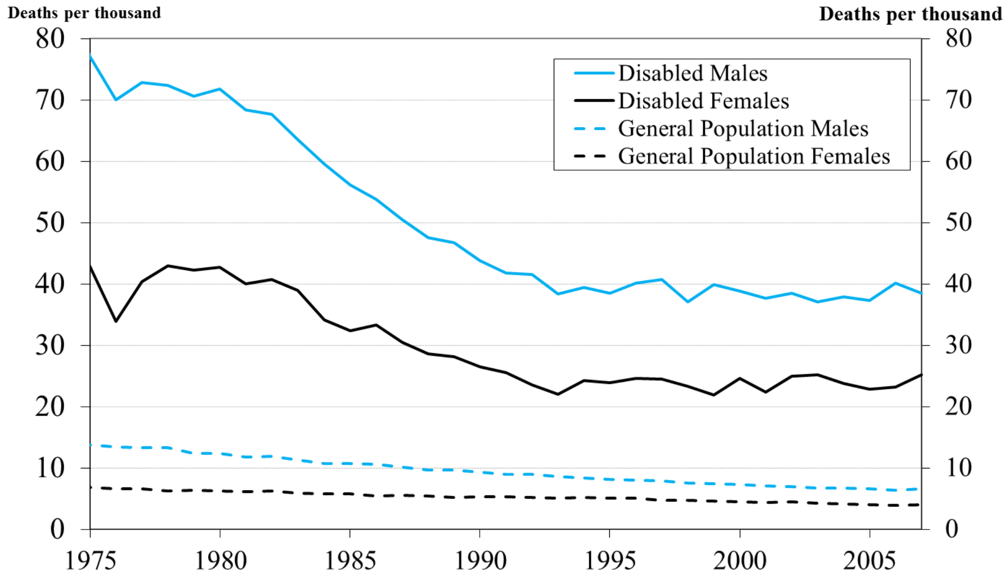


The survivor beneficiary mortality ratio curves for males and females have different shapes. Male mortality ratios generally increase from 1.08 at age 43 to reach a maximum of 1.37 at age 62, and then generally decrease and converge to the level of general male population mortality at the advanced ages. Female mortality ratios increase from 1.19 at age 44 to reach a maximum of 1.48 at age 53, and then generally decrease and converge to the level of general female population mortality at the advanced ages.

C. Disability Beneficiaries

CPP disability beneficiaries mortality rates relative to the rates of the general population are much higher than the relative rates for CPP retirement and survivor beneficiaries. Chart 47 shows that the mortality rates of male and female disability beneficiaries aged 55 to 59 are on average five to six times higher than the mortality rates of the general population for that age group and each sex. Similar relationships are observed for other age groups.

Chart 47: Mortality Rates – Disability Beneficiaries and General Population, Ages 55-59 (2007)



Mortality by Cause of Disability, Level of Benefit, Age, and Sex

In this section, it is shown that the mortality rates pertaining to malignant neoplasms as the cause of disability are much greater than the mortality rates associated with causes other than neoplasms for both sexes. An analysis is also given of the mortality experienced by disability beneficiaries with lower and higher benefit levels. For classification purposes, the higher benefit level was set at 75% or more of the maximum earnings-related benefit for males and 60% or more of the maximum earnings-related benefit for females.

Chart 48 shows that for disabled males because of malignant neoplasms, their mortality rates at the higher benefit level exceed the rates at the lower benefit level by about 20% up to age 60, after which the rates at the two levels are similar. In comparison, Chart 49 shows that for disabled males for reason other than malignant neoplasms, their mortality rates are slightly higher for all ages between 45 and 54 for the higher benefit level compared to the lower level. The reverse is observed at ages 55 to 64, with the difference most pronounced at age 64. The mortality rates are also seen to increase by age for both benefit levels.

Chart 48: Mortality of Disabled Because of Neoplasms, by Level of Benefit, Males (2007)

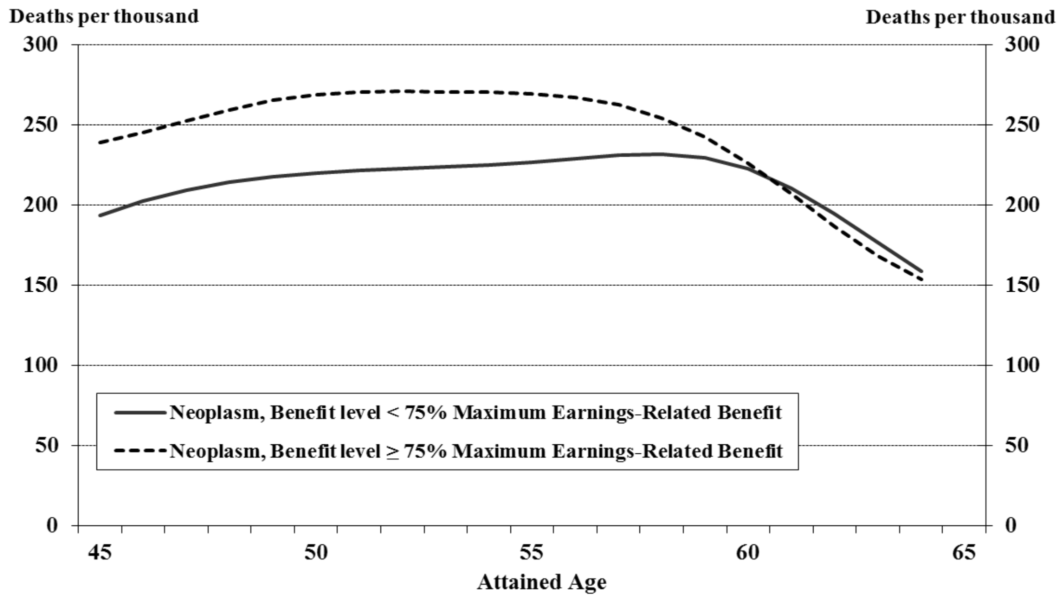


Chart 49: Mortality of Disabled for Reason Other than Neoplasms, by Level of Benefit, Males (2007)

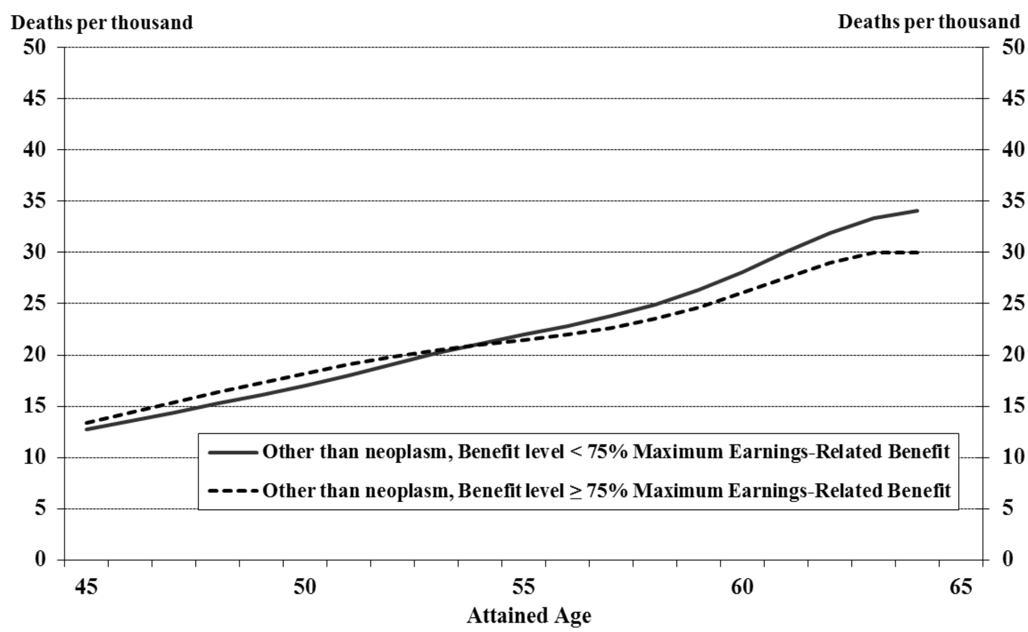


Chart 50 shows that for females, neoplasm-related mortality rates at the higher benefit level exceed the rates at the lower benefit level by about 20% at all ages 45 to 64. Similar to males, mortality rates for females show an initial increasing and then decreasing trend, with the decline for each benefit level starting after age 53. However, the absolute mortality rate differential for females between the two benefit levels is smaller than for males. In addition, the differential remains for females, whereas it disappears for males at the older ages.

Chart 51 shows that for other than neoplasm causes of disability, mortality rates for females at each benefit level increase continuously by age and are similar between benefit levels, with females at the lower benefit level having slightly higher mortality at younger and older ages.

Chart 50: Mortality of Disabled Because of Neoplasms, by Level of Benefit, Females (2007)

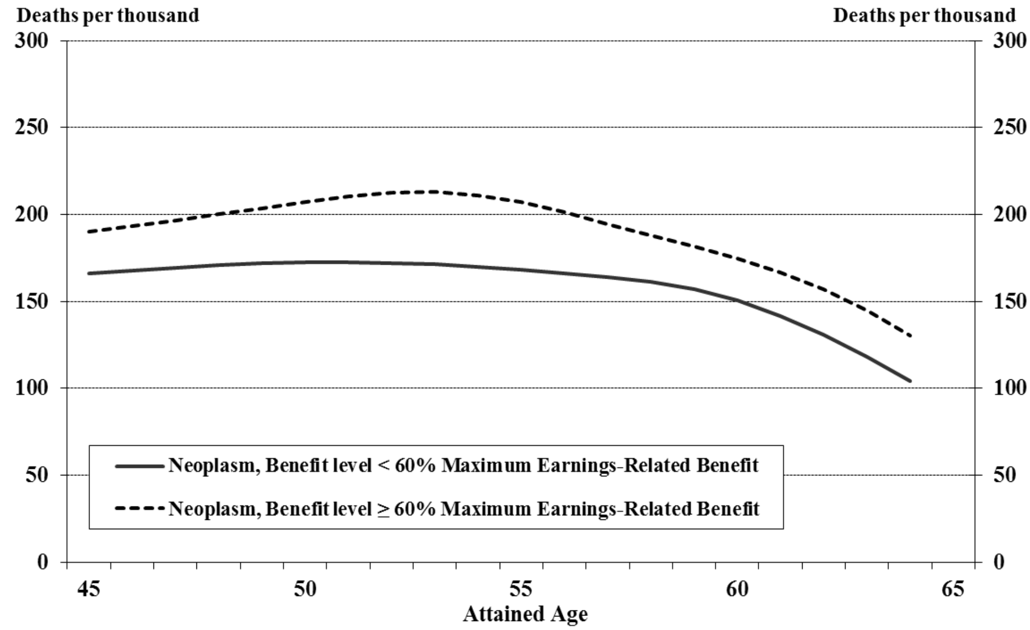
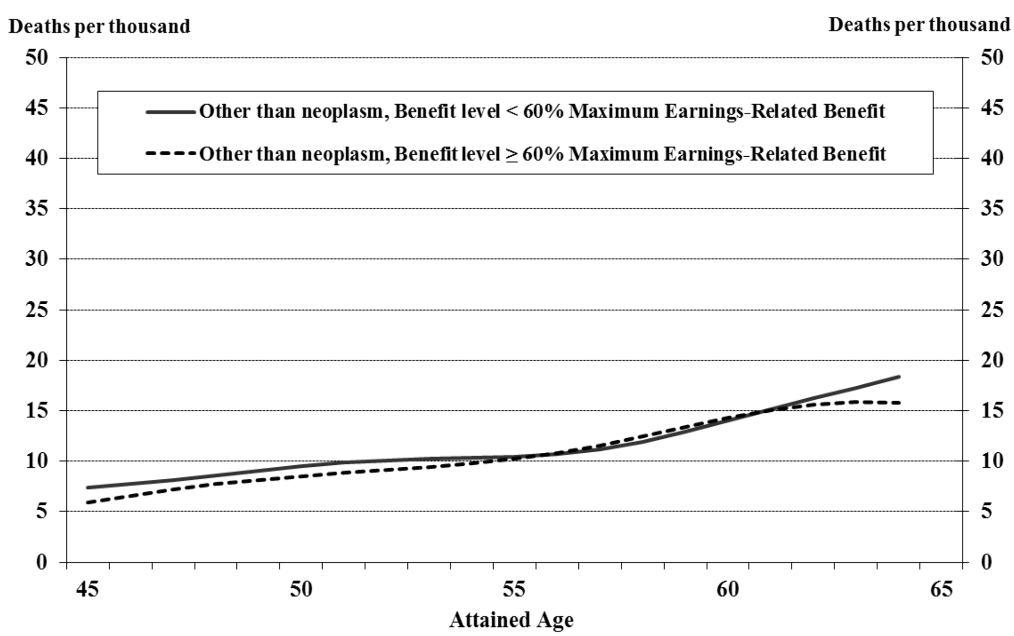


Chart 51: Mortality of Disabled for Reason Other than Neoplasms, by Level of Benefit, Females (2007)



VIII. Sensitivity Analysis of Mortality Rate Assumptions

For the 26th CPP Actuarial Report, the methodology used in last (25th) CPP Actuarial Report to illustrate the evolution and volatility of mortality rates was updated to show the possible impact of different long-term mortality rate assumptions. For the 26th CPP Actuarial Report, the mortality rates were analyzed using the combination of a deterministic model based on judgment with a stochastic time series model. In a stochastic process, random variation is present, which is generally based on fluctuations observed in historical data, in contract to a deterministic model. A stochastic time series model may include the variable's prior-period values, prior-period error terms (actual less projected values), and a random error term. The distribution of potential outcomes comes from a large number of simulations, each with random variation in the variables. Variable states at a particular point in time are not described by unique values, but rather by probability distributions, increasing the information available relative to a deterministic model.

Annual historical mortality rates for the period 1926-2009 from the CHMD were divided into 40 age-sex groups (under 1, 1-4, 5-9, 10-14, … 80-84, 85-89, 90+; male and female). The time series model selected to reproduce the annual mortality rates is a log Autoregressive Integrated Moving Average (0,1,0) or "ARIMA" (0,1,0) model, which gives the difference of consecutive logged terms. This model was selected because the resulting series after logging and differencing consecutive terms is stationary, and an analysis of the goodness-of-fit statistics, including R^2, for all age-sex groups indicate that this model provides a very close fit to the actual data. Other time series models were tested, but none provided as good a fit as the log ARIMA (0,1,0). As well, the use of the log transformation eliminates the need for a lower bound of zero, since the back-transformed projected mortality rates will always remain positive.

The general form of the equation used is:

$$\ln(Y_{k,t}) = \ln(Y_{k,t-1}) + \mu_k + \varepsilon_{k,t}$$

Thus,

$$Y_{k,t} = Y_{k,t-1} e^{\mu_k} e^{\varepsilon_{k,t}}$$

where: $Y_{k,t}$ = number of deaths per 1,000 (mortality rate) for group k in year t
μ_k = the mean of the transformed series (i.e. logged and differenced series)
$\varepsilon_{k,t}$ = a random error for group k in year t

Although the mortality rates of one group are not dependent upon the mortality rates of other groups, there is certainly a degree of correlation among groups, and this correlation must be reflected in the projected rates.

It must be taken into consideration that an ARIMA model cannot explicitly represent a stochastic process with a time-varying mean displacement. However, historical mortality data do exhibit time-varying mean displacement. The purpose of differencing the logged mortality rates is to eliminate this displacement and transform the data such that the mean is stationary. It is possible though that this transformation may not completely eliminate the time-varying mean displacement, which would in turn lead to understating the degree of uncertainty in the simulated probability distributions of the mortality rates.

As well, when projecting future mortality rates, it may not be prudent to rely solely on historical experience. During the 20th century, structural changes in mortality patterns have lessened the validity of using long-term historical experience compared to the recent past and emerging patterns.

Therefore, the time-series equation is designed such that, in the absence of random variation, the value of the variable is equal to the best-estimate assumption. Best-estimate mortality rates for the future are determined by applying the best-estimate mortality improvement rates assumption from the 26th CPP Actuarial Report to the 2009 mortality rates. Projected mortality rates are thus equal to:

$$Y_{k,t} = Y_{k,t}{}^{BE} / Y_{k,t-1}{}^{BE} * Y_{k,t-1} * e^{\varepsilon_{k,t}}$$

where: Y^{BE} = best-estimate mortality rates

Based on this model, a simulation is performed with 1,000 iterations. Correlated sets of random error terms are generated, and future mortality rates are projected 75 years into the future for each age-sex group and the 1,000 scenarios. For each projection year and the 1,000 outcomes, life expectancies are calculated, and an eighty percent confidence interval is determined.

In addition to the stochastic projections of the mortality rates, a deterministic element was introduced in the 26th CPP Actuarial Report to capture the impact of greater uncertainty regarding the long-term mortality improvement rates assumption.

A deterministic model was used to generate two alternatives for the best-estimate mortality improvement rate assumptions presented in Table 4. Under the first alternative, the best-estimate ultimate values (2030+) of the mortality improvement rates are reduced by 0.2%, whereas for the second alternative, the best-estimate ultimate values of the mortality improvement rates are increased by 0.2%.

The alternative mortality improvement rates produced by the deterministic model are then used to determine alternative best-estimate mortality rates for the future, and the stochastic process is repeated using those alternative best-estimate mortality rates.

The following table presents the life expectancies in 2050 at birth and age 65 at the 10th and 90th percentiles determined by the stochastic analysis, as well as the life expectancies determined using the deterministic approach.

Table 28: Stochastic and Deterministic Projections of Life Expectancy in 2050(1)

		Stochastic 10th Percentile	Deterministic Expected	Stochastic 90th Percentile
Best Estimate	Males, at birth	85.8	88.6	91.3
	Females, at birth	88.3	91.3	93.8
	Males, at age 65	21.0	23.0	24.9
	Females, at age 65	23.4	25.3	27.1
Reducing Alternative	Males, at birth	85.1	88.0	90.7
	Females, at birth	87.5	90.8	93.3
	Males, at age 65	20.7	22.5	24.4
	Females, at age 65	22.9	24.8	26.7
Increasing Alternative	Males, at birth	87.0	89.8	92.3
	Females, at birth	89.5	92.4	94.6
	Males, at age 65	21.8	23.6	25.6
	Females, at age 65	24.0	25.9	27.7

(1) These are cohort life expectancies that take into account future improvements in mortality of the general population and therefore differ from calendar year life expectancies, which are based on the mortality rates of the given attained year.

IX. Conclusion

Worldwide, the twentieth century brought tremendous gains in life expectancies at all ages for both men and women. Over the last decade in Canada, life expectancy at age 65 has increased by two years, representing a growth rate of about twice of what has been observed over each of the previous decades since 1929. Life expectancies at age 65 are projected to increase from 21 to 24 years for men and from 23 to 26 years for women by 2075. This means that Canadians are expected to live beyond age 90 on average in the future.

Although it is expected that living to 90 will be easier than in the past, it will remain a challenge to reach a life expectancy of 100. A life expectancy of 100 would be possible if no one died until one's late nineties, and if the same mortality rates at advanced ages as those experienced in 2009 applied. To give a different perspective, currently five out of ten Canadians aged 20 are expected to reach age 90, while only one out of ten is expected to live to 100.

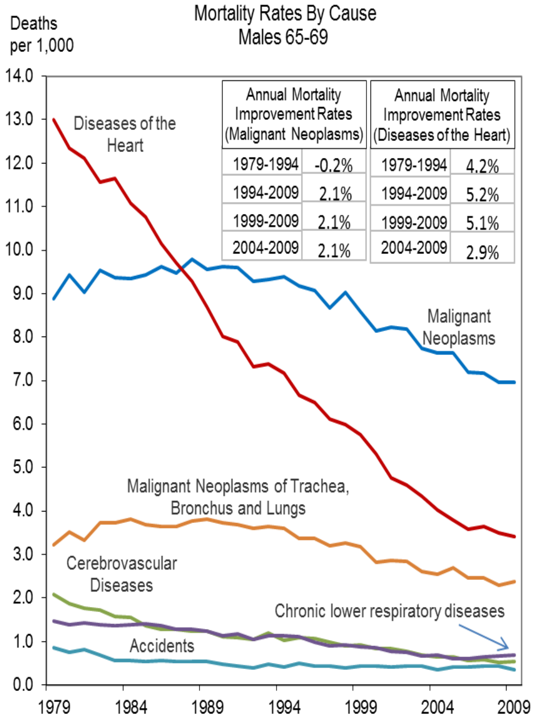
Since mortality rates have continuously decreased over the last two centuries, some may argue that a life expectancy at birth of 100 is achievable. If mortality rates continue to decrease at the same rate as experienced over the last 15 years, a life expectancy at birth of 100 could be reached in in 2094 for men and in 2121 for women.

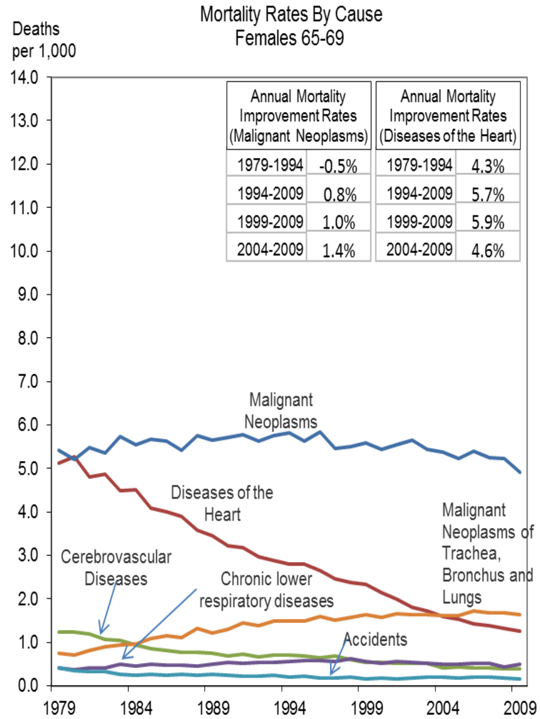
Over the last 30 years, increases in life expectancy have been largely due to the reduction of mortality rates after age 65 as a result of a decrease of deaths caused by diseases of the heart. The 65 to 69 age group experienced the greatest reduction, going from five deaths to one death per thousand for women and from 13 to 5 deaths per thousand for men. Mortality rates associated with malignant neoplasms, the other major cause of death among the elderly, have been relatively stable for ages 65 and older over the period 1979 to 2009. If the same mortality improvement rates as the ones experienced during the last 15 years by cause of death (diseases of the heart, malignant neoplasms, and other causes) were to be sustained over the projection period, males would be expected to outlive females from 2026 onward.

Cohort life expectancies at birth of Canadians are projected to increase from 86 to 90 for men and from 89 to 93 for women over the period of 2013 to 2075. It is expected that Canada will continue to have one of the highest life expectancies of the world along with Japan, France, Switzerland, Italy and Australia.

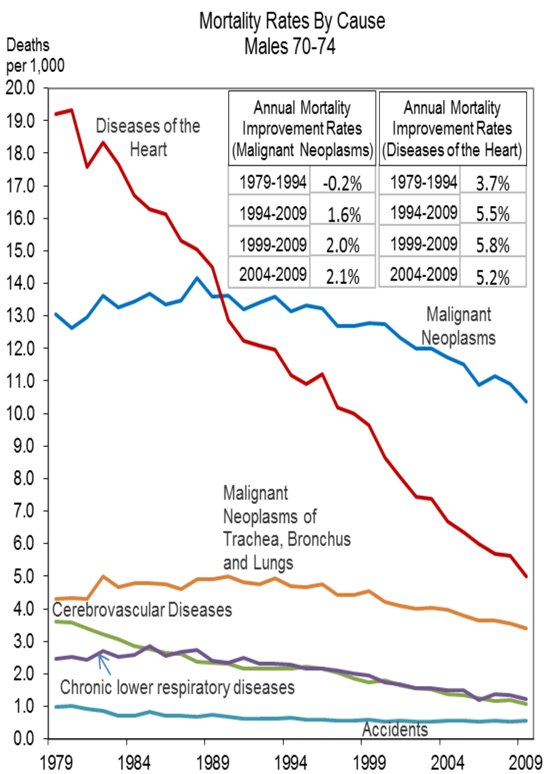
X. Appendices

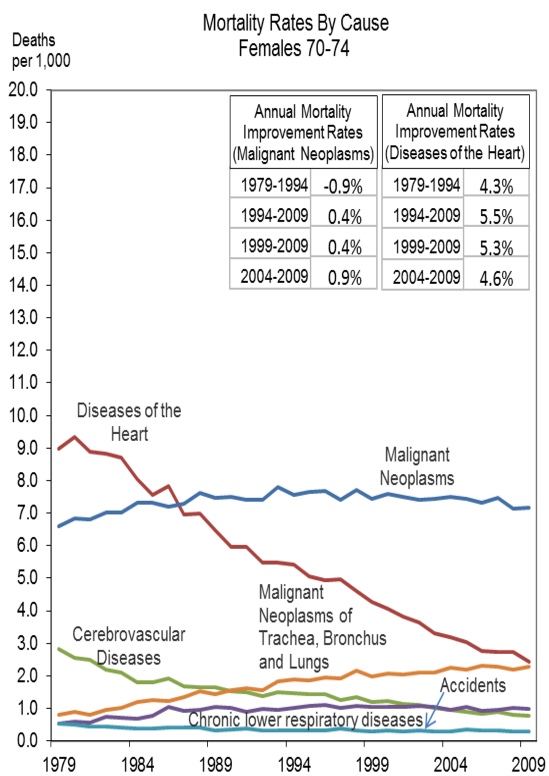
A. Mortality by Cause and Age (1979-2009)



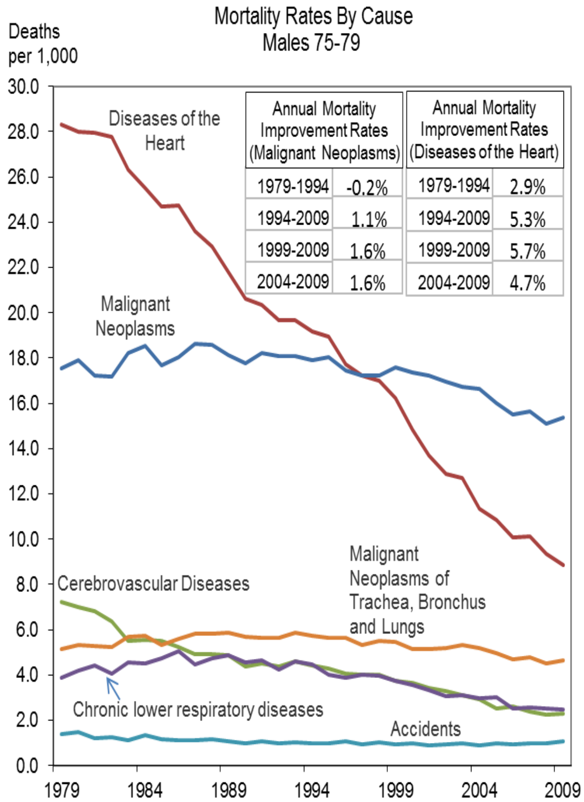


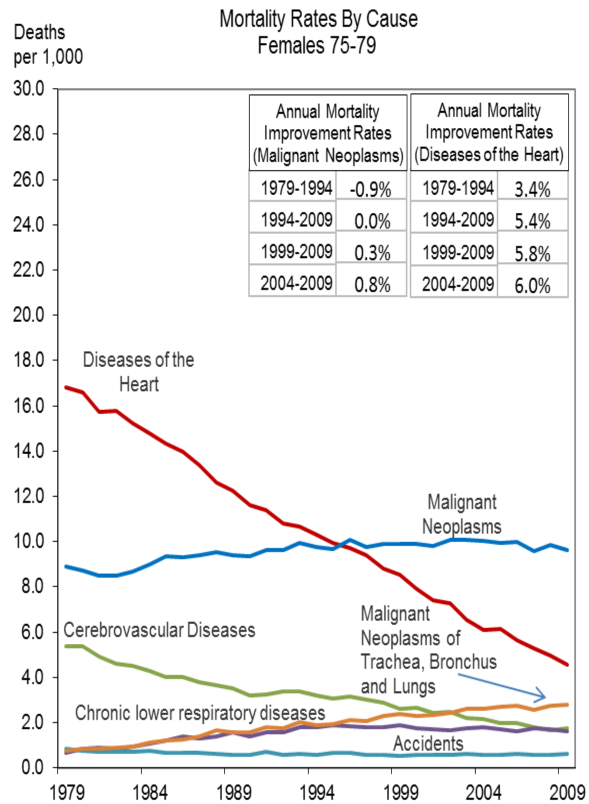
*Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.



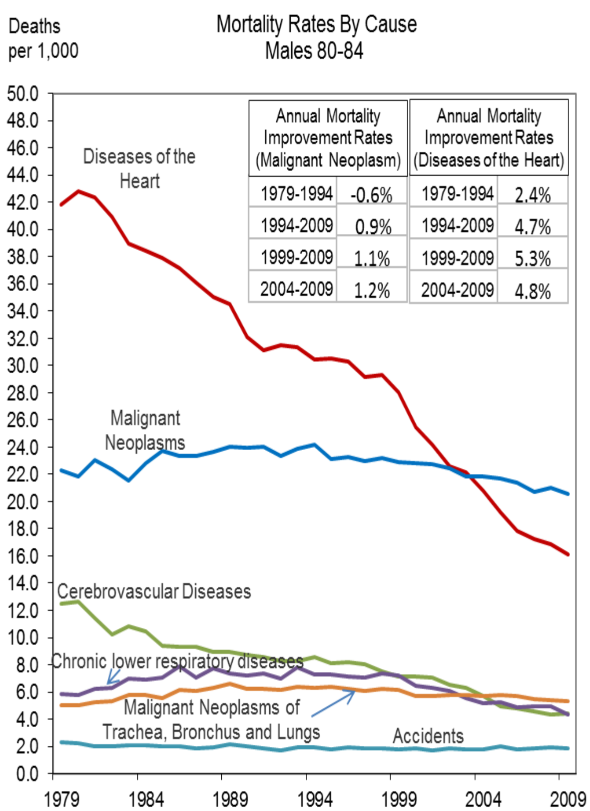


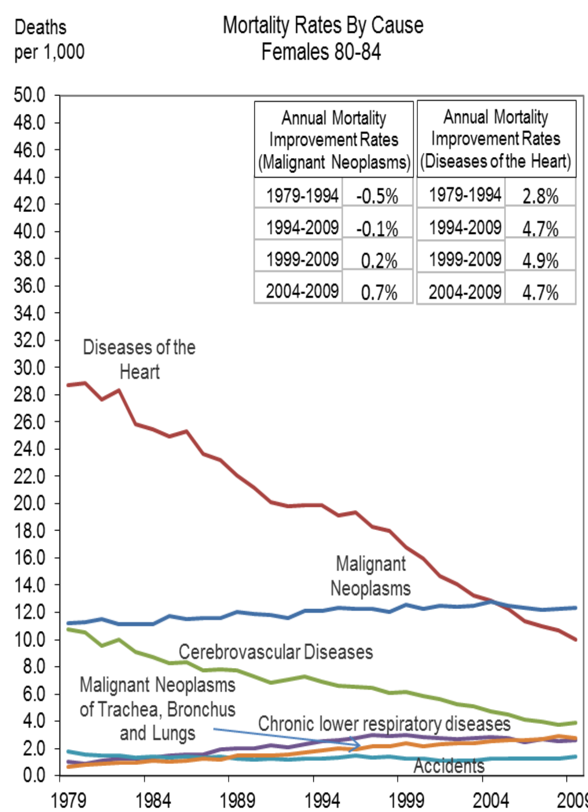
*Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.



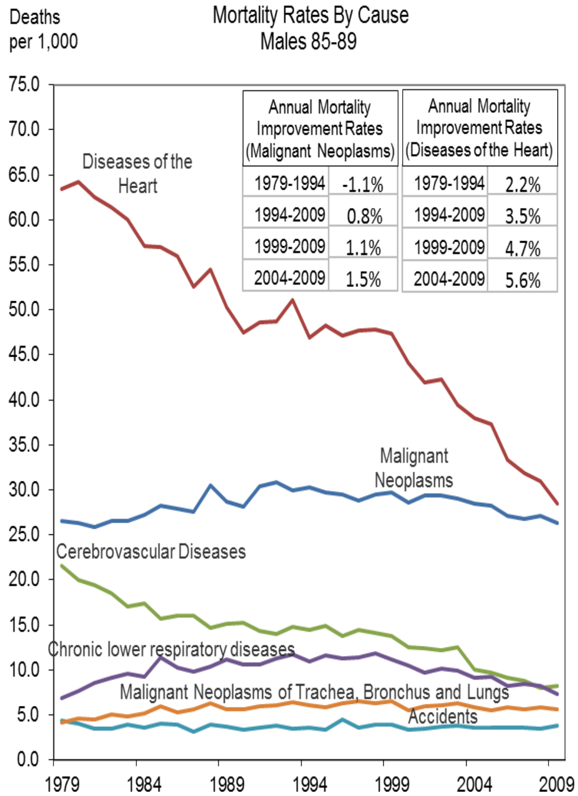


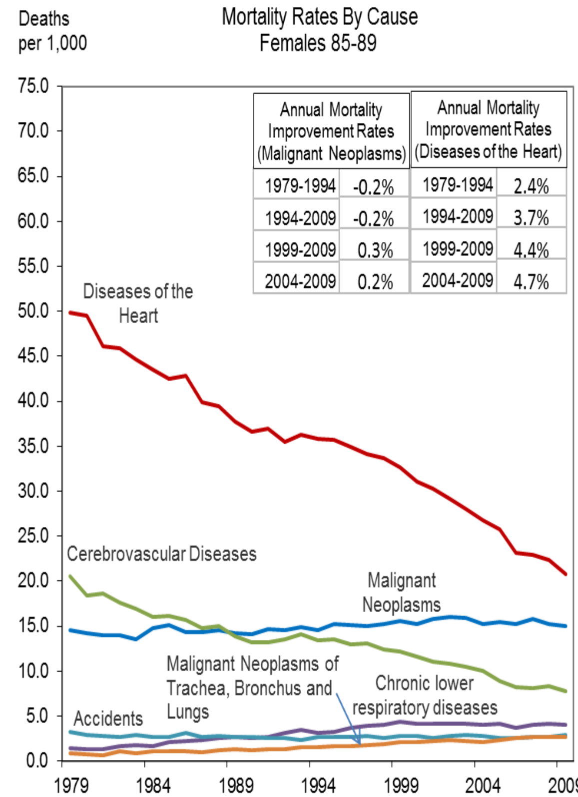
*Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.



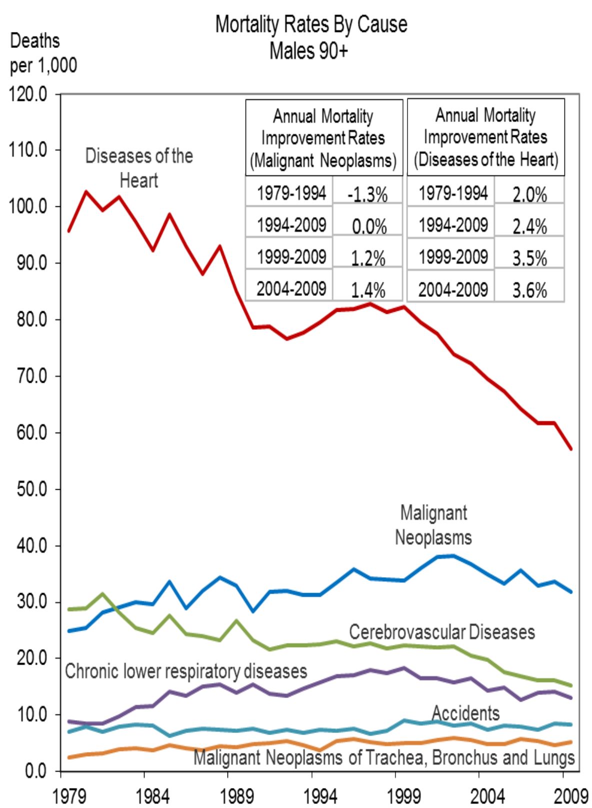


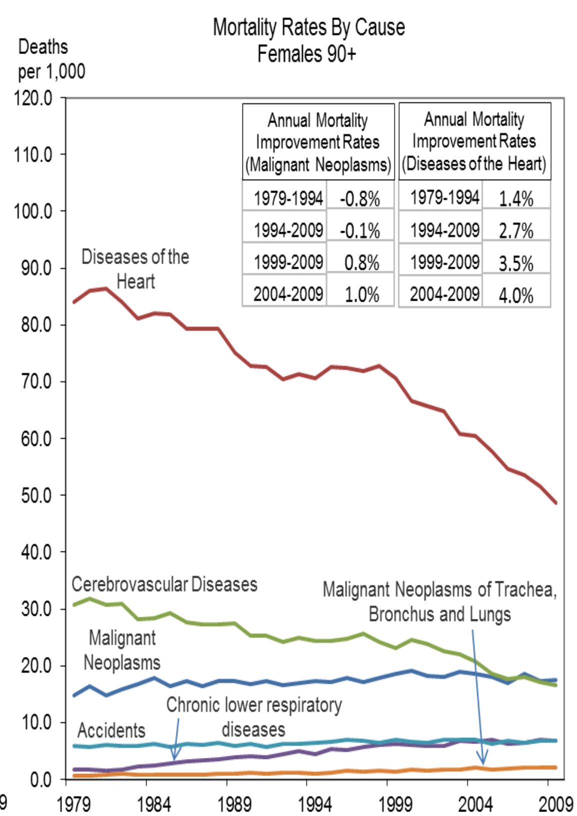
*Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.





*Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.





*Source: Data from Statistics Canada, Health Statistics Division and Improvement rates from OCA calculations.

B. Methodology: Modified Life Expectancies by Removal of a Cause of Death

The goal is to obtain mortality rates where the effect of mortality caused by a certain cause is removed. Therefore the resulting mortality rates will result from exposure to all the other causes of mortality.

The following notations pertaining to multi-decrement mortality rates will be used:

$\boldsymbol{q_{x,y}^{(T)}}$ the overall (Total) mortality rate for a certain population age x in year y in a two-decrement model. Decrements are symbolised with the superscripts (i) with i being 1 or 2.

By definition $\boldsymbol{q_{x,y}^{(T)} = q_{x,y}^{(1)} + q_{x,y}^{(2)}}$

$\boldsymbol{q'^{(i)}_{x,y}}$ is called the absolute probability of dying of cause (i) and can only be approximated. With certain assumptions, it can be estimated as:

$$q'^{(i)}_{x,y} = 1 - \left[\left(1 - q_{x,y}^{(T)}\right)^{q_{x,y}^{(i)} / q_{x,y}^{(T)}}\right] = 1 - \left[\left(1 - q_{x,y}^{(T)}\right)^{q_{x,y}^{(i)} / \left(q_{x,y}^{(1)} + q_{x,y}^{(2)}\right)}\right], \text{ where i = 1, 2}$$

$q'^{(i)}_{x,y}$ may be made to reduce gradually over time until it reaches 0, for any given year y with $y=y_0+t$.

From $\boldsymbol{p_{x,y}^{(T)}} = \left[\left(\boldsymbol{p'^{(1)}_{x,y}}\right) \times \left(\boldsymbol{p'^{(2)}_{x,y}}\right)\right]$ and the above approximation, $\boldsymbol{q_{x,t}^{(T)}}$ can be determined as follows:

$$\boldsymbol{q_{x,y}^{(T)} = 1 - p_{x,y}^{(T)}}$$

$$\boldsymbol{q_{x,y}^{(T)} = 1 - \left[\left(p'^{(1)}_{x,y}\right) \times \left(p'^{(2)}_{x,y}\right)\right]}$$

$$\boldsymbol{q_{x,y}^{(T)} = 1 - \left[\left(1 - q'^{(1)}_{x,y}\right) \times \left(1 - q'^{(2)}_{x,y}\right)\right]}$$

Once a set of $q_{x,t}^{(T)}$ is obtained, it is used to calculate life expectancies.

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