Mortality Projections for Social Security Programs in Canada

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Abstract

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 that is above age 65 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 methods and assumptions used to project future mortality rates in Canada, and the results include assumed annual rates of mortality improvement and projected life expectancies. As well, this paper discusses stochastic time-series methods that are used to help quantify the variability in the mortality rate projections.

1. Introduction

The population of Canada is projected to age significantly over the coming decades. Increasing life expectancies, the aging of the baby boomers and lower 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 is assumed to evolve over the long-term horizon. 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 methods and assumptions used for projecting the mortality component of the population projections which in turn are used in estimating the financial status of the Old Age Security (OAS) Program and the Canada Pension Plan (CPP).

The OAS pension is a monthly benefit available to most Canadians 65 years of age or older who meet certain residence and income requirements. The Canadian OAS program includes a Guaranteed Income Supplement which is a monthly benefit paid to residents of Canada who receive the basic, full or partial OAS 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 and survivor benefits for those who qualify. The CPP provides monthly income in case of disability and provides a monthly income to surviving spouses or common-law partners in case of death.

The methods and assumptions described in this report reflect those included in the 23rd Canada Pension Plan Actuarial Report as at Dec. 31, 2006. The mortality projections cover a long-time horizon (75 years) and place more emphasis on historical trends than on short-term trends.

2. 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 the existence of man, the 20th century was a time of exceptionally rapid rates of decline in mortality. Based on mortality in 1901, roughly 50 percent of the Canadian population would have died before reaching age 65. Based on mortality today, less than 20 percent of the Canadian population would die before reaching age 65. Over the last century, life expectancy at birth increased by an estimated 29 years in Canada with most of the change occurring before 1950. Life expectancy at age 65 also increased dramatically, but in contrast to life expectancy at birth, most of the change occurred after 1950.

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, 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.

TABLE 1

Life Expectancy at Birth and Age 65

	Life Expectancy at Birth			Life Expectancy at Age 65		
Year	**Males**	**Females**	**Difference**	**Males**	**Females**	**Difference**
1901	51.4	51.8	0.4	14.2	14.7	0.5
1921	57.4	58.6	1.2	13.4	13.8	0.4
1931	60.5	62.4	1.9	13.1	13.8	0.7
1941	63.4	66.5	3.2	13.0	14.1	1.1
1951	66.7	71.0	4.3	13.5	15.0	1.5
1956	67.9	73.1	5.1	13.5	15.6	2.1
1961	68.7	74.3	5.6	13.7	16.1	2.4
1966	69.1	75.3	6.2	13.8	16.8	3.0
1971	69.6	76.5	6.8	13.9	17.5	3.6
1976	70.5	77.6	7.1	14.1	18.1	4.0
1981	72.0	79.0	7.0	14.6	18.9	4.3
1986	73.3	80.0	6.6	15.0	19.3	4.3
1991	74.6	80.9	6.3	15.7	19.9	4.2
1996	75.4	81.2	5.7	16.0	19.9	3.9
2001	77.0	82.0	5.1	17.0	20.5	3.5
2006*	78.3	82.8	4.5	18.0	21.1	3.1

* Estimate.

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. Most experts agree that the rapid increase in life expectancy at birth that occurred during the 20th century will not continue and that future increases in life expectancy will have to take place at older ages as opposed to younger ages.

3. Mortality Projections for Social Security Programs in Canada

3.1 Methodology and Assumptions for General Population Mortality Projections

The methodology and assumptions used to make mortality projections that are presented in this section are taken from the 23rd Canada Pension Plan actuarial report as at Dec. 31, 2006. The "best-estimate" mortality assumptions reflect the best judgement of the Chief Actuary of the CPP as to the future pattern of mortality by age and sex of the Canadian population.

3.1.1 Annual Rates of Mortality Improvement

The mortality rates from the Statistics Canada publication "Life Tables, Canada, provinces and territories, "2000-2002" are the starting point for mortality rate projections. According to these tables, life expectancies at birth for males and females in Canada were 77 and 82 years, respectively, for the period 2000-2002.

For the period 2002 to 2004, annual mortality improvement rates based on central death rates by age, sex and year were used to project the 2000-2002 CLT to year 2004. Actual annual mortality improvement rates for years 2002 to 2004 were slightly smoothed such that mortality rates projected for year 2004 would reproduce the 2004 life expectancies at birth and age 65 as published by Statistics Canada. This approach produces life expectancies at birth of 77.8 years for males and 82.6 for females in 2004. The life expectancies at age 65 are 17.7 years and 21.0 years for males and females, respectively. These compare well with figures published by Statistics Canada for 2004. The 2004 mortality rates by age and sex are then further projected for years 2005 and thereafter by applying assumed annual mortality improvement rates that vary by year, age and sex.

The methodology used to project mortality rates into the future involves making assumptions about annual rates of mortality improvement by age and sex. Historical average annual rates of mortality improvement by age group and sex for Canada for various historical time periods are presented in Table 2. Since annual rates of mortality improvement have varied significantly by age and sex in the past, future mortality is projected using separate annual rates of mortality improvement by age and sex.

The historical annual rates of mortality improvement presented in Table 2 were derived by fitting a least squares regression line to the logarithm of central death rates. The central death rate for a calendar year is defined as the ratio of the number of deaths in the year to the corresponding population as at July 1 of that year. The annual rate of mortality improvement is then derived from the slope of the fitted regression line.

TABLE 2

Historical Annual Rates of Mortality Improvement (1944-2004)

	Females			Males		
	1944-1974	**1974-1989**	**1989-2004**	**1944-1974**	**1974-1989**	**1989-2004**
Age	%	%	%	%	%	%
0-14	4.1	4.9	2.4	4.0	4.9	2.8
15-44	2.8	2.8	1.4	0.8	2.8	2.6
45-64	1.7	1.9	1.5	0.3	2.6	2.4
65-84	1.6	1.6	1.2	0.3	1.2	2.0
85-89	1.2	1.5	0.4	0.6	0.8	0.8
90+	0.8	0.1	-0.1	0.4	-0.6	0.0
65+	1.4	1.3	0.8	0.3	1.0	1.6
15-64	2.0	2.1	1.5	0.4	2.7	2.4
0-44	3.3	3.4	1.7	1.9	3.2	2.6
0-64	2.3	2.3	1.5	0.8	2.8	2.4
0-84	1.8	1.8	1.3	0.5	1.8	2.2

There are several historical factors that have affected mortality improvement rates over the years such as access to medical care, immunizations, antibiotics, improvement in sanitary conditions, clean water supply, growth in standard of living and education. Table 2 shows that over the last 15 years (1989-2004) rates of mortality improvement for both males and females have decreased significantly for ages below 15 from levels of between 4 percent and 5 percent per year in the period 1944-1989 to about 2.5 percent per year now. For ages 15 to 64 the rates of improvement for females have decreased from a level of about 2.5 percent in the period 1944-1989 to about 1.5 percent per year over the last 15 years while for males the rates have been relatively stable at about 2.5 percent per year over the last 30 years. Historical improvement rates tend to decline with age and are small or even negative for those aged 90 and over. As we age, it becomes more difficult to improve mortality since death may be the result of simultaneous multiple medical conditions. For those aged 65 and over, over the last 30 years we observe a significant slowdown for females but an increase for males. Males are catching up to females. This explains why the gap in life expectancy between males and females has been reducing more rapidly over the last 30 years.

Future factors that may affect mortality improvements include: new medical techniques and innovations, the presence of pollutants, air quality, the amount of physical activity, improvements in nutrition, prevalence of obesity and diabetes, emergence of new forms of diseases, prevalence of smoking and health education, as well as fresh water supply. Due to the uncertainty that exists with respect to future mortality improvements, it was assumed that annual rates of mortality improvement for the first five years of the projection period would be similar to those experienced recently. Thus, for years 2005 to 2009, annual rates of mortality improvement are assumed to vary by age and sex and are set equal to the smoothed average annual rates of mortality improvement experienced in Canada over the last 15 years (1989-2004). Table 3 shows the resulting rates by age and sex that are assumed to apply for years 2005 through 2009. Annual rates of mortality improvement after the first five years of the projection period reflect both long-term historical trends and an eventual reduction in the rates of improvement at older ages since it may well become more difficult to eradicate the causes of death at those ages. The slowdown in annual rates of mortality improvement after 2009 is assumed to occur linearly over a period of 20 years.

TABLE 3

Mortality Improvement Rates (2005-2009)

	Actual (1989-2004)*		**Smoothed (1989-2004)**	
Age	**Male**	**Fem.**	**Male**	**Fem.**
0	2.21	1.79	2.25	1.75
1-4	4.03	3.19	4.00	3.25
5-9	3.76	5.24	3.75	5.25
10-14	3.67	3.26	3.75	3.25
15-19	3.21	1.62	3.25	1.50
20-24	2.47	1.42	2.50	1.50
25-29	3.23	1.88	3.25	2.00
30-34	3.21	1.69	3.25	1.75
35-39	2.60	1.36	2.50	1.25
40-44	1.83	1.21	1.75	1.25
45-49	1.74	1.52	1.75	1.50
50-54	2.16	1.48	1.94	1.44
55-59	2.53	1.59	2.13	1.38
60-64	2.60	1.39	2.31	1.31
65-69	2.55	1.35	2.50	1.25
70-74	2.29	1.34	2.25	1.25
75-79	1.93	1.29	2.00	1.25
80-84	1.59	1.07	1.50	1.00
85-89	0.76	0.41	0.75	0.50
90+	-0.01	-0.07	0.50	0.25

For years 2029 and thereafter, the ultimate annual rates of mortality improvement vary by age only and not sex or calendar year. The ultimate rates are derived from an analysis of trends in Canadian experience for females over the period 1974 to 2004. The data from the last 30 years clearly show a deceleration of female improvement rates in Canada. Based on that information, an ultimate improvement rate of 0.7 percent has been set for females below age 85 for years 2029 and thereafter. The ultimate improvement rate of 0.7 percent for females aged below 85 is derived by continuing the underlying trend between the average rate of improvements observed between the last two 15-year periods of 1974 to 1989 and 1989 to 2004. The ratio of the average annual improvement rate for females for that age group over the period 1989 to 2004 (1.3 percent) to the average annual improvement rate for the period 1974 to 1989 (1.8 percent) is used as the trending factor (see Table 4). For ages over 85, the ultimate improvement rates have been reduced between 0.6 percent and 0.4 percent to reflect past experience that shows a reduction in improvement rates by age. Male improvement rates are currently higher than for females, but male improvement rates are assumed to be the same as for females for years 2029 and thereafter. Since male improvement rates are currently higher than females, it is thus implicitly assumed that male mortality will continue to improve at a faster pace than for females over the period 2005-2028.

TABLE 4

Forward Looking Mortality Improvement Rates for Females

	Female Experience over Last 30 years		**Continuing the Trend for the Next 30 years**	
	1974-1989	**1989-2004**	**2004-2019**	**2019-2034**
0-14	4.87	2.45	1.23	0.62
0-44	3.41	1.67	0.81	0.40
0-64	2.33	1.53	1.01	0.67
0-74	1.99	1.45	1.05	0.76
0-79	1.86	1.40	1.05	0.79
0-84	***1.80***	***1.31***	***0.96***	***0.70***
65+	1.27	0.76	0.45	0.27
80-84	1.63	1.07	0.71	0.47
85-89	1.49	0.41	0.11	0.03
90+	0.14	-0.07	0.00	0.00

Annual rates of mortality improvement are projected to decrease with age. This was judged to be consistent with historical experience. One reason for declining improvements with age is that diseases at the younger ages are, by and large, easier to overcome than those at the older ages. To eradicate the major diseases affecting the older population, including heart and respiratory diseases, cancer, stroke, diabetes and dementia will take more time, as there is still much to be learned. Table 5 summarizes the assumptions.

TABLE 5

Assumed Annual Rates of Mortality Improvement

	Males			Females		
Age	**2005-2009**	**2010-2028**	**2029+**	**2005-2009**	**2010-2028**	**2029+**
	%	%	%	%	%	%
0	2.3	1.5	0.7	1.8	1.2	0.7
1-14	3.7	2.2	0.7	3.8	2.3	0.7
15-44	2.8	1.7	0.7	1.6	1.1	0.7
45-64	2.0	1.4	0.7	1.4	1.0	0.7
65-84	2.0	1.4	0.7	1.2	0.9	0.7
85-89	0.8	0.7	0.6	0.5	0.6	0.6
90-94	0.5	0.4	0.4	0.3	0.3	0.4
95+	0.0	0.2	0.4	0.0	0.2	0.4

The following compares the ultimate rates of mortality improvement by age group with the United States.

3.1.2 Ultimate Rates of Improvement from Birth to Age 1

If we look at mortality patterns by age group, infant mortality was higher in Canada than in the United States in 1950, but fell much more quickly to reach a level lower than that in the United States in the mid-1960s. The gap with the United States has widened slightly through the 1990s; differences are possibly attributable to differences in hospitalization rates and health care financing policies. Recent Canadian mortality is lower than the U.S. mortality in this age group. Over the last 40 years, the gap between male and female Canadian mortality at age 0 has reduced. We have assumed that the ultimate annual mortality improvement rate for both males and females would be 0.7 percent. This rate is lower than assumed in the 21st CPP Report and lower than the assumed ultimate rate of 1.5 percent for males and 1.6 percent for females used in the 2006 Trustees report in the United States. As a result, the gap between U.S. and Canadian mortality reduces, and U.S. mortality rates eventually become lower than the Canadian rates during the projection period.

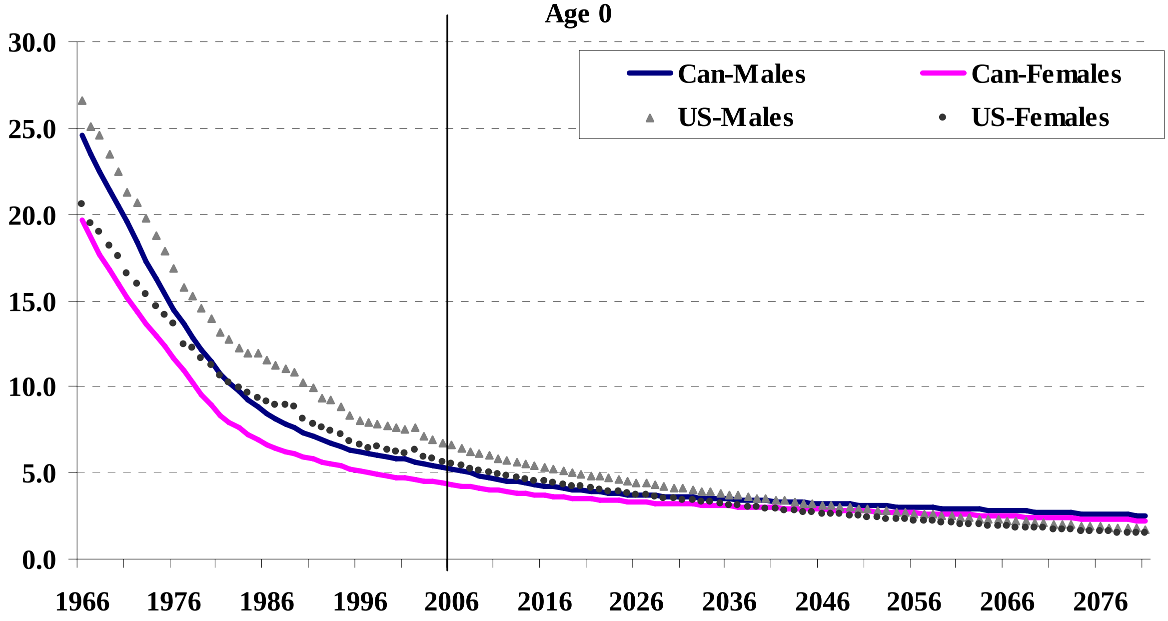
TABLE 6

Ultimate Annual Rates of Mortality Improvement (Birth to Age 1)

Age 0	**23rd CPP Report Ultimate**	**2006 Trustees Report Ultimate**
Males	0.7%	1.5%
Females	0.7%	1.6%

CHART 1

Projected Mortality Rates (Birth to Age 1)



3.1.3 Ultimate Rates of Improvement for Ages 1-14

Most deaths at these ages occur due to accidents and unintentional injuries, followed by cancer and congenital anomalies. Between the ages of 1 and 14, Canadian and U.S. mortality levels were close in 1950, but mortality in Canada has generally fallen faster in this age group, so there has been a widening of the Canadian advantage through the 1990s, noticeably more so for males than females. There is a pronounced excess of male U.S. mortality at these ages. Over the last 40 years we notice that male Canadian mortality follows the female pattern and that the gap between the two has reduced. We have assumed that the ultimate annual mortality improvement rate for both males and females would be 0.7 percent. This rate is lower than assumed in the 21st CPP Report and lower than the assumed ultimate rates of 1.5 percent for males and 1.6 percent for females under the SSA 2006 OASDI trustees report. As a result, the gap between U.S. and Canadian mortality reduces over the projection period.

TABLE 7

Ultimate Annual Rates of Mortality Improvement (Ages 1-14)

Ages 1-14	23rd CPP Report Ultimate	2006 Trustees Report Ultimate
Males	0.7%	1.5%
Females	0.7%	1.6%

3.1.4 Ultimate Rates of Improvement for Ages 15-24

Three-quarters of all male deaths are due to accidents and suicide. We have assumed that the ultimate annual mortality improvement rate would be 0.7 percent for both males and females. Compared to the 21st CPP Report, the assumption is 0.1 percent lower for males and lower than the ultimate rate of 0.9 percent assumed under the 2006 Trustees report, while for females the rate is the same as under the 21st CPP report and the 2006 Trustees report. As a result, the gap between U.S. and Canadian mortality for males reduces over the projection period.

TABLE 8

Ultimate Annual Rates of Mortality Improvement (Ages 15-24)

Ages 15-24	23rd CPP Report Ultimate	2006 Trustees Report Ultimate
Males	0.7%	0.9%
Females	0.7%	0.7%

3.1.5 Ultimate Rates of Improvement for Ages 25-44

Cancer is the leading cause of death for females, while unintentional injuries are still the predominant cause of death for males. For females, medical breakthroughs should bring some more improvements, but mortality rates are already very low. We have assumed an ultimate mortality improvement rate of 0.7 percent for both males and females. Compared to the 21st CPP Report, the assumption for age group 25-44 was decreased by 0.1 percent for males. The rate for males is also lower than the ultimate rate of 0.9 percent assumed under the 2006 Trustees report, while for females the rate is the same as under the 21st CPP report and the 2006 Trustees report. As a result, the gap between U.S. and Canadian mortality reduces over the projection period.

TABLE 9

Ultimate Annual Rates of Mortality Improvement (Ages 25-44)

Ages 25-44	23rd CPP Report Ultimate	2006 Trustees Report Ultimate
Males	0.7%	0.9%
Females	0.7%	0.7%

3.1.6 Ultimate Rates of Improvement for Ages 45-64

Cancer is the leading cause of death for both sexes. Therefore, improvements will come mainly from medical breakthroughs. We have assumed an ultimate improvement rate of 0.7 percent for both males and females. Compared to the 21st CPP Report, the assumption for age group 45-64 was increased by 0.05 percent for males and 0.15 percent for females. The rate for males is lower than the ultimate rate of 0.8 percent for males assumed under the 2006 Trustees report while it is the same for females. As a result, the gap between U.S. and Canadian mortality reduces over the projection period.

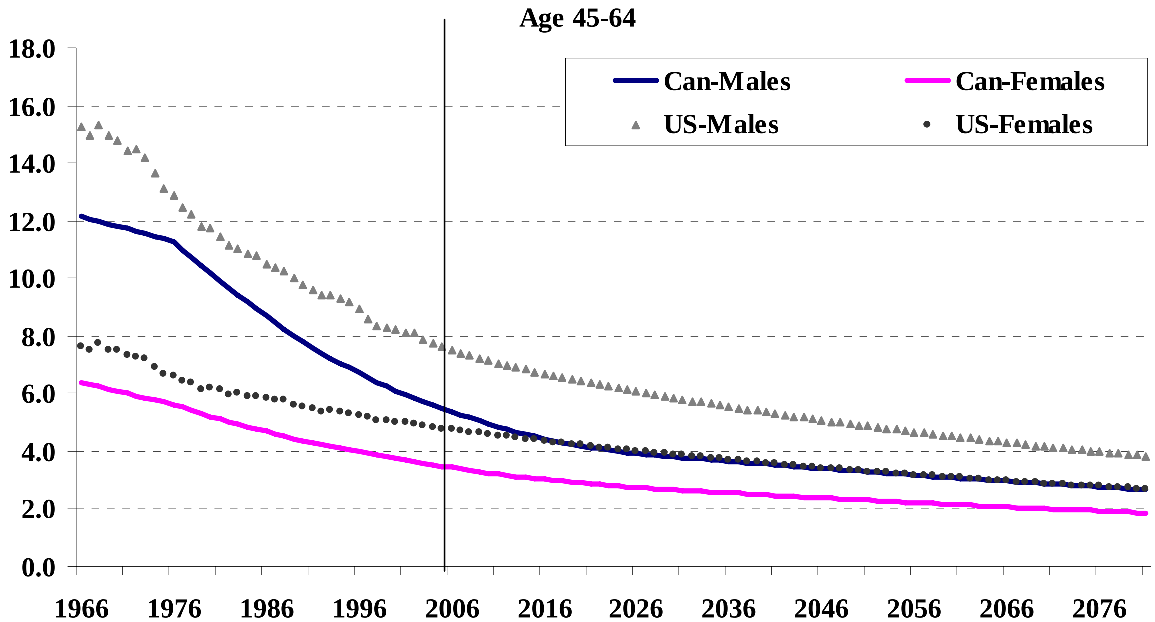
TABLE 10

Ultimate Annual Rates of Mortality Improvement (Ages 45-64)

Ages 45-64	23rd CPP Report Ultimate	2006 Trustees Report Ultimate
Males	0.7%	0.8%
Females	0.7%	0.7%

CHART 2

Projected Mortality Rates (Ages 45-64)



3.1.7 Ultimate Rates of Improvement for Ages 65-84

Heart disease is the leading cause of death for both sexes. In this group, improvements will mainly come from medical breakthroughs and lifestyle changes. The historical gap between the United States and Canada can probably be explained by lower accessibility due to limited insurance coverage and expensive costs of medical treatment. Assuming that males will eventually close up with females, by considering the last 30 years of experience assumed an ultimate improvement rate of 0.7 percent for both males and females. The assumption for age group 65-84 is 0.2 percent higher for both males and females than assumed in the 21st CPP Report. The 2006 Trustees report assumption is the same 0.7 percent in that age group.

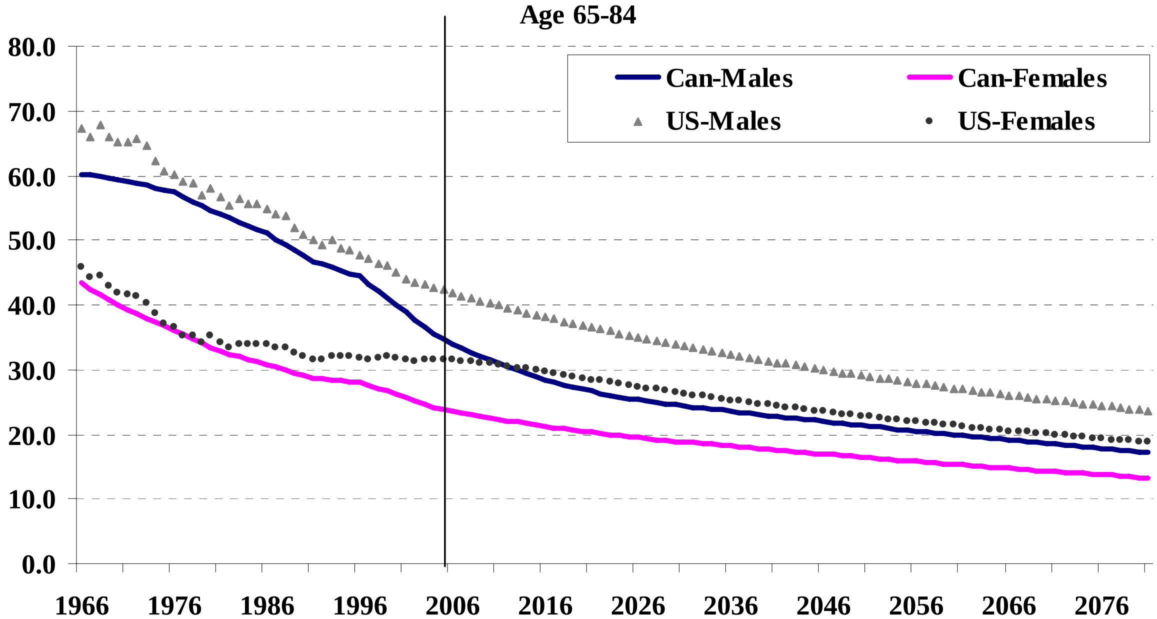
TABLE 11

Ultimate Annual Rates of Mortality Improvement (Ages 65-84)

Ages 65-84	23rd CPP Report Ultimate	2006 Trustees Report Ultimate
Males	0.7%	0.7%
Females	0.7%	0.7%

CHART 3

Projected Mortality Rates (Ages 65-84)



3.1.8 Ultimate Rates of Improvement for Ages 85-89

Considering that mortality improvement rates tend to decrease with age, we have assumed an improvement rate of 0.6 percent for both males and females. The 0.6 percent rate of improvement corresponds to the average unisex experience for this age group over the last 15 years. The same assumption is used in the 2006 Trustees Report in the United States. The assumption for the age group 85-89 is 0.2 percent higher than was assumed in the 21st CPP Report.

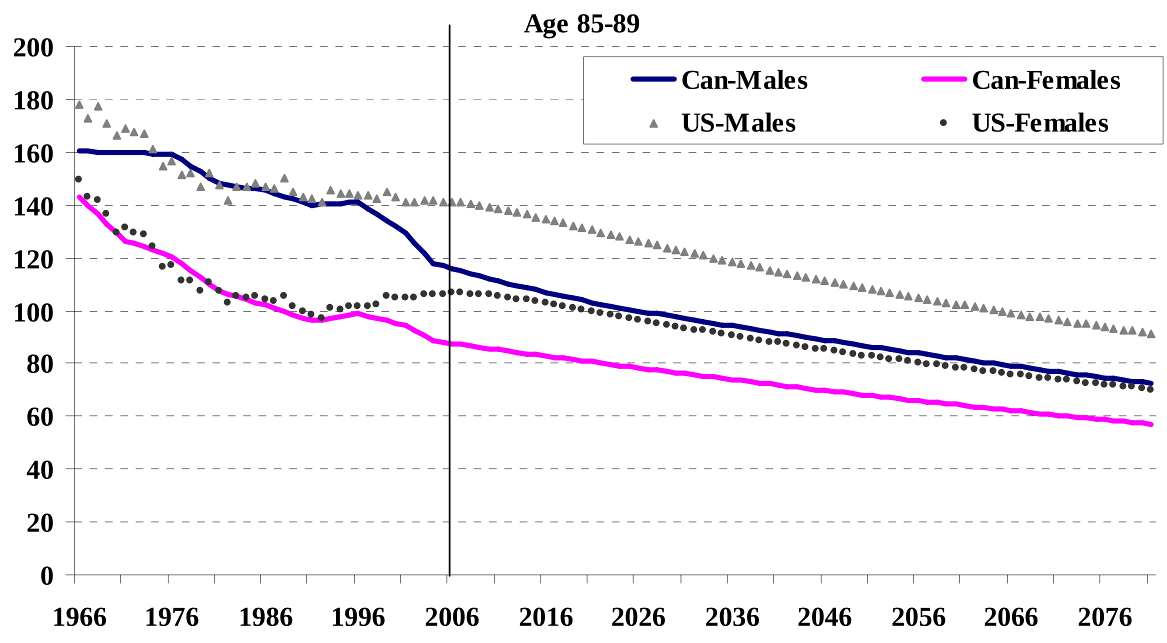
TABLE 12

Ultimate Annual Rates of Mortality Improvement (Ages 85-89)

Ages 85-89	23rd CPP Report Ultimate	2006 Trustees Report Ultimate
Males	0.6%	0.6%
Females	0.6%	0.6%

CHART 4

Projected Mortality Rates (Ages 85-89)



3.1.9 Ultimate Rate of Improvement for Ages 90 and Older

For the oldest, data quality is still a major concern and more uncertainty exists. For age group 90+, although recent experience would suggest no or very small improvements, it was nevertheless assumed that mortality would improve at an annual rate of 0.4 percent. This rate of improvement corresponds to what the age group 85-89 has experienced over the last 15 years for females. The assumption for age group 90+ is higher than assumed in the 21st CPP Report but 0.2% lower than that assumed in the 2006 Trustees Report in the United States.

TABLE 13

Ultimate Annual Rates of Mortality Improvement (Ages 90+)

Ages 90+	23rd CPP Report Ultimate	2006 Trustees Report Ultimate
Males	0.4%	0.6%
Females	0.4%	0.6%

3.1.10 Projection Results

This section presents the projected mortality rates by age and sex along with other resulting mortality measures. Table 14 reveals that the projected mortality rates show a continuous decrease over the long term. For example, the mortality rate for a 65-year-old male is expected to decline from 13.5 deaths per 1,000 people in 2007 to 6.8 deaths per 1,000 people in 2075. The gap between male and female mortality rates for a given age is also expected to decrease over the long term.

TABLE 14

Mortality Rates (Annual Deaths per 1,000 People)

	Males				Females			
Age	**2007**	**2025**	**2050**	**2075**	**2007**	**2025**	**2050**	**2075**
0	5.09	3.76	3.14	2.63	4.26	3.33	2.79	2.34
10	0.08	0.05	0.04	0.04	0.08	0.05	0.04	0.03
20	0.71	0.49	0.41	0.35	0.31	0.25	0.21	0.18
30	0.75	0.50	0.41	0.35	0.35	0.27	0.23	0.19
40	1.35	1.02	0.85	0.71	0.85	0.71	0.59	0.50
50	3.21	2.48	2.08	1.74	2.11	1.70	1.43	1.20
60	8.66	6.41	5.35	4.49	5.42	4.44	3.72	3.12
65	13.46	9.75	8.14	6.83	8.42	6.95	5.82	4.88
70	21.65	15.82	13.20	11.08	13.49	11.17	9.36	7.85
75	35.56	26.74	22.33	18.74	22.29	18.46	15.46	12.97
80	59.17	46.56	38.94	32.67	38.49	32.42	27.16	22.79
85	98.15	83.49	71.02	60.49	71.25	63.04	53.69	45.72
90	155.79	141.72	128.13	115.91	121.91	114.07	103.21	93.37
100	353.25	343.76	311.36	281.68	295.71	287.76	260.64	235.79

Life expectancies for Canadians are assumed to continue to grow, but at a slower rate than was experienced in the 20th century. For the period 2007 to 2075, life expectancy for a male newborn is expected to increase from 78.5 years to 84.6 years. For female newborns, this increase is projected to be from 82.9 years to 87.5 years. These expectations assume no mortality improvements. If, however, future mortality improvements are included, then the increases are from 84.5 to 88.8 for males and from 87.7 to 91.5 for females over the same period. Given the continuing trend toward greater longevity, life expectancies with future mortality improvements are considered to be more realistic than without.

Life expectancies have considerably increased 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 low rates of improvement in mortality assumed for years 2029 and thereafter. It is also expected 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 altogether disappear.

A comparison between life expectancies with and without mortality improvements after the specific years is presented in Tables 15 and 16. Table 15 shows the projected life expectancies at various ages for selected years, assuming no mortality improvements after the specific years, while Table 16 shows the same life expectancies, but with all mortality improvements included. The historical and projected evolution of life expectancies at birth for males and females, with mortality and without mortality improvements after the specific years, is displayed in Chart 5, and a similar evolution at age 65 is displayed in Chart 6.

Mortality improvements have more of an impact on increasing expected lifetimes at younger ages than at older ages, since the improvement factors decrease with age. For instance, by 2075, mortality improvements lead to more than a four-year increase in expected lifetimes for both male and female newborns, compared to those without such improvements (that is, 88.8 minus 84.6, or 4.2 years for males and 91.5 minus 87.5, or four years for females). At age 30, this increase falls to 2.5 years for both sexes, and by age 85, it falls to 0.1 year.

TABLE 15

Life Expectancies, without Improvements after the Year Shown*

	Males				Females			
Age	**2007**	**2025**	**2050**	**2075**	**2007**	**2025**	**2050**	**2075**
0	78.5	81.3	83.0	84.6	82.9	84.5	86.1	87.5
10	69.0	71.6	73.3	74.8	73.4	74.9	76.4	77.8
20	59.2	61.8	63.4	64.9	63.5	65.0	66.5	67.8
30	49.6	52.1	53.7	55.2	53.7	55.1	56.6	58.0
40	40.0	42.4	43.9	45.4	43.9	45.4	46.8	48.1
50	30.7	33.0	34.4	35.8	34.5	35.8	37.1	38.4
60	22.1	24.1	25.4	26.7	25.4	26.6	27.9	29.1
65	18.2	19.9	21.1	22.3	21.2	22.3	23.4	24.6
70	14.5	16.0	17.1	18.2	17.2	18.1	19.2	20.3
75	11.2	12.4	13.3	14.3	13.5	14.2	15.2	16.1
80	8.4	9.2	10.0	10.8	10.1	10.7	11.5	12.3
85	6.1	6.5	7.1	7.7	7.3	7.6	8.2	8.9
90	4.3	4.6	4.9	5.3	5.2	5.3	5.8	6.2
100	2.1	2.1	2.4	2.6	2.5	2.5	2.8	3.1

* These are calendar year life expectancies based on the mortality rates of the given attained year.

TABLE 16

Life Expectancies, with Improvements after the Year Shown**

	Males				Females			
Age	**2007**	**2025**	**2050**	**2075**	**2007**	**2025**	**2050**	**2075**
0	84.5	85.8	87.4	88.8	87.7	88.8	90.2	91.5
10	74.3	75.5	77.1	78.6	77.5	78.6	80.0	81.3
20	63.8	65.1	66.6	68.1	67.1	68.1	69.5	70.9
30	53.5	54.7	56.3	57.7	56.6	57.7	59.1	60.5
40	43.2	44.4	45.9	47.4	46.3	47.4	48.8	50.1
50	33.2	34.4	35.9	37.3	36.2	37.3	38.6	39.9
60	23.7	25.0	26.3	27.6	26.6	27.6	28.9	30.1
65	19.3	20.6	21.9	23.1	22.0	23.0	24.2	25.4
70	15.3	16.5	17.6	18.7	17.8	18.7	19.8	20.8
75	11.7	12.7	13.7	14.7	13.8	14.6	15.6	16.5
80	8.6	9.4	10.2	11.0	10.3	10.9	11.7	12.6
85	6.2	6.6	7.2	7.8	7.4	7.8	8.4	9.0
90	4.3	4.6	5.0	5.4	5.2	5.4	5.8	6.3
100	2.1	2.1	2.4	2.6	2.5	2.5	2.8	3.1

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

CHART 5

Male and Female Life Expectancy at Birth

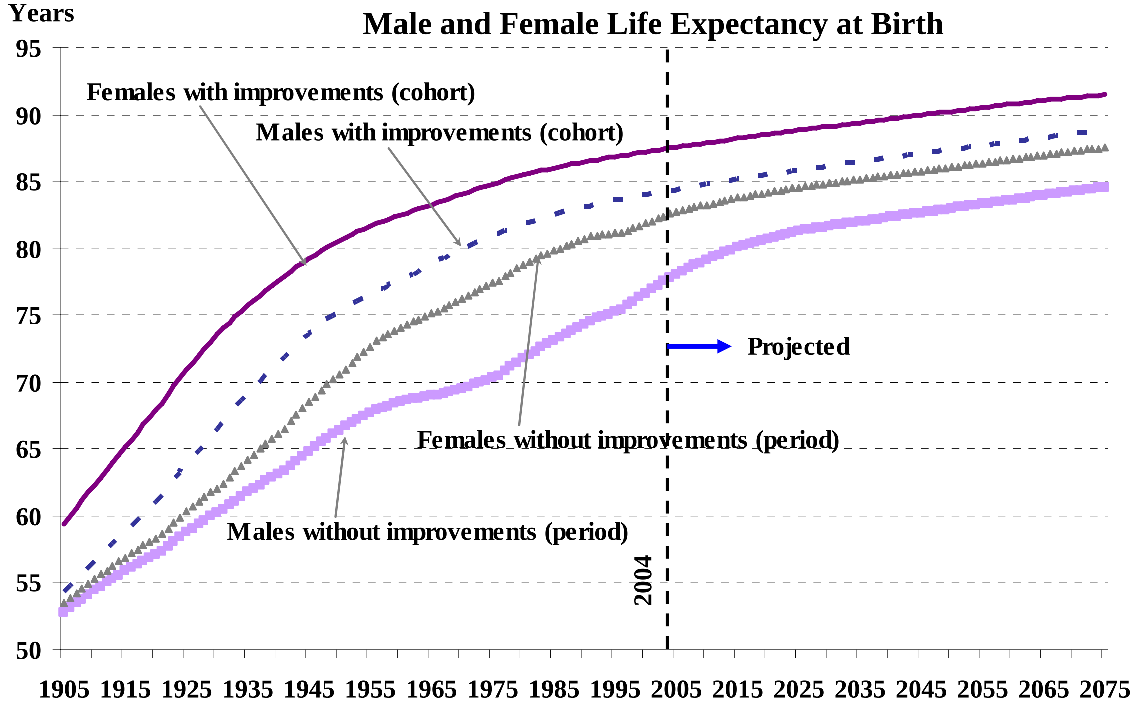
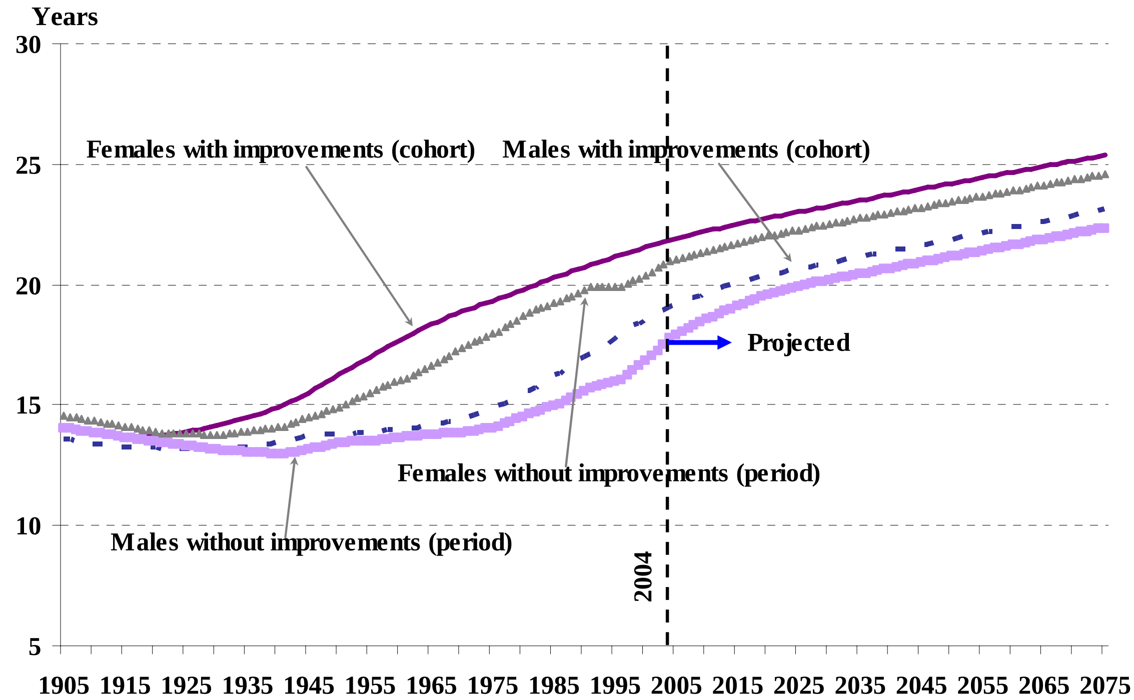


CHART 6

Male and Female Life Expectancy at Age 65

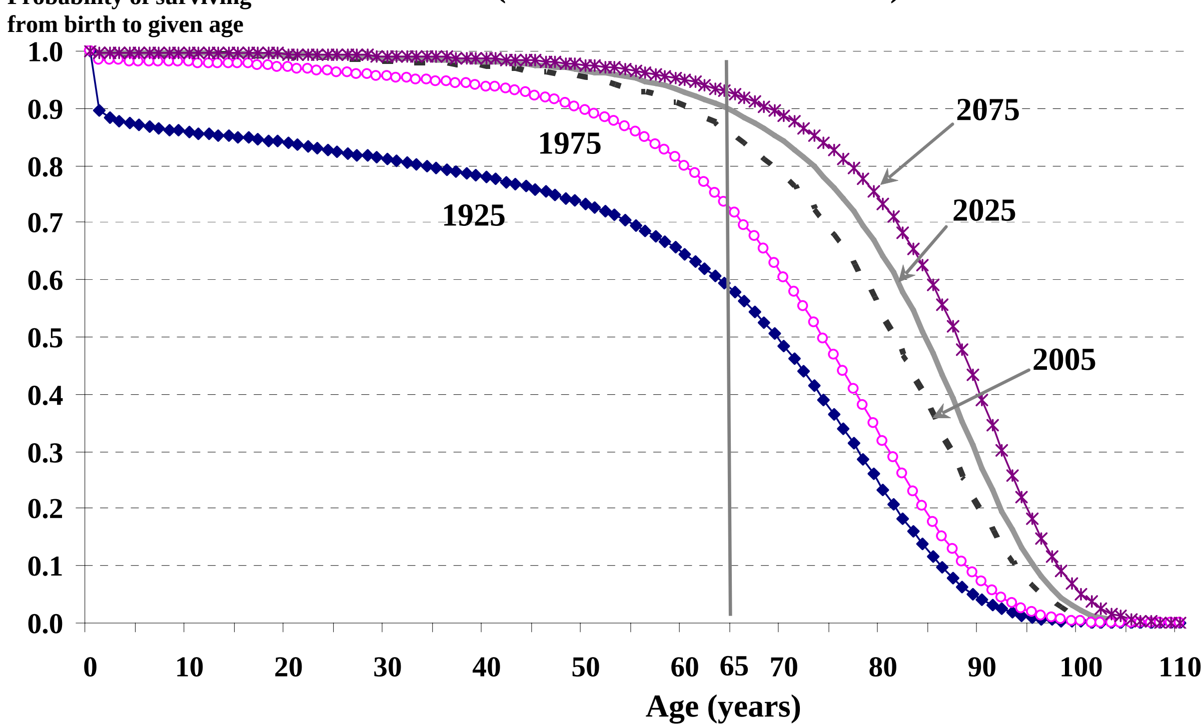


The low probabilities of a newborn reaching a very advanced age can be seen by the survival curves at birth as illustrated in Chart 7. A survival curve at birth represents the probability of a newborn reaching a given age. The “squaring” of the survival curves over time from 1925 to 2075 is the result of expected lifetimes increasing and the maximum age that can be attained being about 120 years. Note from the following two graphs that the probability of surviving from birth to ages beyond 110 is practically zero.

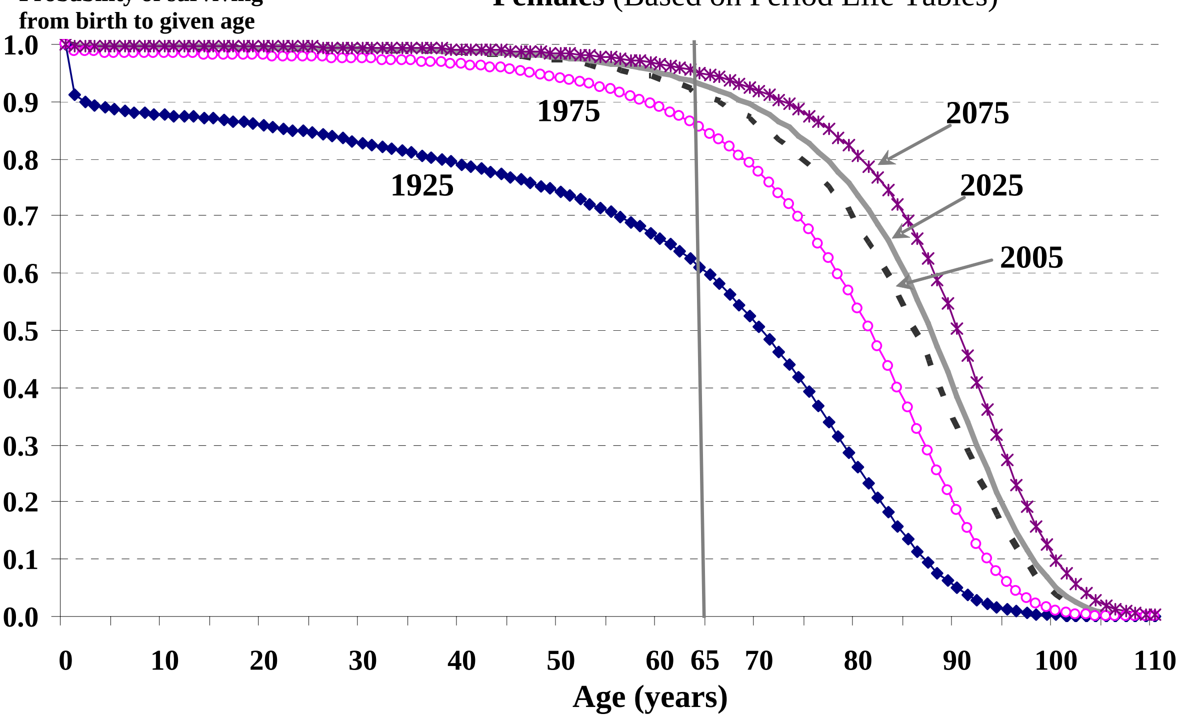
CHART 7

Survival Curves at Birth

Males (Based on Period Life Tables)



Females (Based on Period Life Tables)



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 increased substantially in the past. Based on period life tables of 1925, males had a probability of 58 percent of reaching age 65. By 2005, this figure had increased to 85 percent, and by 2075 it is projected to reach 92 percent. For females, the probability of reaching age 65 was 60 percent, increased to 91 percent by 2005, and is projected to reach 95 percent by 2075. In general, probabilities of surviving to older ages have increased over the last century and this trend is expected to continue at a slower pace.

Another perspective on viewing the aging of the population is to consider the median age at death and the proportion of deaths over time (see Tables 17 and 18). It is projected that deaths resulting from those aged 85 and older will eventually comprise the largest proportion of deaths compared to the younger age groups shown, as the proportions of younger age groups decline. By 2075, over 62 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 well above age 85 by 2075.

TABLE 17

Median Age at Death

Year	Males	Females
1925	70	71
1950	73	77
1975	74	82
2005	82	86
2025	85	88
2050	86	89
2075	88	91

TABLE 18

Distribution of Deaths, Number and Proportion

Calendar Year/ Age Group	Deaths					Proportion of Deaths (%)				
	0-64	65-74	75-84	85+	Total	0-64	65-74	75-84	85+	Total
1925	72,000	15,400	14,300	5,700	107,400	67.0	14.3	13.3	5.3	100.0
1950	58,400	27,900	26,000	11,400	123,700	47.2	22.6	21.0	9.2	100.0
1975	61,200	37,500	41,000	27,200	166,900	36.7	22.5	24.6	16.3	100.0
2005	53,500	41,400	71,600	64,100	230,600	23.2	18.0	31.0	27.8	100.0
2025	47,500	57,900	94,400	125,300	325,100	14.6	17.8	29.0	38.5	100.0
2050	41,600	53,500	118,700	291,800	505,600	8.2	10.6	23.5	57.7	100.0
2075	37,000	45,900	117,500	330,000	530,400	7.0	8.7	22.2	62.2	100.0

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, Table 19 shows the progression over time of the age range in which 70 percent of deaths are expected to occur. 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 16 and 83; that is, 15 percent of males died prematurely before age 16 while 15 percent who were the strongest died after age 83. By 2005, this range had both moved forward and narrowed to an age range of 66 to 91. 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.

TABLE 19

Evolution of Age Range in Which Given Percentage of Deaths Occur

	Male Range			**Female Range**		
Year	15%	70%	15%	15%	70%	15%
1925	(0-15)	(16-83)	(84+)	(0-23)	(24-84)	(85+)
1950	(0-50)	(51-84)	(85+)	(0-55)	(56-86)	(87+)
1975	(0-55)	(56-86)	(87+)	(0-64)	(65-91)	(92+)
2005	(0-65)	(66-91)	(92+)	(0-70)	(71-94)	(95+)
2025	(0-69)	(70-93)	(94+)	(0-73)	(74-95)	(96+)
2050	(0-71)	(72-94)	(95+)	(0-75)	(76-97)	(98+)
2075	(0-73)	(74-95)	(96+)	(0-77)	(78-98)	(99+)

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 later on in life, such as diabetes and heart disease, could act to reduce future projected gains in life expectancy. The threat of worldwide pandemics resulting from more virulent forms of infectious diseases is also a reality, which could impact longevity.

3.2 Old Age Security Program Beneficiaries Mortality

Historically, the level and age trajectory of mortality rates at advanced ages in Canada have not been readily and precisely measured due to problems concerning the reliability of data on deaths and on population counts beyond a certain point in official vital statistics. For instance, Life Tables for Canada (LTC) published by Statistics Canada are based on Census data and on the national system of 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 20. Those with middle to high retirement incomes experience lower mortality compared to all OAS beneficiaries collectively. However, the 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 21. This group experiences higher mortality compared to all OAS beneficiaries. For each sex, mortality rates converge to the overall OAS rates at the advanced ages. Chart 8 illustrates the difference in mortality between those with middle to high retirement incomes and those with low incomes.

TABLE 20

Mortality Rates of OAS Beneficiaries (with Middle to High Retirement Incomes, 2001)

Age Group	Males			Females		
	Middle to High Income	Overall OAS	Ratio Middle to High Income Overall to OAS	Middle to High Income	Overall OAS	Ratio Middle to High Income Overall OAS
65-69	0.0170	0.0203	0.84	0.0097	0.0118	0.82
70-74	0.0286	0.0328	0.87	0.0158	0.0190	0.83
75-79	0.0483	0.0532	0.91	0.0273	0.0318	0.86
80-84	0.0795	0.0858	0.93	0.0487	0.0549	0.89
85-89	0.1304	0.1377	0.95	0.0897	0.0970	0.92
90-94	0.2001	0.2086	0.96	0.1541	0.1623	0.95
95-99	0.2886	0.2957	0.98	0.2398	0.2482	0.97
100+	0.3954	0.3977	0.99	0.3463	0.3500	0.99

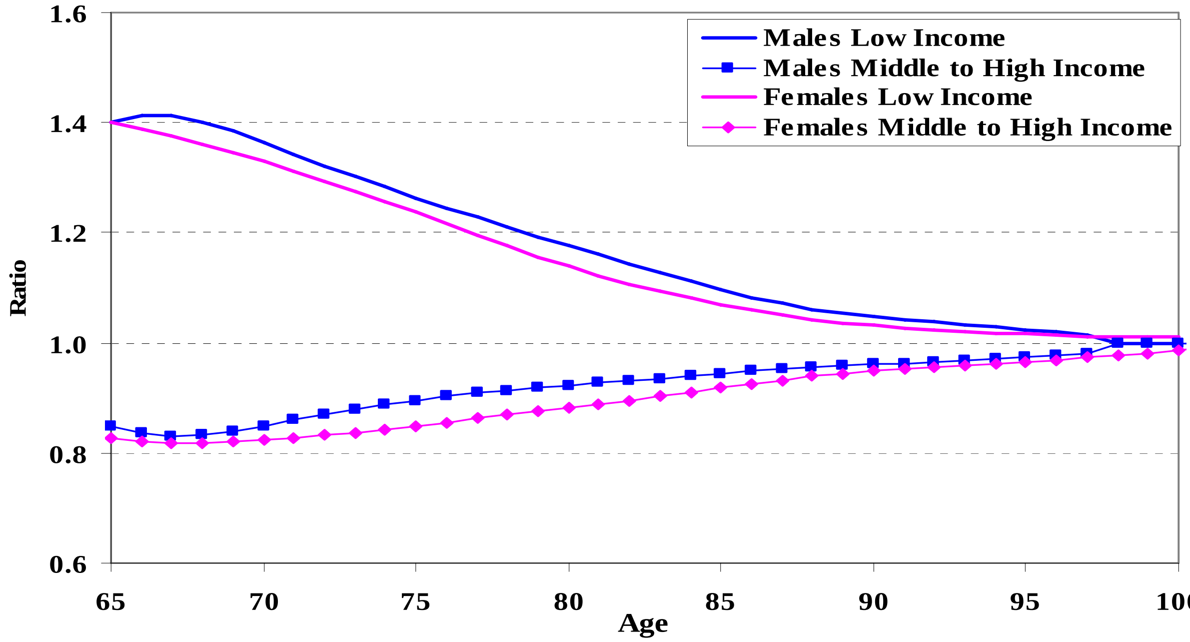
TABLE 21

Mortality Rates of OAS Beneficiaries (with Low Retirement Incomes, 2001)

Age Group	Males			Females		
	Low Income	Overall OAS	Ratio Low Income to Overall OAS	Low Income	Overall OAS	Ratio Low Income to Overall OAS
65-69	0.0286	0.0203	1.41	0.0163	0.0118	1.38
70-74	0.0433	0.0328	1.32	0.0247	0.0190	1.30
75-79	0.0653	0.0532	1.23	0.0381	0.0318	1.20
80-84	0.0990	0.0858	1.15	0.0613	0.0549	1.12
85-89	0.1489	0.1377	1.08	0.1026	0.0970	1.06
90-94	0.2180	0.2086	1.05	0.1668	0.1623	1.03
95-99	0.3016	0.2957	1.02	0.2520	0.2482	1.02
100+	0.3977	0.3977	1.00	0.3533	0.3500	1.01

CHART 8

Mortality Ratios of OAS Beneficiaries by Level of Retirement Income (2001)



OAS mortality rates are also dependent on whether beneficiaries were born in Canada or are immigrants. Immigration to Canada has historically been volatile. However, historical levels have been relatively high compared to the general population. Moreover, as the total fertility rate has fallen significantly since the late 1950s to below replacement level, immigration has composed an increasing portion of the growth of the Canadian population. The proportion of OAS beneficiaries who were born outside of Canada increases with age.

As presented in Table 22, 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.[1] They 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

‡ Chen J., Wilkins R. and Ng E., *Health Expectancy by Immigrant Status, 1986 and 1991*. Health Reports, Winter 1996, Vol. 8, No. 3, Statistics Canada.

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 22

OAS Beneficiary Mortality Rates by Place of Birth (2001)

Age Group	Males					Females				
	Born in Canada	Ratio Born in Canada to Overall OAS	Born Outside of Canada	Ratio Born Outside of Canada to Overall OAS	Overall OAS	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	0.0221	1.09	0.0157	0.77	0.0203	0.0129	1.09	0.0087	0.73	0.0118
70-74	0.0352	1.07	0.0269	0.82	0.0328	0.0202	1.06	0.0156	0.82	0.0190
75-79	0.0561	1.06	0.0460	0.86	0.0532	0.0332	1.04	0.0281	0.88	0.0318
80-84	0.0894	1.04	0.0754	0.88	0.0858	0.0562	1.02	0.0505	0.92	0.0549
85-89	0.1412	1.03	0.1287	0.93	0.1377	0.0980	1.01	0.0944	0.97	0.0970
90-94	0.2112	1.01	0.2046	0.98	0.2086	0.1618	1.00	0.1623	1.00	0.1623
95-99	0.3025	1.02	0.2929	0.99	0.2957	0.2538	1.02	0.2453	0.99	0.2482
100+	0.3995	1.00	0.3956	0.99	0.3977	0.3604	1.03	0.3446	0.98	0.3500

A comparison of life expectancies at age 65 between the various subgroups of OAS beneficiaries and life expectancies based on Statistics Canada Life Tables for Canada 2000-2002 is shown in Table 23. Life expectancies shown in Table 23 do not include future mortality improvements.

Overall, since the mortality level of OAS beneficiaries is higher than that of the Life Tables for Canada 2000-2002, life expectancies at age 65 are correspondingly lower. The differential in life expectancies at age 65 between the overall OAS program and the Life Tables for Canada is larger for males (0.4 year) than for females (0.3 year).

OAS beneficiaries born outside of Canada have greater life expectancies than those born in Canada. The differential for males is 1.6 years and for females, it is 1.2 years. For those born in Canada, the gap between female and male life expectancies is 3.7 years, which is higher than the corresponding differential of 3.3 years for those born outside of Canada.

An analysis of the differential in life expectancies at age 65 by level of income shows that males experience a wider range in life expectancies at age 65 between the wealthier and poorer OAS beneficiaries. The differential in life expectancies at age 65 between those with the highest retirement income and those with the lowest income is 4.5 years for males and 3.4 years for females. Moreover, the gap in life expectancies at age 65 between the two sexes decreases the higher the level of income, from 4.0 for those with low income to 2.9 for those with the highest income.

The results presented in Table 23 also confirm that both males and females who are married experience better mortality than their single counterparts. The positive impact on mortality of being married is more pronounced for males. Individuals who are married with middle to high retirement income experience the lowest mortality.

TABLE 23

OAS Beneficiary Life Expectancies at Age 65 (2001)

	Males	Females	Female – Male Differential
All Income Levels	16.6	20.2	3.6
-Married	17.9	21.0	3.1
-Single	14.2	19.7	5.5
Low Income	15.0	19.0	4.0
-Married	16.3	19.8	3.5
-Single	13.0	18.6	5.6
Middle Income	17.2	21.1	3.9
-Married	18.4	21.4	3.0
-Single	14.8	20.8	6.0
High Income	19.5	22.4	2.9
-Married	20.6	23.3	2.7
-Single	17.6	22.1	4.5
Born in Canada	16.2	19.9	3.7
Born outside of Canada (immigrants)	17.8	21.1	3.3
Life Tables for Canada 2000-2002	17.0	20.5	3.5
Differential between Life Tables and All Income Levels	0.4	0.3	
Differential between High and Low Income	4.5	3.4	
Differential between Immigrants and those Born in Canada	1.6	1.2	
Differential Between Married and Single	3.7	1.3	

3.3 Stochastic Process

A new methodology has been developed for determining the evolution, as well as volatility, of mortality rates. The mortality rates will be analyzed using a stochastic time series model. In a stochastic process, random variation is present, which is generally based on fluctuations observed in historical data, compared to a fitted model, for a selected period prior to the current year being modeled. A stochastic time series model may include the variable’s prior-period values, prior-period error terms, 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 the deterministic model.

Annual historical mortality rates are calculated for 40 age-sex groups (under 1, 1-4, 5-9, 10-14,…80-84, 85-89, 90+; male and female) for the period 1926-2003 as the ratio of annual deaths to the population for each age-sex group. Data for the annual numbers of deaths and the Canadian population were obtained from Statistics Canada. The first year of data available for the analysis is 1926.

The time series model selected to reproduce the annual mortality rates is a log ARIMA (0, 1, 0), which is 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 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). In fact, the R^2 value for all but one age-sex group was above 0.9. As well, the use of the log transformation eliminates the need for a lower bound of zero, since logged 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 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. This correlation must continue to be reflected in the projected rates and is done so by correlating the error terms of the 40 age-sex groups using Cholesky decomposition.

Random error terms with the Uniform(0,1) distribution are generated using a random number generator. In order to reflect correlation between these error terms, they must be transformed to a Normal(0,**V**) distribution**,** where **V** is the variance-covariance matrix of residuals, the differences between the actual historical data points and the estimated data points (using the chosen ARIMA model). The random error terms are first converted to a Normal(0,1) distribution. The final step is to convert the standard normal error terms to a multivariate normal distribution with variance-covariance matrix **V**. Cholesky Decomposition is used to decompose the matrix **V** into a lower triangle matrix **L** such that $\mathbf{V} = \mathbf{LL}^{\mathbf{T}}$**.** As an example, let us consider a case where it is necessary to correlate the error terms of three variables, denoted x, y and z. Let the variance-covariance matrix **V** be the following matrix:

$$\mathbf{V} = \begin{bmatrix} 36 & -36 & 18 \\ -36 & 117 & -72 \\ 18 & -72 & 189 \end{bmatrix} \quad \text{where} \quad \mathbf{V} = \begin{bmatrix} \sigma_X^2 & \sigma_{XY} & \sigma_{XZ} \\ \sigma_{YX} & \sigma_Y^2 & \sigma_{YZ} \\ \sigma_{ZX} & \sigma_{ZY} & \sigma_Z^2 \end{bmatrix}$$

Then, **V** is decomposed into the lower triangle matrix **L** such that $\mathbf{V} = \mathbf{LL}^{\mathbf{T}}$,

$$\text{where } \mathbf{L} = \begin{bmatrix} 6 & 0 & 0 \\ -6 & 9 & 0 \\ 3 & -6 & 12 \end{bmatrix} \quad \text{and} \quad \mathbf{L}^{\mathbf{T}} = \begin{bmatrix} 6 & -6 & 3 \\ 0 & 9 & -6 \\ 0 & 0 & 12 \end{bmatrix}$$

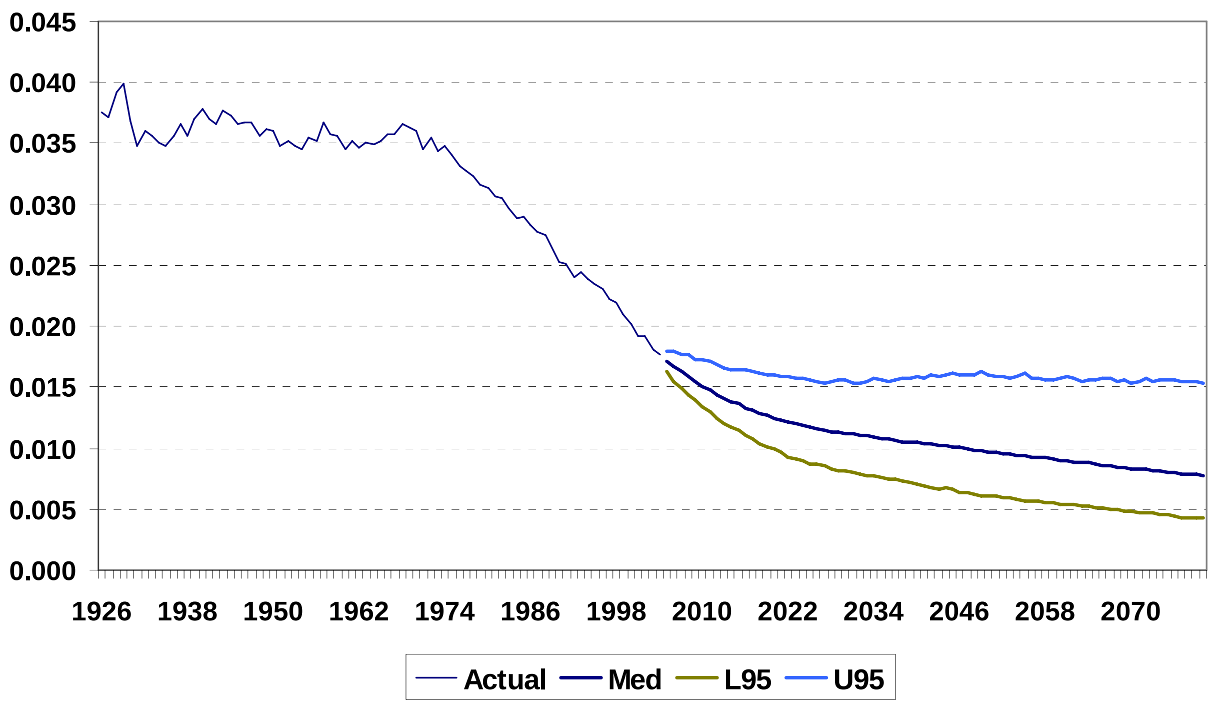
By multiplying the Cholesky matrix **L** by the Normal(0,1) vector of error terms, $\vec{\varepsilon}$, we obtain a vector of correlated error terms, $\mathbf{L}\vec{\varepsilon}$, with the required multivariate normal distribution. These error terms are then used in the projection of future mortality rates.

Once the equation has been determined and the Cholesky Decomposition has been performed, future mortality rates are projected for each age-sex group 75 years into the future for 1,000 scenarios. The resulting mortality rate is the median mortality rate over all 1,000 scenarios. In addition, 95 percent confidence intervals are calculated to create awareness about the range of possible mortality rates.

The graph below shows the historical and projected mortality rates for males in the age range 65-69. The middle line represents the median mortality rates of the 1,000 scenarios run, while the lines above and below represent the bounds of the 95 percent confidence interval.

CHART 9

Mortality Rates, Male Age 65-69 (1926-2079)



Having projected mortality rates for each age-sex group, the next step is to convert those values into mortality improvement factors. The equation used for this purpose is:

$$MIR_{k,t} = (MR_{k,t} \div MR_{k,t-1}) - 1$$

where $MIR_{k,t}$ = mortality improvement factor for group k at time t

$MR_{k,t}$ = mortality rate for group k at time t

Mortality improvement factors are calculated for each age-sex group 75 years into the future for all 1,000 scenarios. The results tend to show that mortality improvement rates are rather constant over the projection period with little fluctuation.

It must be taken into consideration that an ARIMA model can not explicitly represent a stochastic process with a time-varying mean displacement. However, historical mortality data does 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's possible that this transformation may not completely eliminate the time-varying mean displacement, which would 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 historical experience compared to the recent past and emerging patterns. Thus, the use of judgement may be necessary in determining appropriate mortality improvement factors.

Therefore, the next step is to incorporate some judgment into the process. The evolution of a 15-year moving average of historical improvement rates is analyzed through time and then compared to the mortality improvement factors produced by the model in order to finalize the best-estimate mortality improvement factors for each age group.

Next, the best-estimate mortality improvement factors determined above are applied to the 2001 Canada Life Table (CLT) in order to establish the best-estimate mortality rates for the future. Finally, a stochastic process is used to project 1,000 future mortality rate paths that are centered around this best-estimate. The life expectancy for each of the 1,000 paths is then calculated and the best-estimate life expectancy is equal to the median of the 1,000 life expectancies. The tables below show the best-estimate life expectancy at ages 0 and 65 as compared to the values from CPP 23, as well as the 95 percent confidence interval of these life expectancies.

TABLE 24

Life Expectancies without Improvements after the Year Shown

		CPP23	Stochastic Process	Lower 95% CI	Upper 95% CI
Male, Age 0	2007	78.5	78.2	77.8	79.1
	2025	81.3	80.9	79.0	83.4
	2050	83.0	82.5	78.9	86.4
	2075	84.6	84.1	79.0	88.6
Male, Age 65	2007	18.2	18.0	17.6	18.6
	2025	19.9	19.8	17.8	21.6
	2050	21.1	21.0	17.6	23.8
	2075	22.3	22.2	17.7	25.6
Female, Age 0	2007	82.9	82.6	82.3	83.5
	2025	84.5	84.2	81.5	87.0
	2050	86.1	85.6	80.6	90.0
	2075	87.5	86.9	80.3	92.1
Female, Age 65	2007	21.2	21.1	20.5	21.8
	2025	22.3	22.2	19.4	24.6
	2050	23.4	23.4	18.5	26.7
	2075	24.6	24.4	18.3	28.4

TABLE 25

Life Expectancies with Improvements after the Year Shown

		CPP23	Stochastic Process	Lower 95% CI	Upper 95% CI
Male, Age 0	2007	84.5	83.9	79.1	88.4
	2025	85.8	85.1	80.0	89.8
	2050	87.4	86.5	80.8	91.3
	2075	88.8	87.7	81.6	92.8
Male, Age 65	2007	19.3	19.2	17.6	20.7
	2025	20.6	20.5	17.7	22.9
	2050	21.9	21.6	17.8	25.1
	2075	23.1	22.7	17.9	26.6
Female, Age 0	2007	87.7	87.1	80.6	92.0
	2025	88.8	88.0	81.1	93.1
	2050	90.2	89.1	81.9	94.6
	2075	91.5	90.1	81.9	95.9
Female, Age 65	2007	22.0	21.9	19.5	24.0
	2025	23.0	22.9	18.9	25.9
	2050	24.2	24.1	18.6	27.9
	2075	25.4	25.0	18.4	29.4

4. Conclusion

Mortality in Canada declined significantly in the 20th century at all ages and for both males and females. In fact, in the last century, life expectancy at birth increased by an estimated 29 years in Canada. Female life expectancies have exceeded male life expectancies; however the gap between the two has varied over time. The gap between female and male life expectancies at birth reached its peak of just over seven years in the mid-1970s. Since then, the gap has narrowed, reaching 4.5 years in 2006, due to males experiencing greater improvements in mortality than females.

In the 23rd CPP actuarial report, the ultimate mortality improvement factors for years 2029 and thereafter vary by age and were derived from an analysis of experience in Canada over the last 30 years. The ultimate annual mortality improvement rates rely on the assumption that trends in female mortality improvements over the last 30 years will continue for another 30 years. It is also expected 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 completely disappear.

In Canada mortality is assumed to continue to decline throughout the 75-year projection period. The growth in life expectancies is expected to be at a slower rate than was experienced in the 20th century. However, for ages 65 and above, future mortality improvement is expected to be close to that experienced over the last century.

Finally, methodologies involving stochastic time series models have been developed for illustrating the evolution, as well as volatility, of mortality rates. The main advantage of a stochastic projection is that it provides a reasonable quantification of the range of uncertainty around the central (best estimate) projection.