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Abstract

Background: Over the past century, life expectancy at birth in Canada has risen substantially. However, these gains in the quantity of life say little about gains in the quality of life.

Methods: Health-adjusted life expectancy (HALE), an indicator of quality of life, was estimated for the household and institutional populations combined every four years from 1994/1995 to 2015. Health status was measured by the Health Utilities Index Mark 3 instrument in two national population health surveys, and was used to adjust life expectancy. The percentage of the population living in health-related institutions was estimated based on the Census of Population. Attribute-deleted HALE was calculated to determine how various aspects of health status contributed to the differences between life expectancy and HALE.

Results: HALE has increased in Canada. Greater gains among males have narrowed the gap between males and females. The ratio of HALE to life expectancy changed little for males, and a marginal improvement was observed for females aged 65 or older. Mobility problems and pain, the latter mainly among females, accounted for an increased share of the burden of ill health over time. Exclusion of the institutional population significantly increased the estimates of HALE and yielded higher ratios of HALE to life expectancy.

Interpretation: Although people are living longer, the share of years spent in good functional health has remained fairly constant. Data for both the household and institutional populations are necessary for a complete picture of health expectancy in Canada.

Keywords: Gender differences, health expectancy, Health Utility Index, morbidity, mortality, summary measures of health

Over the past century, life expectancy at birth in Canada has risen substantially to 79.8 years for males, and 83.9 years for females.[1,2] These increases in the quantity of life say little about the quality of life. How quality of life is keeping pace with the increase in life expectancy is an important health indicator.[3,4]

Health expectancy is a summary indicator that incorporates information on mortality (such as life expectancy) and health status (such as morbidity) into a single estimate that can be considered a measure of quality of life.[5-7] Health expectancy represents the number of years of life lived in good health that could be expected,[4] based on the average experience in a population if current patterns of mortality and health states persisted.[3,7,8]

Several Canadian studies have estimated health expectancy using various measures of health status (such as health utility indices, prevalence of disability, incidence of disease) and data sources.[3,9-15] The most recent study found that, in general, the health expectancy of the population living in private households was relatively stable from 1994 to 2010, and that absolute gains in health expectancy were due mainly to a decrease in mortality with little change in morbidity.[14] However, a limitation of this and many other studies is exclusion of the institutional population, who are more likely to be in ill health; excluding them may create an overly optimistic picture of population health.[16]

This study calculates health-adjusted life expectancy (HALE) for the combined household and institutional population every four years from 1994/1995 to 2015. Trends over time in health status, life expectancy, and HALE are examined. Health status is estimated using the Health Utilities Index Mark 3 (HUI3) instrument,[17] which has been used for previous estimates of HALE in Canada.[10,12-15] The study also discusses how HALE has changed relative to life expectancy. To better understand how specific aspects of health status contribute to differences between HALE and life expectancy, attribute-deleted HALE is estimated and assessed over time.

Methods

Data sources

National Population Health Survey and Canadian Community Health Survey

Estimates for the HUI3 are derived from responses to the 1994/1995 and 1998/1999 National Population Health Survey (NPHS), and the 2001, 2005, 2009/2010 and 2015 Canadian Community Health Survey (CCHS). Information about the NPHS and the CCHS is available at www.statcan.gc.ca, and is summarized briefly here.

The target population of the NPHS Household component was residents of private households in the ten provinces, excluding residents of Indian Reserves, Crown Lands, some remote areas in Ontario and Quebec and health institutions, and full-time members of the Canadian Forces. The selected household/selected person response rates for the 1994/1995 and 1998/1999 NPHS were 88.7%/96.1% and 87.6%/98.5%, respectively. The target population of the 1994/1995 NPHS Institution component consisted of residents of health institutions (long-term, at least four beds, and residents not autonomous) sampled in five geographic regions (Atlantic Provinces, Quebec, Ontario, Prairie Provinces, and British Columbia) from three types of institution: institutions for the aged; cognitive institutions; and other rehabilitative institutions. The selected institution/selected resident response rates in 1994/1995 were 95.5%/93.6%.

The CCHS covers the population aged 12 or older in the ten provinces and three territories. Residents of Indian Reserves, Crown lands, certain remote regions and institutions and full-time members of the Canadian Forces are excluded; together these exclusions represent less than 3% of the target population. The combined household/selected person response rates for the 2001, 2005, 2009/2010, and 2015 CCHS were: 84.7%; 78.9%; 72.3% and 57.5%.

Authors: Tracey Bushnik (tracey.bushnik@canada.ca) and Michael Tjepkema are with the Health Analysis Division and Laurent Martel is with the Demography Division at Statistics Canada, Ottawa, Ontario.

This study uses data from respondents with a valid HUI3. In general, the household non-response rate for HUI3 was less than 1% in any survey year, resulting in the following sample sizes for this analysis: 15,989 (1994/1995); 16,408 (1998/1999); 129,834 (2001); 30,809 (2005); 121,606 (2009/2010) and 49,747 (2015 - excludes the territories). As well, 2,283 out of 2,287 institutional respondents had a valid HUI3 in 1994/1995, 713 of which had been imputed.

What is already known on this subject?

- Life expectancy has increased substantially in Canada over the past century
- Life expectancy describes quantity of life, whereas health-adjusted life expectancy (HALE) describes quality of life
- As of 2010, there has been little evidence of a faster increase in HALE than in life expectancy among the household population.

What does this study add?

- Between 1994/1995 and 2015, HALE increased in Canada.
- The gap between males and females in life expectancy and in HALE narrowed because of greater gains by males.
- Males spent a larger share of their years of life in good functional health, compared with females.
- The percentage of years in good functional health was relatively unchanged over time for males, with a marginal improvement for females aged 65 or older.
- The importance of sensory problems declined, while mobility problems and pain accounted for an increased share of the burden of ill health.
- Excluding the institutional population significantly increased estimates of HALE, resulting in higher ratios of HALE to life expectancy, particularly for people aged 65 or older.

Census of Population

The Census of Population enumerates the entire population, which consists of Canadian citizens (by birth and by naturalization), landed immigrants and non-permanent residents and their families living with them in Canada (detailed information is available at www12.statcan.gc.ca/census-recensement/2016/ref/index-eng.cfm). The census collected information on dwelling type (private or collective); type of collective dwelling was used to estimate the percentage of the population living in health-related institutions in 1996, 2001, 2006, 2011, and 2016.

Life tables

Life tables use provincial and territorial mortality data from the Vital Statistics–Death Database and population estimates to calculate life expectancy at birth and at different ages, death probabilities, probabilities of survival between two ages, years of life lived, and the number of survivors at different ages.[18] Life expectancy and HALE were estimated for each survey year using complete (by single-year-of-age) life table data for males and females for 1993-to-1995, 1997-to-1999, 2000-to-2002, 2004-to-2006, 2009-to-2011, and 2013-to-2015.[2]

Measures

Health Utilities Index Mark 3 (HUI3)

The Health Utilities Index Mark 3 (HUI3) measures eight attributes of self-reported health status: vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain.[17] A respondent's attribute levels—from normal to highly impaired—are summarized by a weighted scoring function into a single value representing their overall health state. The value can range from -0.36 (state worse than death; death represented by 0) to 1.00 (best possible health state).

Institutional population

For this study, the institutional population was defined as individuals living in the following types of health-related collective dwellings on census day: general and specialty hospitals (including chronic care, short- or long-term care); nursing homes; residences for senior citizens; group homes or institutions for the physically handicapped and treatment centres; and group homes and institutions or residential care facilities for people with psychiatric disorders or developmental disabilities. Individuals not living in such dwellings were considered to be in the household population.

Statistical analysis

Health-adjusted life expectancy (HALE)

To estimate HALE, mean HUI3 scores by sex and age group were tabulated for the household population in each survey year and the institutional population in 1994/1995. Age groups were: 0 to 11 (for the household population in 1994/1995 and 1998/1999, the mean value for 4- to 11-year-olds was assigned to the entire 0-to-11 age group, and the mean value from 1998/1999 was carried forward to all subsequent years), 12 to 14 (HUI3 is available in the CCHS starting at age 12), 15 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, 75 to 84, and 85 or older. Survey weights were applied so that the mean HUI3 estimates were representative of the health status of the underlying target populations by sex and age group, and bootstrap weights were applied so that the standard errors were estimated taking into account each survey's complex design.[19]

The percentages of people living in private households and in health-related institutions were estimated by sex and age group using census data. Mean HUI3 scores (by sex and age group) for the household population (*HUI3 household*) in each survey year were multiplied by the percentage in households by sex and age group estimated from each census year as follows (survey year**census year*): 1994/1995**1996*; 1998/1999**1996*; 2001**2001*; 2005**2006*; 2009/2010**2011*

and 2015**2016*. For the institutional population, the mean HUI3 scores (by sex and age group) in 1994/1995 (*HUI3 institution*) were carried forward to all subsequent survey years, multiplied by the percentage by sex and age group in health-related institutions estimated from each census year as shown above. The resulting two values—*HUI3 household* and *HUI3 institution*—were summed to provide *overall* HUI3 scores by sex and age group for each survey year. The variance of the *overall* HUI3 score by sex and age group was estimated from the sum of the variance of *HUI3 household* multiplied by the square of the percentage in households and the variance of *HUI3 institution* multiplied by the square of the percentage in institutions.

HALE was estimated for each survey year using a modified version of the Sullivan method.[20] The life expectancy information from each three-year set of complete life tables by sex was weighted by the number of life-years lived at a particular age x using the mean HUI3 for that age. The sum of the adjusted life-years beyond age x was then divided by the number of survivors at that age to yield HALE by age and sex.[6] The variance of HALE was estimated using the method proposed by Mathers,[21] which takes stochastic fluctuations in the observed death probabilities and the mean global HUI3 scores into account.

Attribute-deleted HALE

Attribute-deleted HALE for the household and institutional populations was estimated for 1994/1995 and 2015 to determine how much of the difference between HALE and life expectancy was ascribed to each HUI attribute. To produce attribute-deleted HALE, the overall HUI3 score was recalculated for the household and institutional populations separately six times, each time assigning a perfect score (1.0) to one attribute but leaving the others at their actual levels. Vision, hearing, and speech were combined into "sensory."

There were no missing values for the household population in 1994/1995 or 2015, but for the 1994/1995 institutional population, missing values for each attribute—vision (n = 271), hearing (n = 117), speech (n = 60), ambulation (n = 20), dexterity (n = 50), emotion (n = 185), cognition (n = 95), and pain (n = 137)—were assigned the average score by sex and age group from those with complete data for that attribute. The HUI3 estimates for the institutional population in 1994/1995 were carried forward to 2015.

The attribute-deleted HUI3 estimates for the household and institutional populations in each survey year were summed to provide an overall attribute-deleted HUI3 score by sex and age group in 1994/1995 and 2015.

Sensitivity analyses

The estimates of HUI3 for the institutional population that were used to calculate HALE in 2015 were adjusted to reflect three scenarios: 0.03 added to each institutional respondent's HUI3 score from 1994/1995; 0.03 subtracted from each HUI3 score; and the score replaced by HUI3 values derived from the 2012 interRAI assessments of the nursing home population in Ontario.[22] The amount 0.03 was selected because it is the smallest difference in HUI3 that reflects a meaningful change.[23] Adjusted mean values of HUI3 (up, down, and replaced) were estimated by sex and age group, and then multiplied by the percentage of the population living in institutions in 2016 and combined with the HUI3 values for the CCHS household population in 2015 for an overall HUI3 estimate. HALE in 2015 was then recalculated. A second sensitivity analysis excluded the HUI3 estimates for the institutional population from the HALE estimated at each period, thereby limiting the results to the household population.

Results

Health status of household and institutional populations

In 2015, the average HUI3 of men and women in the household population who were younger than 65 was similar to that in 1994/1995 (Table 1). For those aged 65 or older, the average HUI3 in 2015 was higher than in 1994/1995.

Owing to the increased likelihood of institutionalization with advancing age, estimates for household residents are less representative of the older population. In

Table 1
Mean HUI3 scores, by sex and age group, household and institutional population, Canada, 1994/1995, 1998/1999, 2001, 2005, 2009/2010 and 2015

	Household population												Institutional population	
Sex/Age group	1994/1995		1998/1999		2001		2005		2009/2010		2015		1994/1995	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Males														
15 to 24	0.889	0.007	0.940	0.005	0.915	0.002	0.897	0.005	0.913	0.002	0.892	0.006	0.556	0.192
25 to 34	0.900	0.006	0.943	0.004	0.919	0.003	0.915	0.004	0.916	0.003	0.902	0.004	0.193	0.060
35 to 44	0.897	0.006	0.922	0.006	0.903	0.002	0.900	0.006	0.904	0.003	0.898	0.004	0.331	0.050
45 to 54	0.872	0.007	0.894	0.006	0.879	0.003	0.883	0.007	0.882	0.003	0.873	0.004	0.308	0.081
55 to 64	0.847	0.010	0.873	0.008	0.858	0.004	0.861	0.007	0.865	0.004	0.852	0.006	0.345	0.072
65 to 74	0.816	0.010	0.806	0.011	0.832	0.004	0.856	0.007	0.850	0.003	0.849	0.006	0.219	0.038
75 to 84	0.753	0.019	0.740	0.023	0.753	0.008	0.771	0.013	0.788	0.006	0.782	0.010	0.146	0.024
85 or older	0.592	0.053	0.644	0.056	0.591	0.019	0.619	0.042	0.627	0.024	0.614	0.033	0.170	0.030
Females														
15 to 24	0.882	0.007	0.933	0.004	0.907	0.002	0.895	0.005	0.906	0.003	0.872	0.005	0.584	0.181
25 to 34	0.895	0.006	0.912	0.009	0.908	0.002	0.904	0.005	0.918	0.002	0.900	0.004	0.138	0.070
35 to 44	0.889	0.006	0.910	0.005	0.888	0.002	0.898	0.005	0.898	0.003	0.878	0.005	0.155	0.065
45 to 54	0.839	0.009	0.875	0.009	0.862	0.003	0.874	0.005	0.863	0.004	0.850	0.007	0.305	0.079
55 to 64	0.828	0.009	0.849	0.009	0.845	0.003	0.850	0.006	0.849	0.003	0.836	0.006	0.265	0.070
65 to 74	0.787	0.014	0.823	0.009	0.826	0.004	0.836	0.007	0.832	0.003	0.825	0.006	0.196	0.038
75 to 84	0.708	0.016	0.727	0.016	0.729	0.006	0.758	0.012	0.762	0.006	0.762	0.009	0.157	0.025
85 or older	0.571	0.036	0.572	0.033	0.588	0.014	0.584	0.028	0.629	0.012	0.620	0.019	0.097	0.016

HUI3 = Health Utility Index Mark 3
SE = standard error
Sources: 1994/1995 and 1998/1999 National Population Health Survey; 2001, 2005, 2009/2010 and 2015 Canadian Community Health Survey.

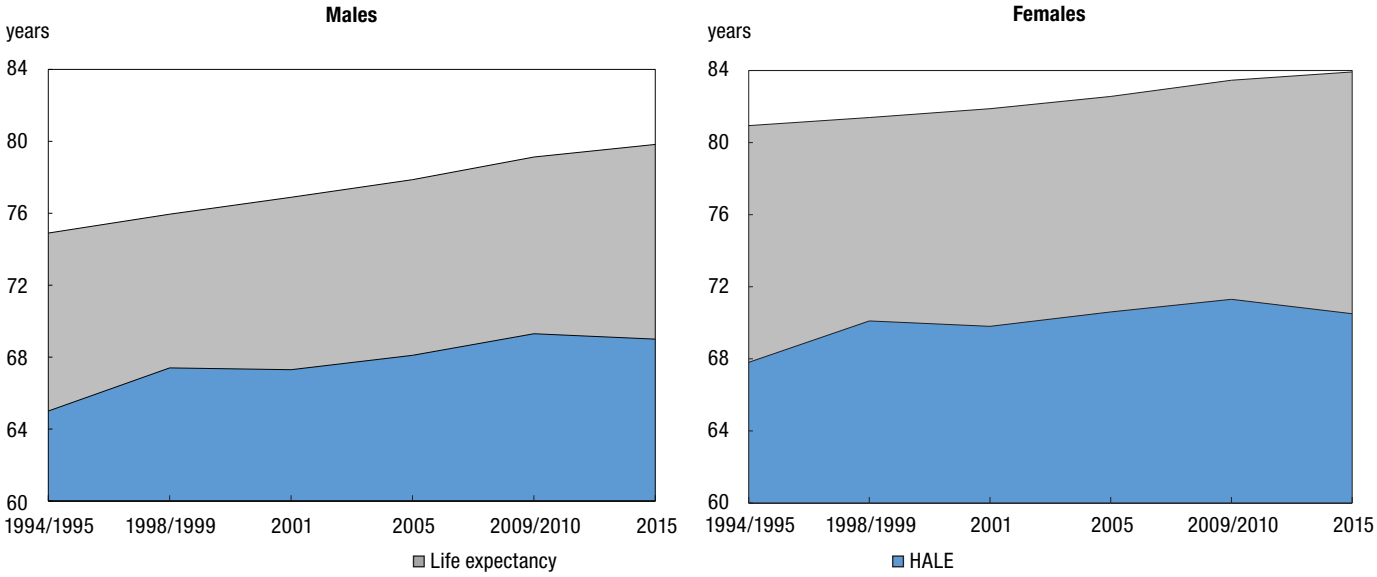
2016, 5.7% of men and 9.1% of women aged 75 to 84, and 23.1% of men and 35.6% of women aged 85 or older lived in health-related institutions.

According to the 1994/1995 NPHS, the average HUI3 of the institutional population was substantially lower than that of the household population (Table 1). For men aged 75 to 84, average HUI3 was .146 for the institutional population versus .753 for the household population; for men aged 85 or older, the figures were .170 versus .592. Similar differences were observed for women in these age groups: .157 versus .708, and .097 versus .571.

Life expectancy and HALE

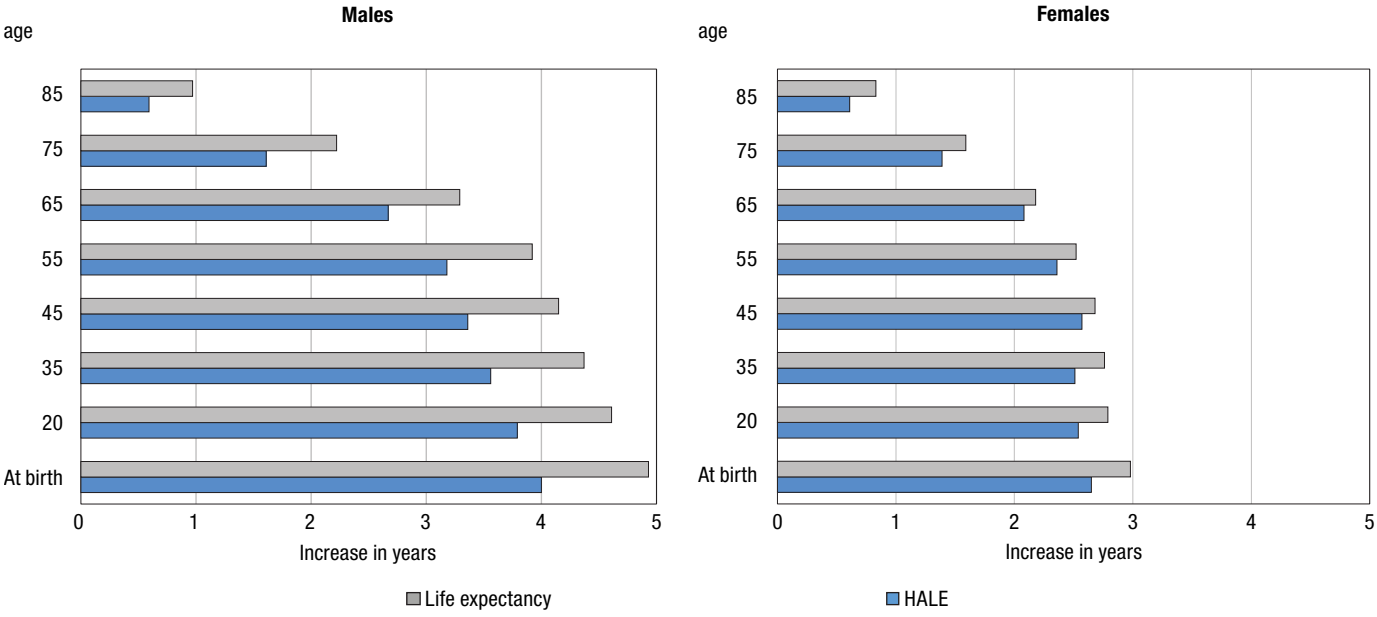
Between 1994/1995 and 2015, life expectancy and HALE increased among both sexes and at all ages (Appendix Table A). Male life expectancy at birth rose from 74.9 to 79.8 years, and HALE, from 65.0 to 69.0 years (Figure 1). Females' life expectancy at birth

Figure 1
Life expectancy and health-adjusted life expectancy (HALE) at birth, by sex, household and institutional populations combined, Canada, 1994/1995, 1998/1999, 2001, 2005, 2009/2010 and 2015



Sources: 1994/1995 and 1998/1999 National Population Health Survey; 2001, 2005, 2009/2010 and 2015 Canadian Community Health Survey; 1996, 2001, 2006, 2011 and 2016 Census of Population; life tables for 1993-to-1995, 1997-to-1999, 2000-to-2002, 2004-to-2006, 2009-to-2011 and 2013-to-2015.

Figure 2
Increase in life expectancy and health-adjusted life expectancy (HALE) between 1994/1995 and 2015 at selected ages, by sex, household and institutional populations combined, Canada



Sources: 1994/1995 National Population Health Survey; 2015 Canadian Community Health Survey; 1996 and 2016 Census of Population; life tables for 1993-to-1995 and 2013-to-2015.

increased from 80.9 to 83.9 years, and HALE, from 67.8 to 70.5 years.

Among males, the absolute increase was greater for life expectancy than for HALE (Figure 2). For example, during the past 20 years, at age 65, men gained 3.3 years of life expectancy and 2.7 years of HALE. By contrast, among females, the absolute increase in life expectancy and HALE was similar but lower than for males. Consequently, the gap between males and females in years of life expectancy and HALE has narrowed over time.

HALE relative to life expectancy

The ratio of HALE to life expectancy—the percentage of years spent in good functional health—changed marginally between 1994/1995 and 2015 (Figure 3). Change among males was negligible at all ages, whereas among females, a modest gain was apparent at age 65 or older. Nevertheless, at all ages and at all time points, a smaller share of females' remaining years was spent in good health compared with males. For example, in 1994/1995 and in 2015, at age 20, females could expect to spend 81% of their remaining years in good health; the percentage for males was 85%.

Attribute-deleted HALE

The HUI3 is comprised of six health attributes: sensory, mobility, dexterity, emotion, cognition, and pain. The relative importance of each in explaining the difference between HALE and life expectancy (years of ill health) varied by age and sex, and over time. At age 20, for both sexes, pain was a greater source of diminished health in 2015 than it had been in 1994/1995 (Table 2). The relative importance of mobility also increased slightly, while that of sensory problems declined.

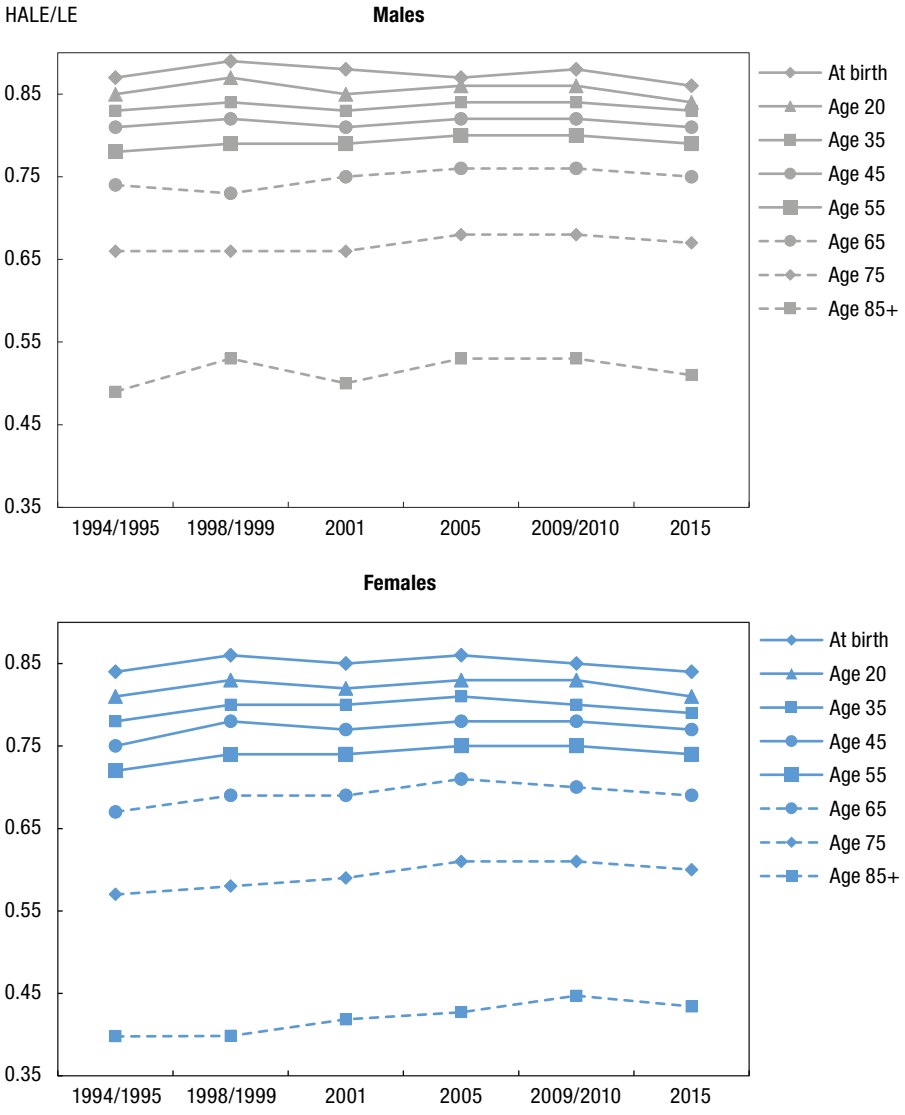
At age 65, mobility became a more important source of diminished health for males; mobility and pain became more important for females (Table 2). Sensory problems declined in relative importance for seniors of both sexes.

When estimates of attribute-deleted HALE were restricted to the household population, in both periods (1994/1995 and 2015), the percentage of years in ill health due to pain was higher at both ages (at age 20 and at age 65), while the percentage assigned to the combined effect of multiple attributes (the residual) was lower (results not shown).

Sensitivity analyses

Recalculating HALE in 2015 by assuming a 0.03 increase or a 0.03 decrease in individual HUI3 for the institutional population from 1994/1995, or by using the HUI3 based on the 2012 interRAI assessments, had little effect on HALE, even at the oldest ages (results not shown). Recalculating HALE excluding the institutional population, however, resulted in increased values, particularly among females (results not shown). It also yielded higher ratios of HALE to life expectancy for both sexes (Figure 4). The exclusion had little effect on ratios at birth or at age 20, but at older ages, it resulted in a larger share of remaining years in good functional health.

Figure 3
Ratio of health-adjusted life expectancy (HALE) to life expectancy (LE) at selected ages, by sex, household and institutional populations combined, Canada, 1994/1995, 1998/1999, 2001, 2005, 2009/2010 and 2015



Sources: 1994/1995 and 1998/1999 National Population Health Survey; 2001, 2005, 2009/2010 and 2015 Canadian Community Health Survey; 1996, 2001, 2006, 2011 and 2016 Census of Population; life tables for 1993-to-1995, 1997-to-1999, 2000-to-2002, 2004-to-2006, 2009-to-2011 and 2013-to-2015.

Table 2
Difference (years) between life expectancy and health-adjusted life expectancy at ages 20 and 65, by sex and HUI3 attribute, household and institutional population combined, Canada, 1994/1995 and 2015

Attribute and sex	Age 20				Attribute and sex	Age 65			
	1994/1995		2015			1994/1995		2015	
	Years	%	Years	%		Years	%	Years	%
Males					**Males**				
Overall†	8.6	100.0	9.4	100.0	Overall†	4.1	100.0	4.7	100.0
Cognition	2.3	26.7	2.4	25.5	Sensory	1.0	24.4	1.0	21.3
Pain	1.8	20.9	2.2	23.4	Pain	0.8	19.5	0.9	19.1
Sensory	1.7	19.8	1.5	16.0	Cognition	0.8	19.5	0.9	19.1
Emotion	1.2	14.0	1.1	11.7	Mobility	0.4	9.8	0.6	12.8
Mobility	0.5	5.8	0.7	7.4	Emotion	0.3	7.3	0.3	6.4
Dexterity	0.1	1.2	0.1	1.1	Dexterity	0.1	2.4	0.1	2.1
Residual‡	*1.0*	*11.6*	*1.4*	*14.9*	*Residual‡*	*0.7*	*17.1*	*0.9*	*19.1*
Females					**Females**				
Overall†	11.9	100.0	12.1	100.0	Overall†	6.6	100.0	6.7	100.0
Cognition	2.7	22.7	2.8	23.1	Sensory	1.4	21.2	1.0	14.9
Pain	2.6	21.8	3.2	26.4	Pain	1.2	18.2	1.4	20.9
Sensory	2.2	18.5	1.7	14.0	Cognition	1.2	18.2	1.1	16.4
Emotion	1.3	10.9	1.1	9.1	Mobility	0.8	12.1	1.1	16.4
Mobility	0.9	7.6	1.2	9.9	Emotion	0.4	6.1	0.4	6.0
Dexterity	0.2	1.7	0.1	0.8	Dexterity	0.1	1.5	0.1	1.5
Residual‡	*1.9*	*16.8*	*2.0*	*16.5*	*Residual‡*	*1.5*	*22.7*	*1.6*	*23.9*

† sum of differences assigned to each attribute, plus residual

‡ contribution of combined effects of multiple attributes

HUI3 = Health Utilities Index Mark 3

Note: Percentages may not add up to 100 due to rounding.

Sources: 1994/1995 National Population Health Survey and 2015 Canadian Community Health Survey; 1996 and 2016 Census of population; life tables for 1993-to-1995 and 2013-to-2015.

Discussion

Over the past 20 years, life expectancy and HALE increased in Canada, and the gap between the sexes narrowed because of greater gains by males. In 2015, HALE at birth was 69.0 years for males and 70.5 years for females, increases of 4.0 and 2.7 years, respectively, since 1994/1995. Throughout the period, the ratio of HALE to life expectancy—the share of years in good functional health—was higher for males than for females. However, there was little change in this ratio over time for males, but a marginal improvement among women aged 65 or older. The importance of sensory problems as a source of diminished health declined for both sexes, while mobility and pain, the latter among females, accounted for a higher percentage of the burden of ill health.

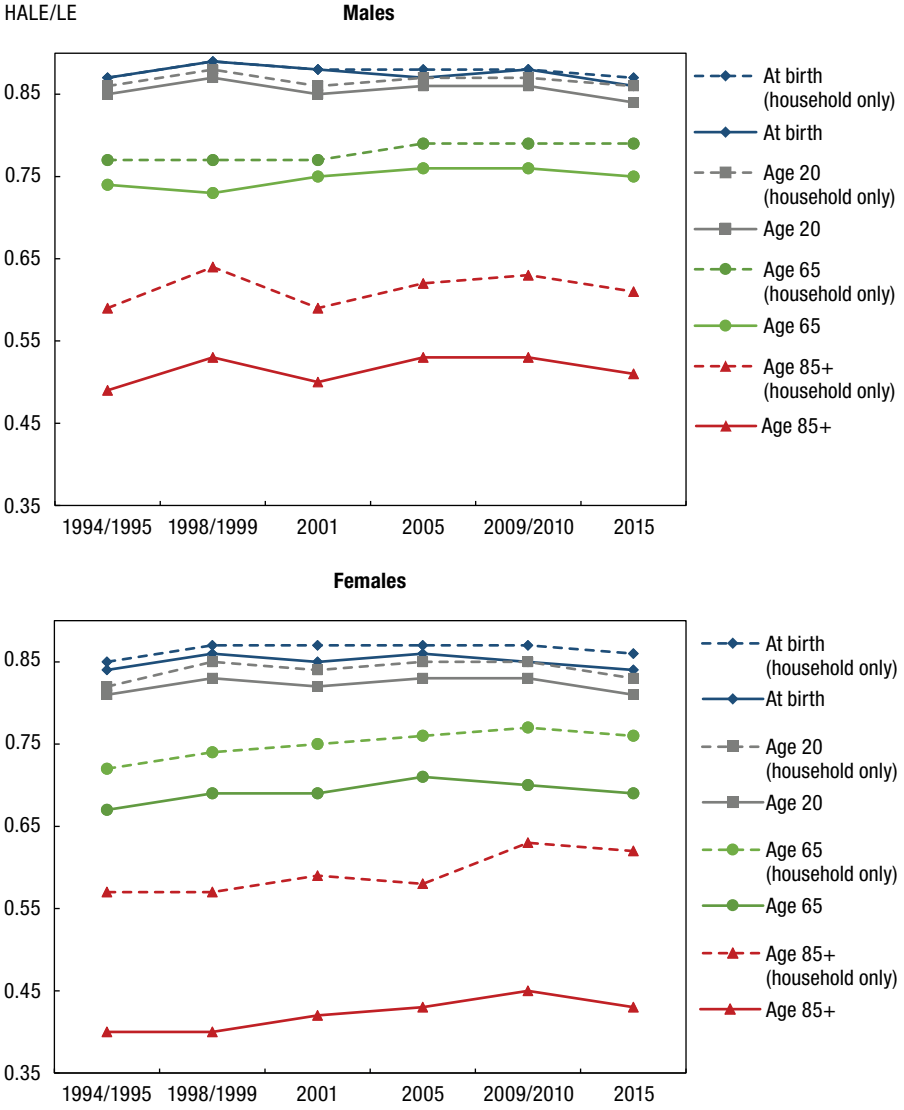
The well-documented increase in life expectancy in Canada is due in large part to a decline in late-life mortality since the 1950s.[24,25] That HALE also increased has been reported in Canada and elsewhere,[14,26,27] although how much of the improvement that can be attributed to reductions in morbidity versus mortality depends on the health expectancy indicator. A study based on the HUI3 reported that gains in HALE came primarily through improvements in mortality,[14] whereas studies using other measures found that declines in symptoms and impairments[27] or in disability prevalence[26] accounted for some of the improvement.

The present study found differences in life expectancy and HALE between males and females. Narrowing of the life expectancy gap between the sexes has been attributed to factors that include a reduction in violent deaths among male teenagers and young adults, better treatment for cardiovascular diseases, and increasing similarity in women's and men's behaviour, notably, smoking, drinking, and work-related stress.[1] That males spend a greater share of their lives in good functional health compared with females has been reported in many countries.[26,28-30] Women may live longer with illness because their health problems are less lethal, whereas men may be more likely to suffer from conditions that lead to earlier death.[29]

The present study measured health expectancy using the Health Utilities Index Mark 3 (HUI3) instrument, which assigns an overall score to a respondent's self-reported level of impairment associated with sensory (vision, hearing, and speech), ambulation, dexterity, emotion, cognition, and pain. Over time, sensory problems accounted for a smaller share of the burden of ill health for both sexes, while mobility problems increased in relative importance. A decline in the prevalence of sensory problems has also been reported in the United States,[31] as has an increase in mobility disability.[32] The present study found that pain accounted for a greater share of ill health among females, whereas Stewart et al.[27] reported a decrease in pain prevalence between 1987 and 2008. This difference might reflect how pain was defined. The Stewart study pertained to pain that interfered with normal work, but pain in the present study prevented activities in general.

If morbidity is compressed into a shorter period before death, the impact is less severe than if longer life involved many years of costly care and treatment of illness and disability.[31] The present study found that the ratio of HALE to life expectancy remained relatively stable for people younger than 65, which suggests neither compression nor expansion of morbidity relative to life expectancy. For females aged 65 or older, the ratio increased marginally, as their self-reported health status improved slightly over time. Cutler et al. reported an improvement in the ratio of disability-free life expectancy to life expectancy between 1991 and 2009 for men and women aged 65 or older in the U.S., with greater improvements among women.[31] Findings from other studies are mixed. Although it has been suggested that more populations worldwide are spending more time with functional health loss,[5] Freedman et al. reported improvements between 1982 and 2011 in the percentage of years expected to be lived without a disability for males in the United States and little change for females.[26] By contrast, in Canada, Steensma et al. found little change for either sex in the percentage of life spent in an unhealthy state

Figure 4
Ratio of health-adjusted life expectancy (HALE) to life expectancy (LE) at selected ages, with and without institutional population, by sex, Canada, 1994/1995, 1998/1999, 2001, 2005, 2009/2010 and 2015



Sources: 1994/1995 and 1998/1999 National Population Health Survey; 2001, 2005, 2009/2010 and 2015 Canadian Community Health Survey; 1996, 2001, 2006, 2011 and 2016 Census of Population; life tables for 1993-to-1995, 1997-to-1999, 2000-to-2002, 2004-to-2006, 2009-to-2011 and 2013-to-2015.

between 1994 and 2010.[14] Data from the Canadian Chronic Disease Surveillance System, on the other hand, suggest that from 2000 to 2011, a growing percentage of people were living with diseases including ischemic heart disease, chronic obstructive pulmonary disorder, and diabetes, all of which decreased in incidence among those 50 or older, but increased in prevalence.[33] These seemingly contradictory findings point to the difficulty of drawing definitive conclusions from studies with different data sources, target populations, reference periods, and indicators of health expectancy.[34]

Strengths and limitations

This study has many strengths. HUI3 is a continuous scale, which makes it less sensitive to measurement error than dichotomous estimates of health status such as prevalence of disability. Data were available over a 20-year period. HALE was estimated not only for the household population, but also incorporated the health status and the percentage of people in health-related institutions, thereby providing a more complete picture of health expectancy. Without the institutional population, HALE would have been significantly higher, particularly at age 65 or older.

At the same time, the lack of recent estimates of the health status of the institutional population is a limitation and a major data gap. Although this population is included in administrative databases that collect information about diseases and chronic conditions, national information about their health-related quality of life is not regularly collected. Life expectancy and HALE for the year 2015 were based on life table data for the 2013-to-2015 period, which was the most recent available. Variations in the collection modes of the NPHS and the CCHS, and declining CCHS response rates could affect health-related estimates over time.[35,36] Although applying the survey weights ensured that the sample was representative of the target population, bias might exist if non-respondents differed systematically from respondents.

Conclusion

Life expectancy and HALE have increased over time in Canada. The gap between males and females has narrowed because of greater gains by males during the past 20 years. The ratio of HALE to life expectancy has remained stable, which suggests neither a reduction nor improvement in overall functional health relative to life expectancy. Mobility problems and pain, the latter mainly among females, now account for a greater percentage of the burden of ill health. Future years of data for both the household and institutional populations are necessary to provide further insight into the components of and trends in health expectancy.

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Appendix

Table A
Life expectancy (LE) and health-adjusted life expectancy (HALE) at selected ages, by sex, Canada, 1994/1995, 1998/1999, 2001, 2005, 2009/2010 and 2015

		1994/1995		1998/1999		2001		2005		2009/2010		2015	
		Years	SE	Years	SE	Years	SE	Years	SE	Years	SE	Years	SE
Males													
At birth	**LE**	74.9	0.02	76.0	0.02	76.9	0.02	77.9	0.02	79.1	0.02	79.8	0.02
	HALE	65.0	0.07	67.4	0.07	67.3	0.04	68.1	0.06	69.3	0.04	69.0	0.06
Age 20	**LE**	55.9	0.02	56.8	0.02	57.7	0.02	58.7	0.02	59.8	0.02	60.5	0.02
	HALE	47.3	0.06	49.3	0.06	49.3	0.03	50.2	0.05	51.3	0.03	51.1	0.05
Age 35	**LE**	41.7	0.02	42.5	0.02	43.4	0.02	44.3	0.02	45.5	0.02	46.1	0.02
	HALE	34.6	0.06	35.8	0.06	36.1	0.03	37.2	0.05	38.1	0.03	38.2	0.04
Age 45	**LE**	32.5	0.02	33.2	0.02	33.9	0.02	34.9	0.02	36.0	0.02	36.6	0.02
	HALE	26.3	0.06	27.2	0.06	27.6	0.03	28.7	0.05	29.5	0.03	29.6	0.04
Age 55	**LE**	23.6	0.02	24.2	0.02	25.0	0.02	25.9	0.02	26.9	0.02	27.6	0.02
	HALE	18.5	0.05	19.1	0.06	19.7	0.03	20.7	0.05	21.5	0.03	21.7	0.04
Age 65	**LE**	15.9	0.02	16.3	0.02	17.0	0.02	17.7	0.02	18.6	0.02	19.2	0.02
	HALE	11.8	0.05	12.0	0.06	12.6	0.02	13.5	0.04	14.2	0.03	14.4	0.04
Age 75	**LE**	9.7	0.02	9.9	0.02	10.3	0.02	10.8	0.02	11.5	0.02	12.0	0.02
	HALE	6.4	0.05	6.5	0.06	6.8	0.02	7.3	0.05	7.9	0.03	8.0	0.04
Age 85 or older	**LE**	5.4	0.02	5.3	0.02	5.5	0.02	5.7	0.02	6.1	0.02	6.4	0.02
	HALE	2.7	0.07	2.8	0.08	2.7	0.03	3.0	0.06	3.2	0.04	3.3	0.05
Females													
At birth	**LE**	80.9	0.02	81.4	0.02	81.9	0.02	82.6	0.02	83.5	0.02	83.9	0.02
	HALE	67.8	0.08	70.1	0.07	69.8	0.03	70.6	0.06	71.3	0.04	70.5	0.05
Age 20	**LE**	61.7	0.02	62.1	0.02	62.5	0.02	63.2	0.02	64.0	0.02	64.5	0.02
	HALE	49.8	0.07	51.6	0.07	51.5	0.03	52.3	0.05	53.0	0.03	52.3	0.05
Age 35	**LE**	47.0	0.02	47.4	0.02	47.8	0.02	48.5	0.02	49.3	0.02	49.8	0.02
	HALE	36.7	0.07	38.1	0.06	38.1	0.03	39.1	0.05	39.5	0.03	39.2	0.04
Age 45	**LE**	37.5	0.02	37.8	0.02	38.2	0.02	38.9	0.02	39.7	0.02	40.1	0.02
	HALE	28.2	0.07	29.3	0.06	29.6	0.03	30.4	0.05	30.8	0.03	30.7	0.04
Age 55	**LE**	28.3	0.02	28.6	0.02	29.0	0.02	29.6	0.02	30.4	0.02	30.8	0.02
	HALE	20.4	0.06	21.2	0.05	21.5	0.03	22.2	0.04	22.7	0.03	22.7	0.04
Age 65	**LE**	19.8	0.02	20.0	0.02	20.3	0.02	20.9	0.02	21.6	0.02	22.0	0.02
	HALE	13.2	0.06	13.8	0.05	14.1	0.02	14.7	0.04	15.2	0.02	15.3	0.03
Age 75	**LE**	12.5	0.02	12.5	0.02	12.7	0.02	13.2	0.02	13.8	0.02	14.1	0.01
	HALE	7.1	0.05	7.3	0.05	7.5	0.02	8.0	0.04	8.4	0.02	8.5	0.03
Age 85 or older	**LE**	6.8	0.02	6.7	0.02	6.8	0.01	7.0	0.01	7.4	0.01	7.6	0.01
	HALE	2.7	0.05	2.7	0.04	2.8	0.02	3.0	0.04	3.3	0.02	3.3	0.03

SE = standard error

Sources: 1994/1995 and 1998/1999 National Population Health Survey; 2001, 2005, 2009/2010 and 2015 Canadian Community Health Survey; 1996, 2001, 2006, 2011 and 2016 Census of Population; life tables for 1993-to-1995, 1997-to-1999, 2000-to-2002, 2004-to-2006, 2009-to-2011 and 2013-to-2015.