Canada's Global Position in Life Expectancy: A Longitudinal Comparison with the Healthiest Countries in the World

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ABSTRACT

Objective: To assess the global position of Canadian life expectancy and to determine the areas of greatest negative impact on life expectancy.

Methods: Using retrospective data on life expectancy at birth (LE_0) and age-standardized mortality rates, Canada was compared with 13 other countries with the longest LE_0 . Linear regression models were used to produce trends and projections of LE_0 until 2010.

Results: Canadian women and men currently rank 8th and 5th, respectively, in LE_0 among the 14 nations. Canada has one of the smallest annual LE_0 improvement rates among the countries studied. Canadian women progressed significantly slower than nine countries and Canadian men progressed slower than five. Women are improving at only half the rate of men due to narrowing gaps in most mortality risks – mostly for cardiovascular diseases, lung cancer and injury. These trends lowered projected LE_0 ranks of Canadians, especially for women, for 2010.

Conclusion: LE_0 of Canadians is slipping relative to most of the other 13 countries, and more so for women than men. This phenomenon is explained by historically higher mortality rates from ischemic heart disease, cancer and respiratory system disease for all Canadians, coupled with recently lower improvement rates in most mortality risks for Canadian women and in cancers and diabetes for Canadian men. Improving the health and wellness of Canadians, particularly women, demands a priority focus on enhanced chronic disease detection and management as well as strategies to reduce obesity and tobacco use by addressing the determinants of these behavioural risk factors.

Key words: Life expectancy; age-standardized mortality rates; longitudinal trends; regression analysis

La traduction du résumé se trouve à la fin de l'article.

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Life expectancy at birth (LE_0), the estimated number of years a newborn can be expected to live given prevailing mortality rates, is a universal indicator for comparing the health status of jurisdictions. It is also a proxy measure of such social conditions as wealth, economic opportunity, health care, and education. For this reason, inequalities in life expectancy usually signal inequities in other social, economic and environmental conditions.

Over the past century, global improvements in public health, medicine, working conditions and nutrition have led to a dramatic increase in life expectancy.¹ In 1921, LE_0 for Canadian men and women were only 56.0 and 58.2 years, respectively. By 2003, those corresponding values had increased by about 40% to 77.4 and 82.4 years.² Meanwhile, the gap in life expectancy between women and men in Canada increased from 2.2 years in early 1920s to its peak of 7.4 years in late 1970s, and then has been narrowing over the past three decades. In fact, the gender gap in LE_0 in most developed nations has become progressively smaller.^{3,4}

We know that Canada is among the world's leading nations with the longest LE_0 . However, neither systematic review nor longitudinal analysis of LE_0 has ever been conducted to recognize Canada's strength and weakness relative to other nations. Using annual rankings, improvement rates and projections, this study provides a robust picture of Canada's global position in LE_0 . Mortality rate comparisons of major causes of death further help to identify the areas for improvement of life expectancy in Canada.

METHODS

Countries under comparison

Estimates of LE_0 are sensitive to population size. To ensure robust trend analyses of LE_0 and mortality rates, only those countries with

LE_0 rankings in the top 10 for either men or women and with populations over 1,000,000 were selected. This resulted in the selection of 14 countries, as listed in Table 1.

Source of data

The 14 countries that met the selection criteria are all members of the Organization for Economic Cooperation and Development (OECD). Age-standardized mortality rates (ASMR)^{5,6} and LE_0 data for all countries were directly obtained from the Health Data 2006⁷ – an annual health report from the OECD. Annual rankings, increment rates and projected values for 2010 for the 14 countries in LE_0 were calculated in this study.

Comparisons by disease-specific mortality rates

Since LE_0 is a summary number reflecting overall death rates, further examining disease-specific mortality rates behind the LE_0 values is crucial to identifying areas for improvement. For each specific mortality risk in a year, the difference in ASMR values between Canada and the best performing country from the other 13 countries was calculated. A

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Table 1. Life Expectancy at Birth for Canada and Selected Healthiest Countries

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	R ² †	Gain*(p-value‡)	2010 (95%PI)§
Males																		
Canada	74.0	74.4	74.6	74.8	74.8	75.0	75.1	75.4	75.7	76.0	76.2	76.7	77.0	77.2	77.4	98%	87	79.0(78.5-79.5)
Rank 	5	4	4	3	6	5	4	4	4	4	4	4	4	5	5			5
Switzerland	74.1	74.0	74.1	74.5	74.9	75.2	75.3	75.9	76.3	76.3	76.8	76.9	77.4	77.8	78.0	99%	111(<0.001)	80.1(79.6-80.6)
Japan	75.9	75.9	76.1	76.1	76.3	76.6	76.4	77.0	77.2	77.2	77.1	77.7	78.1	78.3	78.4	95%	69(0.0013)	79.6(79.0-80.2)
France	72.5	72.8	72.9	73.2	73.3	73.7	73.9	74.1	74.6	74.8	75.0	75.3	75.5	75.8	75.9	99%	93(0.4260)	77.8(77.5-78.0)
Austria	71.9	72.2	72.3	72.5	72.8	73.2	73.3	73.7	74.1	74.5	74.8	75.1	75.6	75.8	75.9	99%	112(0.0002)	78.1(77.7-78.6)
Italy	73.6	73.6	73.6	74.0	74.4	74.6	74.9	75.3	75.7	75.7	76.1	76.6	76.7	76.8	76.8	98%	98(0.0354)	79.0(78.5-79.5)
Netherlands	73.7	73.8	74.0	74.3	74.0	74.6	74.6	74.7	75.2	75.2	75.3	75.5	75.8	76.0	76.2	97%	65(0.0002)	77.4(77.0-77.8)
Sweden	74.8	74.8	74.9	75.4	75.5	76.1	76.2	76.5	76.7	76.9	77.1	77.4	77.6	77.7	77.9	98%	88(0.9094)	79.7(79.4-80.1)
Australia	73.3	73.9	74.4	74.5	75.0	75.0	75.0	75.2	75.6	75.9	76.2	76.6	77.0	77.4	77.8	97%	104(0.0037)	79.5(78.9-80.2)
Norway	73.3	73.4	74.0	74.2	74.2	74.9	74.8	75.4	75.5	75.6	75.6	76.0	76.2	76.4	77.1	97%	90(0.7500)	78.6(78.0-79.1)
Spain	73.3	73.3	73.4	73.8	73.9	74.3	74.3	74.4	75.0	75.1	75.1	75.8	76.1	76.2	76.9	96%	91(0.9637)	78.2(77.6-78.9)
Germany	72.1	72.0	72.2	72.6	72.7	73.1	73.3	73.6	74.0	74.5	74.7	75.0	75.5	75.4	75.7	98%	105(0.0028)	77.8(77.3-78.3)
Finland	70.9	70.9	71.3	71.7	72.1	72.8	72.8	73.0	73.4	73.5	73.8	74.2	74.6	74.9	75.1	99%	113(<0.001)	77.4(76.9-77.8)
Greece	74.5	74.6	74.7	74.7	75.0	75.2	75.0	75.1	75.6	75.4	75.5	75.6	76.1	76.4	76.5	92%	49(<0.001)	77.2(76.7-77.8)
Females																		
Canada	80.6	80.8	80.9	81.2	80.9	81.0	81.1	81.2	81.3	81.5	81.7	81.9	82.1	82.1	82.4	92%	43	83.0(82.6-83.5)
Rank	3	4	4	4	5	6	7	7	7	7	8	8	7	7	8			11
Switzerland	80.9	80.7	81.1	81.3	81.4	81.7	81.7	82.0	82.1	82.4	82.5	82.6	83.0	83.0	83.1	98%	64(<0.001)	84.4(84.1-84.7)
Japan	81.8	81.9	82.1	82.2	82.5	83.0	82.9	83.6	83.8	84.0	84.0	84.6	84.9	85.2	85.3	98%	98(<0.001)	87.2(86.8-87.7)
France	80.6	80.9	81.1	81.4	81.4	81.8	81.8	82.0	82.3	82.4	82.5	82.7	82.9	83.0	82.9	98%	62(<0.001)	84.4(84.0-84.7)
Austria	78.6	78.8	78.9	79.1	79.3	79.6	79.9	80.1	80.5	80.8	80.8	81.1	81.5	81.7	81.6	98%	87(<0.001)	83.5(83.1-83.8)
Italy	80.0	80.1	80.2	80.6	80.7	81.0	81.3	81.4	81.6	81.8	82.2	82.5	82.8	82.9	82.5	97%	80(<0.001)	84.5(84.0-85.0)
Netherlands	79.9	80.1	80.1	80.3	80.0	80.3	80.4	80.3	80.5	80.6	80.5	80.5	80.7	80.7	80.9	88%	22(<0.001)	81.2(80.9-81.5)
Sweden	80.6	80.4	80.5	80.8	80.8	81.4	81.4	81.5	81.8	81.9	81.9	82.0	82.1	82.1	82.5	94%	53(0.0443)	83.5(83.0-84.0)
Australia	79.6	80.1	80.4	80.4	80.9	80.9	80.8	81.1	81.3	81.5	81.8	82.0	82.4	82.6	82.8	97%	76(<0.001)	84.2(83.7-84.6)
Norway	79.8	79.8	80.1	80.3	80.2	80.6	80.8	81.0	81.0	81.3	81.1	81.4	81.5	81.5	82.0	96%	54(0.0365)	82.9(82.5-83.3)
Spain	80.3	80.3	80.5	81.0	81.0	81.4	81.5	81.7	82.0	82.1	82.1	82.5	82.8	82.9	83.6	98%	81(<0.001)	84.8(84.3-85.2)
Germany	78.5	78.4	78.7	79.2	79.2	79.6	79.7	79.9	80.3	80.6	80.7	81.0	81.3	81.2	81.4	98%	84(<0.001)	83.2(82.8-83.6)
Finland	78.9	78.9	79.3	79.4	79.5	80.1	80.2	80.5	80.5	80.8	81.0	81.0	81.5	81.5	81.8	98%	77(<0.001)	83.3(82.9-83.7)
Greece	79.4	79.5	79.7	79.6	79.9	80.2	80.3	80.4	80.8	80.4	80.6	80.5	80.9	81.1	81.3	92%	46(0.2259)	82.1(81.6-82.6)

* Annual improvement of LE_0 in days converted from regression slope

† R-squared representing the degree of linearity of the linear regression line;

‡ p-value from testing hypothesis of equal slopes in comparison to Canada is considered significant if less than 0.05 or more conservatively 0.0039 by Bonferroni correction

§ Prediction intervals of projected LE_0 for 2010

|| Ranks are accurate to the first decimal place and ties are permitted.

positive difference indicates Canada had a higher mortality rate than the country with the lowest rate for that cause of death in that year, and illustrates the magnitude of improvement required for Canada in this mortality area. A negative difference indicates Canada's leading position compared to the next best country. Parallel temporal comparisons of major mortality rates of cancer and circulatory system disease for Canada and five leading nations were also performed.

Statistical analysis

To reflect recent trends and establish a reliable basis for projecting LE_0 values up to 2010, LE_0 trends were modeled from data for a period (1989 to 2003), which was twice as long as the projection period (2004 to 2010).

The progression of LE_0 for all countries studied demonstrated a strong linear association with time. The linearity measured by R-squared (R^2) in linear regression models⁸ was greater than 90%, except for women in the Netherlands (88%), indicating that more than 90% of the variations in LE_0 can be explained by time with linear regression models.

The linear progressive trend of life expectancy records over time by women from some wealthy countries in the past 160 years has been discussed by Oeppen and Vaupel⁹ and White.¹⁰ Linear trends were apparent in our study and currently hold true for most developed nations.

The regression slopes¹¹ measuring annual improvements in LE_0 for the regression period can be used to compare the sustainability of a country in gaining LE_0 relative to other countries. To address the potential multiplicity problem in multiple comparisons, analysis of covariance (ANCOVA) with year-by-country interaction was

performed to test statistical differences between regression slopes. Using ANCOVA, we first examined the overall difference among the 14 regression slopes and after the overall slope difference was confirmed to be statistically significant, we then simultaneously tested differences of slopes between Canada and each of 13 other countries at both 0.05 and the adjusted significance levels using the most conservative Bonferroni correction.* Bonferroni correction sets alpha value for the entire set of n comparisons equal to α/n (0.05/13 = 0.0039 in our case).

Additionally, point estimates with 95% prediction intervals (PI)¹² for LE_0 in 2010 were calculated for all countries through linear extrapolation from fitted regression equations, reflecting tendency of LE_0 progression if present trends continued.

RESULTS

Canada's position in life expectancy

As shown in Table 1, Canada is among the healthiest nations in the world as measured by LE_0 . In 2003, Canadian women and men ranked 8th and 5th in LE_0 , respectively. In recent years, Canadian women whose rank fell from 3rd in 1989 to 8th in 2003 have been losing position relative to women from other leading countries. In contrast, rankings for Canadian men have been steady around 5th place for the same period. The advantage of women over men for LE_0 in Canada has also been reduced from 7.4 years in the late 1970s to 5.0 years in 2003.

* The Bonferroni correction is a statistical adjustment for the multiple comparisons used when several dependent or independent statistical tests are being performed.

Figure 1. Actual and Projected Life Expectancy at Birth **Life expectancy comparison by annual gain**

Table 1 also shows that Canada has one of the smallest annual gains in LE_0 among the countries studied. After the hypotheses of equal slopes among the 14 countries in both women and men were rejected, our analyses of covariance tested slope differences between Canada and each of 13 other nations simultaneously and statistically confirmed that Canadian women's annual improvement rate in LE_0 (43 days per year) is significantly slower than those for women from 11 countries at a significance level of $\alpha=0.05$ or 9 countries at significance level of $\alpha=0.0039$ (with Bonferroni correction). These nations included Japan [98($p<0.0001$)], Austria [87($p<0.0001$)], Germany [84($p<0.0001$)], Spain [81($p<0.0001$)], Italy [80($p<0.0001$)], Finland [77($p<0.0001$)], Australia [76($p<0.0001$)], Switzerland [64($p<0.0001$)], France [62($p<0.0001$)], Norway [54($p=0.0365$)] and Sweden [53($p=0.0443$)].

Canadian men also performed below the average, with an estimated annual LE_0 gain of 87 days (11th place by point estimate among the 14 countries), which is significantly lower than values for Finland [113($p<0.0001$)], Austria [112($p<0.0001$)], Switzerland [111($p<0.0001$)], Germany [105($p=0.0028$)] and Australia [104($p=0.0037$)] at $\alpha=0.0039$ and Italy [98($p=0.0354$)] at $\alpha=0.05$.

Life expectancy comparison by projection to 2010

If current trends continue, Figure 1(a) shows Canadian men are likely to maintain their position alongside men from the other leading nations. By 2010, there is no statistically significant difference between Canadian men [LE_0 : 79.0(95%PI: 78.5-79.5)] and other countries, except Switzerland [LE_0 : 80.1(95%PI: 79.6-80.6)]. Also for men, Canada is significantly ahead of five nations: France [LE_0 : 77.8(95%PI: 77.5-78.0)], Germany [LE_0 : 77.8(95%PI: 77.3-78.3)], Netherlands [LE_0 : 77.4(95%PI: 77.0-77.8)], Finland [LE_0 : 77.4(95%PI: 76.9-77.8)] and Greece [LE_0 : 77.2(95%PI: 76.7-77.8)].

In contrast, Figure 1(b) shows Canadian women are unlikely to maintain their position. Assuming current trends, Canadian women [LE_0 : 83.0(95%PI: 82.6-83.5) in 2010] are expected to fall

significantly behind six countries: Japan [LE_0 : 87.2(95%PI: 86.8-87.7)], Spain [LE_0 : 84.8(95%PI: 84.3-85.2)], Italy [LE_0 : 84.5(95%PI: 84.0-85.0)], Switzerland [LE_0 : 84.4(95%PI: 84.1-84.7)], France [LE_0 : 84.4(95%PI: 84.1-84.7)] and Australia [LE_0 : 84.2(95%PI: 83.7-84.6)]. By point estimates, though statistically non-significant, Canadian women are also ranked behind Austria (83.5), Sweden (83.5), Finland (83.3) and Germany (83.2).

Comparisons of disease-specific mortality rates

Figure 2 provides clear pictures of temporal variations in ASMR values for some of the healthiest nations relating to cancer and circulatory system disease (CSD) where the fitted lines were obtained from linear regression on log-transformed ASMR over time. Canadian men have made smaller progressions in mortality rates of cancer (Figure 2(a)) and CSD (Figure 2(c)) than men from Switzerland, and those from Australia, Spain and Japan, respectively. Similarly, Canadian women had much higher rates of cancer death among the nations compared and have progressed slower in cancer death reduction than women from Switzerland and Australia (Figure 2(b)). The reduction of CSD mortality rates among Canadian women has been much slower than that of Japanese women (Figure 2(d)).

As shown in Figure 3(a), the ASMR values for Canadian men are close to the best records for all major diseases except ischemic heart disease and lung cancer. In this regard, Canadian men are far behind the healthiest countries, but are rapidly improving.

Figure 3(b) shows that Canadian women are behind the best records in the areas of ischemic heart disease, all cancers (especially lung cancer) and respiratory system diseases. The mortality rate for ischemic heart disease among Canadian women, however, has been continuously improving relative to the foremost records in this study.

Due to strong socio-economic ties, we have also compared LE_0 of Canada and the United States and found no statistically significant difference in improvement rates of LE_0 between the two countries. However, Canada is about 2.5 years ahead of the United States in LE_0 values in recent years.

Figure 2. Gaps in Selected ASMR between Canada and the Overall Leaders **Figure 3.** Position of Canadians Relative to the Best Performing Countries by Mortality Risk

DISCUSSION

While Canada boasts one of the longest-living populations in the world, two trends have been uncovered through this study. First, Canadians, especially women, are experiencing a lower rate of annual life expectancy gain, compared to the other healthiest nations studied. Second, Canadian women are making slower progress in LE_0 than their male counterparts.

This study has some limitations. For instance, single-year age- and cause-specific mortality counts were not available for all nations under comparison. Consequently more sophisticated statistical modeling¹³ on life tables could not be implemented. Due to the unavailability and incomparability of data, no causal models linking various determinants of health to LE_0 could be established for all countries studied.

Nevertheless, our analysis of mortality risks found that the declining position of Canadian women in LE_0 is related to historically higher mortality rates and, recently, smaller mortality rate reduction in comparison to other countries in the areas of circulatory system disease and cancer. These mortality risks, in turn, are closely related to the prevalence of obesity, diabetes, and lifestyle factors like tobacco use in the population.

According to the World Health Organization, Canada had the third highest prevalence rate of diabetes in populations aged 20 and above in 2000, among the 14 countries studied. From OECD Health Data,⁷ both Canadian women and men aged 15 and over had the 5th highest rate of overweight and obesity (Body-Mass Index (BMI) ≥ 25 kg/m²) based on 2003 and latest data among the 13 countries, except Australia which had no comparable self-reported data. Obesity rates in Canada have continued to rise from 10% in 1970 to 23% in 2004 (8% to 23% in men; 13% to 22% in women).¹⁴ Obesity is a risk factor for Type 2 diabetes, cardiovascular diseases, some types of cancer¹⁵ and other chronic conditions.^{16,17} Also from OECD data, Canadians had the worst level of sugar consumption and 5th worst total fat and calories intakes among the 14 nations studied – both are risk factors for diabetes and cardiovascular disease.

While ASMR for lung cancer among Canadian women has increased 27.6% between 1988 and 2002, Canadian women also had the highest incidence rate of lung cancer (31.6 per 100,000 population), which is much higher than Norway (18.7 per 100,000), the second highest in 2002. The higher incidence and mortality rates for lung cancer in Canada are partially explained by the relatively higher smoking rates of Canadian women in earlier decades, among the 14 nations.

In conclusion, Canada is one of the healthiest nations in the world. However, the health status of Canadian women is slipping relative to the health status of both women from other leading countries of the world and Canadian men. Improving the health and wellness of Canadians, particularly women, demands a priority focus on enhanced chronic disease detection and management as well as strategies to reduce obesity and tobacco use by addressing the determinants of these behavioural risk factors.

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RÉSUMÉ

Objectif : Évaluer l'espérance de vie des Canadiens dans une perspective mondiale et déterminer les aspects ayant le plus d'effets nuisibles sur l'espérance de vie.

Méthode : À l'aide de données rétrospectives sur l'espérance de vie à la naissance (EV0) et de taux de mortalité normalisés selon l'âge, nous avons comparé le Canada aux 13 autres pays où l'EV0 est la plus longue. Des modèles de régression linéaire ont été utilisés pour produire des tendances et des projections de l'EV0 jusqu'en 2010.

Résultats : Les Canadiens, femmes et hommes, occupent actuellement le 8^e et le 5^e rang, respectivement, pour l'EV0 parmi les 14 pays à l'étude. Le Canada a l'un des plus faibles taux annuels d'amélioration de l'EV0 de tous les pays étudiés. La progression du taux des femmes au Canada a été plus lente que dans neuf autres pays, et celle du taux des hommes, plus lente que dans cinq autres pays. Le taux des femmes ne s'améliore que dans une proportion correspondant à la moitié du taux des hommes en raison du rétrécissement des écarts entre les sexes pour la plupart des risques de mortalité (principalement les maladies cardiovasculaires, le cancer du poumon et les traumatismes). Ces tendances atténuent les projections du rang que devraient occuper les Canadiens pour l'EV0 en 2010, surtout pour les femmes.

Conclusion : L'EV0 des Canadiens évolue plus lentement que dans la plupart des 13 autres pays, et plus encore pour les femmes que pour les hommes. Ce phénomène s'explique par les taux de mortalité attribuables aux cardiopathies ischémiques, au cancer et aux maladies du système respiratoire, qui ont jusqu'à maintenant été supérieurs chez tous les Canadiens, ainsi que par les taux d'amélioration plus faibles, récemment, de la plupart des risques de mortalité (pour les femmes) et des risques de cancer et de diabète (pour les hommes) au Canada. Pour améliorer la santé et le bien-être des Canadiens, particulièrement les femmes, il faut en priorité améliorer la détection et la prise en charge des maladies chroniques et élaborer des stratégies de réduction de l'obésité et du tabagisme axées sur les déterminants de ces facteurs de risque comportementaux.

Mots clés : espérance de vie; taux de mortalité normalisés selon l'âge; tendances longitudinales; analyse de régression