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Socioeconomic disparities in life and health expectancy among the household population in Canada

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Abstract

Background: Life expectancy (LE) and health expectancy have increased throughout much of the world. However, these gains have not been shared equally across all population groups. Socioeconomic disparities exist, though varied methodologies and data sources have made it difficult to ascertain changes over time in Canada.

Methods: The 1996 and 2011 Canadian Census Health and Environment Cohorts, with a five-year mortality follow-up, were used to estimate the LE of the household population at ages 25 and 65, according to individual-level education and income. Health status was measured by the Health Utilities Index Mark 3 instrument in two national population health surveys and was used to adjust LE to estimate health-adjusted life expectancy (HALE). Disparities in LE and HALE, and differences between cohorts, were examined.

Results: LE, HALE and the ratio of HALE to LE were greater at higher levels of education or income. A stepwise gradient was also observed by level of education within and across income quintiles, with people in the lowest combined education and income categories at the greatest disadvantage. Disparities were wider in the 2011 cohort compared with the 1996 cohort, but not necessarily to the same extent for both sexes or at different ages.

Interpretation: In Canada, education-related and income-related disparities in life and health expectancy persist and may be wider than they were in the past. This underscores the importance of ongoing data development for routine monitoring of trends in mortality and morbidity, which can, in turn, inform policy development and planning to advance health equity.

Keywords: health equity, health disparities, life expectancy, health expectancy, Health Utilities Index, income, education

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Life expectancy (LE) and health expectancy have increased throughout much of the world,¹ including Canada.^{2,3} However, these gains in years lived and years lived in good health are not distributed equally across all population groups. Disparities exist, particularly according to socioeconomic position. Understanding the magnitude, distribution and shift over time in these disparities is increasingly relevant for policy development and planning to advance health equity.^{1,4}

It has been reported in many countries—including the United States, Norway, Denmark and Belgium—that people with less education or lower income are disadvantaged in terms of life and health expectancies, and that this disadvantage has persisted or increased over time.⁵⁻⁹ Past and current findings suggest that such disparities also exist in Canada.^{4,10,11} However, differences in methodologies and data sources have made it difficult to ascertain how, if at all, these disparities have changed with time.

This study uses the 1996 and 2011 Canadian Census Health and Environment Cohorts (CanCHECs), with a five-year mortality follow-up, to estimate the LE of the household population. It also incorporates information from two national health surveys to estimate health-adjusted life expectancy (HALE).

The objectives of this study are to examine LE, HALE and disparities in LE and HALE in the 1996 and 2011 cohorts at ages 25 and 65 for men and women, according to highest level of educational attainment and household income quintile; to examine these disparities according to the combination of education and income in the 2011 cohort; and to examine how education- and income-related disparities in LE and HALE changed over time.

Methods

Data sources

1996 and 2011 CanCHECs

The 1996 and 2011 CanCHECs are population-based linked datasets that follow the non-institutional population at the time of the census for different health outcomes such as mortality, cancer and hospitalizations.^{12,13} In brief, records from census years 1996 and 2011 were linked to mortality data using Statistics Canada's Social Data Linkage Environment (SDLE). The records from 1996 included mandatory long-form census respondents only,¹⁴ aged 19 or older, from about one in five non-institutional households including collectives. The records from 2011 included voluntary National Household Survey (NHS) respondents,¹⁵ from about one in three households in private dwellings, and no age restriction. The SDLE helps create linked population data files for social analysis through linkage to the Derived Record Depository (DRD), a dynamic relational database that contains only basic personal identifiers. For this analysis, records were included for individuals who were aged 25 or older on Census Day and who were living in private households. This resulted in an analytical sample of 3,203,700 in the 1996 cohort and 4,526,300 in the 2011 cohort (count rounded to the nearest 100).

Mortality

Mortality data were based on the Canadian Vital Statistics Death Database, which was linked to the DRD. The linkage rate of deaths to the DRD exceeded 99% for 1996 and 2011.

The National Population Health Survey and the Canadian Community Health Survey

Estimates for the Health Utilities Index Mark 3 (HUI3) are derived from responses to the 1994/1995 National Population Health Survey (NPHS) and the 2009 and 2010 Canadian Community Health Survey (CCHS). Information about both surveys is available at www.statcan.gc.ca. The target population of the NPHS household component was residents of private households in the provinces, excluding residents of Indian reserves, Canadian Armed Forces bases, and some remote areas in Ontario and Quebec. The selected household and selected person response rates were 88.7% and 96.1%, respectively. The target population of the CCHS was the household population aged 12 or older in the provinces and territories, with similar exclusions as the NPHS (representing less than 3% of the CCHS target population). The combined household and selected person response rate for the 2009/2010 CCHS was 72.3%.

This study uses data from respondents with a valid HUI3. In general, the non-response rate for HUI3 was less than 1% in either survey year, resulting in an analytical sample size of 15,989 from the NPHS and 121,606 from the CCHS.

Measures

Health Utilities Index Mark 3

HUI3 measures eight attributes of self-reported health status: vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain.¹⁶ A respondent's attribute levels—from normal to highly impaired—are summarized by a weighted scoring function into a single value that represents their overall health state. This value can range from -0.36 (state worse than death; death is represented by 0) to 1.00 (best possible health state).

Highest level of educational attainment

This was the highest certificate, diploma and degree of the individual collected by

the census and NHS and the NPHS and CCHS. It was grouped into four separate categories: less than secondary graduation (E1), secondary graduation or trades certificate (E2), postsecondary certificate or diploma excluding university degree (E3), and university degree or equivalent (E4). The proportion of men and women in each category is presented in Appendix Table A.

Income quintiles

Income was self-reported in the NPHS and CCHS, and in the 1996 Census. In the 2011 NHS, 73% of respondents gave permission for income information available from their tax data to be used.¹⁷ Weighted quintiles—Q1 (lowest), Q2, Q3, Q4 and Q5 (highest)—were derived from total annual household pre-tax income from all sources, adjusted for household size.¹⁸ In the NPHS and CCHS, these were tabulated within each census metropolitan area (CMA) or provincial residual. In the census and the NHS, the weighted quintiles were derived within each CMA, census agglomeration or provincial residual.

Statistical analysis

Life expectancy

The number of deaths by sex, age group and socioeconomic measure (education and income in 1996 and 2011, composite in 2011 only) during a five-year follow-up period were tabulated for each CanCHEC. The number of people who were alive during the follow-up periods (i.e., the at-risk population) by sex, age and socioeconomic measure was also tabulated. Person-years-at-risk were calculated based on census date and date of death or end of follow-up. Since most individuals who were alive during the follow-up period did not remain at the same age for an entire follow-up year, a year-at-risk was partitioned between two ages, and potentially two age groups. For example, someone who turned from age 49 to 50 exactly halfway through the follow-up year contributed 0.5 person-years-at-risk to the 45-to-49 age group, and 0.5 person-years-at-risk to

the 50-to-54 age group. A five-year follow-up period was chosen to ensure enough deaths to provide reliable estimates and to minimize mortality overlap in follow-up periods across the different CanCHEC years.

Life expectancy (LE) is the number of years a person at a given age would be expected to live if the mortality rates observed during a specific period persisted throughout their remaining life. For this study, abridged period life tables (based on five-year age groups starting at age 25 and ending at age 90 or older) were calculated according to the Chiang method,¹⁹ using deaths and person-years-at-risk from each CanCHEC for men and women according to education category and income quintile, with an additional table based on a composite measure of education and income by sex for the 2011 CanCHEC only. Because of data constraints, a table for the composite measure was not estimated for the 1996 CanCHEC. The cohort weight was applied to ensure that the LE estimates were representative of the target population (people aged 25 years or older in private households on Census Day), and the bootstrap replicate weights were used to estimate appropriate standard errors and 95% confidence intervals.²⁰

Health-adjusted life expectancy

To estimate HALE, mean HUI3 scores by sex and age group according to education category and income quintile were tabulated using the 1994/1995 NPHS and the 2009 and 2010 CCHS, and according to the composite measure of education and income using the 2009 and 2010 CCHS only. The age groups were 25 to 44, 45 to 54, 55 to 64, 65 to 79, and 80 or older. These age groups maximized sample size and were age groups within which mean HUI3 scores—assessed for the full population—remained relatively stable. Survey weights were applied so that the mean HUI3 estimates were representative of the health status of the underlying target populations, and bootstrap weights were applied so that the standard errors were estimated taking into account each survey's complex design.²⁰ Appendix

Table A presents estimates for age groups 25 to 44 and 65 to 79 by education and income categories. A difference of 0.03 or greater in mean HUI3 is considered clinically important.²¹

HALE was estimated for each cohort using a modified version of the Sullivan method.²² The life expectancy information from each set of CanCHEC-based abridged period life tables was weighted by the number of life-years lived at a particular age x using the mean HUI3 for that age, sex and socioeconomic measure. HALE was obtained by then dividing the sum of the adjusted life-years beyond age x by the number of survivors at that age.²³ The HALE variance was estimated using the method proposed by

Mathers,²⁴ which takes into account stochastic fluctuations in the observed death probabilities and the mean global HUI3 scores. The ratio of HALE to LE (HALE/LE) was multiplied by 100 and expressed as a percentage. The HALE/LE variance was estimated taking into account the variance of the mortality rates, using the Jagger et al.²⁵ approach (Appendix Equation 1).

Testing of equality

The equality of two estimates of LE, HALE or HALE/LE across groups (disparities) or over time (2011 versus 1996) was conservatively tested by the following Z-score²⁵ (Appendix Equation 2).

Results

Education and income

In the 2011 cohort, 17% of men and women had less than a secondary graduation (E1), compared with 23% and 24%, respectively, with a university degree (E4) (Appendix Table 1). In the 1996 cohort, 32% of men and 33% of women were at E1, compared with 16% and 13%, respectively, at E4. In both cohorts, a larger proportion of men were in the highest income quintile (Q5) than in the lowest income quintile (Q1). Among women, 21% were in Q1 and 19% were in Q5 in the 1996 cohort, while 20% were in both Q1 and Q5 in the 2011 cohort. In the 2011 cohort only, 5% of men and 6%

Table 1
Life expectancy (LE) and health-adjusted life expectancy (HALE) in years at ages 25 and 65 by education categories and income quintiles, by sex, household population, Canada, 2011 with five-year mortality follow-up

	LE ₂₅				HALE ₂₅				HALE ₂₅ /LE ₂₅			
	Men		Women		Men		Women		Men		Women	
	years	SE	years	SE	years	SE	years	SE	percent	SE	percent	SE
Education												
E1: less than secondary graduation	53.5	0.1	58.9	0.2	43.4	0.3	46.6	0.4	81.2	0.8	79.0	0.9
E2: secondary graduation or trades certificate	56.6	0.1	61.8	0.1	48.5	0.2	51.6	0.3	85.7	0.6	83.4	0.8
E3: postsecondary diploma excluding university degree	59.0	0.1	64.0	0.2	50.9	0.4	54.2	0.4	86.3	0.9	84.7	1.0
E4: university degree or equivalent	61.3	0.2	65.6	0.3	54.6	0.5	57.2	0.5	89.2	1.1	87.2	1.2
Disparity between E1 and E4	-7.8*	0.2	-6.7	0.4	-11.3	0.6	-10.6	0.6	-8.0	1.4	-8.1	1.5
Income												
Q1: 1st (lowest) income quintile	52.9	0.1	59.0	0.1	42.0	0.3	46.0	0.4	79.4	0.8	77.8	0.8
Q2: 2nd income quintile	55.9	0.1	61.8	0.1	47.4	0.3	51.5	0.5	84.9	0.8	83.3	1.0
Q3: 3rd income quintile	57.8	0.1	62.3	0.2	50.1	0.4	52.8	0.5	86.7	1.0	84.7	1.0
Q4: 4th income quintile	59.0	0.1	63.4	0.2	52.1	0.4	54.2	0.6	88.4	0.9	85.5	1.2
Q5: 5th (highest) income quintile	60.6	0.1	64.4	0.2	54.3	0.4	56.0	0.6	89.6	1.0	87.0	1.4
Disparity between Q1 and Q5	-7.7*	0.2	-5.4	0.2	-12.2*	0.5	-10.1	0.7	-10.1	1.3	-9.2	1.6
	LE ₆₅				HALE ₆₅				HALE ₆₅ /LE ₆₅			
	Men		Women		Men		Women		Men		Women	
	years	SE	years	SE	years	SE	years	SE	percent	SE	percent	SE
Education												
E1: less than secondary graduation	18.8	0.1	23.2	0.1	14.4	0.1	17.2	0.1	76.5	0.8	74.1	0.7
E2: secondary graduation or trades certificate	20.2	0.1	24.6	0.1	16.1	0.1	19.1	0.1	80.0	0.7	77.8	0.7
E3: postsecondary diploma excluding university degree	21.8	0.1	26.1	0.2	17.3	0.2	20.3	0.2	79.6	1.1	78.0	1.1
E4: university degree or equivalent	23.1	0.1	27.2	0.3	19.2	0.2	21.9	0.2	83.1	1.1	80.5	1.7
Disparity between E1 and E4	-4.3	0.2	-4.0	0.3	-4.8	0.2	-4.7	0.3	-6.6	1.3	-6.3	1.9
Income												
Q1: 1st (lowest) income quintile	18.2	0.1	23.1	0.1	13.6	0.1	17.2	0.1	75.1	1.1	74.3	0.8
Q2: 2nd income quintile	19.6	0.1	24.5	0.1	15.4	0.1	18.7	0.1	78.3	0.8	76.2	0.9
Q3: 3rd income quintile	20.9	0.1	24.7	0.1	16.9	0.1	19.0	0.2	81.0	0.9	77.2	1.0
Q4: 4th income quintile	21.6	0.1	25.3	0.2	17.9	0.2	19.2	0.3	82.7	1.0	76.0	1.4
Q5: 5th (highest) income quintile	22.9	0.1	25.9	0.2	19.2	0.2	20.4	0.3	84.1	1.2	78.7	1.6
Disparity between Q1 and Q5	-4.7*	0.2	-2.8	0.2	-5.6*	0.2	-3.3	0.3	-9.0	1.6	-4.4	1.8

* disparity estimate for men significantly different from estimate for women (p < 0.05)

SE = standard error

Source: 2011 Canadian Census Health and Environment Cohort with five-year mortality follow-up, Statistics Canada.

of women were in the lowest combined education and income category (E1, Q1), whereas 9% of men and women were in the highest (E4, Q5) (data not shown).

Education-related disparities in LE and HALE

LE₂₅ and HALE₂₅ of men and women increased monotonically from E1 to E4 (Table 1). The disparity in LE₂₅ between E1 and E4 was significantly larger for men (7.8 years) than for women (6.7 years). The disparity in HALE₂₅ was larger than for LE₂₅, but was similar for men (11.3 years) and women (10.6 years). The disparity in HALE₂₅/LE₂₅ was also similar for both sexes. Respectively, men and women in E1 could expect to spend 81% and 79% of their remaining years in good health, compared with 89% and 87% for those in E4. Education-related disparities in LE₆₅, HALE₆₅ and HALE₆₅/LE₆₅ were similar for both sexes, but smaller than at age 25.

Income-related disparities in LE and HALE

There was a positive gradient in LE₂₅, HALE₂₅ and HALE₂₅/LE₂₅ moving from the lowest to the highest income quintile (Table 1). The disparity in LE₂₅ and HALE₂₅ between Q1 and Q5 was significantly larger for men (7.7 and 12.2 years) compared with women (5.4 and 10.1 years), and the disparity in HALE₂₅/LE₂₅ was 10 percentage points for men and 9 percentage points for women. Income-related disparities in LE₆₅ and HALE₆₅ were larger for men than for women, but smaller than at age 25.

Education-within-income-related disparities in LE and HALE

For the most part, the gradient in LE₂₅ and HALE₂₅ for men and women persisted by level of education within and across income quintiles (Figure 1). Among women with a university degree (E4), however, LE varied little by income. Those in the lowest combined socioeconomic category (E1, Q1) had the greatest LE₂₅ and HALE₂₅ disadvantage,

which was larger than disadvantages in either E1 or Q1. The LE₂₅ of men and women in E1, Q1 was 13.0 and 9.7 years lower, respectively, than the LE₂₅ of men and women in E4, Q5. The HALE₂₅ disadvantage was even greater: 19.9 fewer HALE₂₅ years for men and 16.2 fewer HALE₂₅ years for women. There was also a gradient in HALE₂₅/LE₂₅ across combined socioeconomic categories. Those in E1, Q1 could expect to spend about 75% of their total life expectancy in good health, compared with 89% to 91% among those in E4, Q5. Gradients in LE₆₅ and HALE₆₅ across combined categories were evident but attenuated, and there was less of an education gradient in HALE₆₅/LE₆₅ within income categories (data not shown).

LE and disparities in LE over time

The gradient in LE₂₅ across education and income categories in 2011 was also present in 1996 (Table 2). Although LE₂₅ increased significantly between 1996 and 2011 for all groups—with a larger increase for men than for women—the gradient in 2011 was steeper for both sexes because of greater gains in LE₂₅ among those with more education or a higher income. This steeper gradient resulted in a significant increase in the disparity between E1 and E4 and between Q1 and Q5 for men and women over the period. The greater relative increase in LE₂₅ over time in favour of E4 versus E1 and in favour of Q5 versus Q1 was higher among women than men. However, in absolute terms, men gained more years of LE₂₅ and had larger disparities in LE₂₅ than women. LE₆₅ also increased over the period for all groups, as did the disparity between E1 and E4 for men and between Q1 and Q5 for both sexes (Appendix Table B).

HALE and disparities in HALE over time

Like LE₂₅, the gradient in HALE₂₅ in 2011 was also evident in 1996, but was steeper in 2011 because of greater gains in HALE₂₅ over time among people with more education or a higher income

What is already known on this subject?

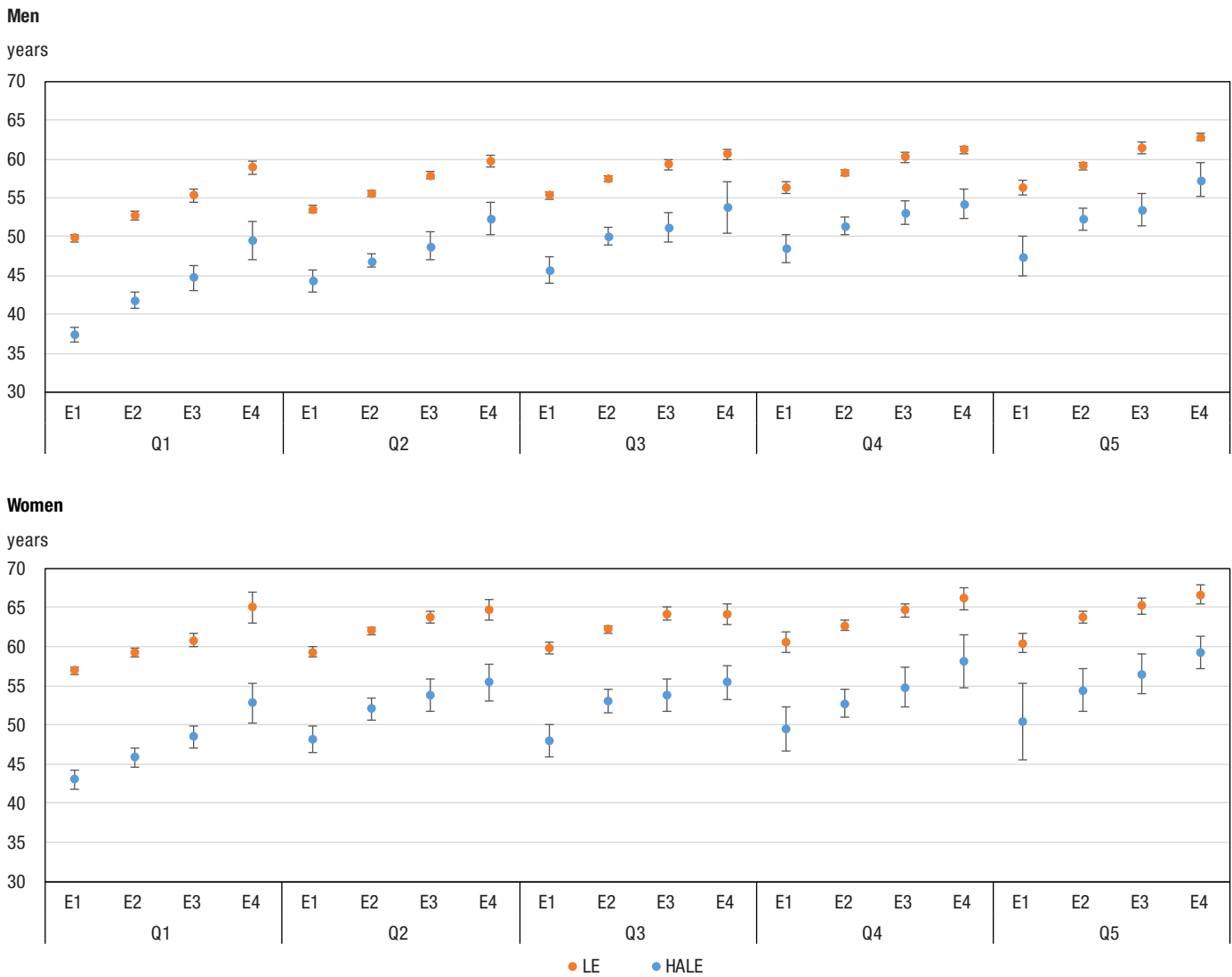
- Gains in life and health expectancy in many parts of the world have not been shared equally across all population groups.
- Persistent or increasing disparities in life and health expectancy according to education or income have been reported.
- Varied methodologies and data sources have made it difficult to ascertain whether these disparities have changed over time in Canada.

What does this study add?

- The 1996 and 2011 Canadian Census Health and Environment Cohorts allow for a robust examination of life expectancy (LE) and health-adjusted life expectancy (HALE) according to individual-level educational attainment, income quintiles and education combined with income.
- In both cohorts, LE and HALE at age 25 and age 65 were greater at higher levels of education or income.
- Disparities in LE and HALE were wider in the 2011 cohort compared with the 1996 cohort, but not necessarily to the same extent for both sexes or at different ages.
- In the 2011 cohort, a stepwise gradient in LE, HALE and the ratio of HALE to LE was observed by level of education within and across income quintiles, with people in the lowest combined education and income categories at the greatest disadvantage.

(Table 3). The gains in favour of E4 versus E1 were higher among men than women, whereas the gains in favour of Q5 versus Q1 were higher among women than men. As a result, there was a significant increase in the disparity between E1 and E4 over the period for men (2.7 years, $p=0.003$), but not for

Figure 1
Life expectancy (LE) and health-adjusted life expectancy (HALE) at age 25, by sex, by highest level of educational attainment within income quintile, household population, Canada, 2011 with five-year mortality follow-up



Notes: E1 = less than secondary graduation; E2 = secondary graduation; E3 = postsecondary diploma or certificate excluding university degree; E4 = university degree or equivalent. Q1 = 1st (lowest) income quintile; Q2 = 2nd income quintile; Q3 = 3rd income quintile; Q4 = 4th income quintile; Q5 = 5th (highest) income quintile. Error bars indicate 95% confidence interval.
Source: Statistics Canada, 2011 Canadian Census Health and Environment Cohort with five-year mortality follow-up.

women (1.5 years, $p=0.149$), whereas the disparity between Q1 and Q5 significantly increased for women (2.6 years, $p=0.030$), but not for men (1.1 years, $p=0.202$). Like LE_{25} , men generally had larger disparities in $HALE_{25}$ in absolute terms than women. There was less of a gradient to the increase over time in $HALE_{65}$ across education and income categories, resulting in the disparities in $HALE_{65}$ remaining relatively unchanged (Appendix Table B).

Discussion

This study found that disparities in LE and HALE still exist in Canada. People with higher levels of education or a higher income have longer life expectancies and are expected to spend a greater portion of those years in good health compared with those with less education or with a lower income. A distinct stepwise gradient in LE and HALE also exists by level of education within and across income quintiles. There is evi-

dence that disparities are wider than they were 15 years ago, but not necessarily to the same extent for both sexes or at different ages.

The pathways through which socioeconomic position can affect health outcomes are multi-factorial and complex.²⁶ Education and income are frequently used as indicators of socioeconomic position in health disparities research²⁷ and, though related, are not considered interchangeable.²⁸ Education is widely thought to increase health

Table 2

Life expectancy (LE) at age 25, disparities and change over time by education categories and income quintiles, by sex, household population, Canada, 1996 and 2011 with five-year mortality follow-up

	Life expectancy				Disparities			
	LE ₂₅ 1996	LE ₂₅ 2011	Δ in LE ₂₅	P value	LEdis ₂₅ 1996	LEdis ₂₅ 2011	Δ in LEdis ₂₅	P value
Education								
Men								
E1: less than secondary graduation	51.3	53.5	2.2	0.000	-6.4	-7.8	1.4	0.000
E2: secondary graduation or trades certificate	53.8	56.6	2.8	0.000	-3.9	-4.7	0.8	0.010
E3: postsecondary diploma excluding university degree	55.5	59.0	3.5	0.000	-2.2	-2.3	0.1	0.759
E4: university degree or equivalent	57.7	61.3	3.6	0.000	ref	ref	...	...
Women								
E1: less than secondary graduation	58.5	58.9	0.4	0.033	-4.8	-6.7	1.9	0.009
E2: secondary graduation or trades certificate	60.1	61.8	1.7	0.000	-3.2	-3.8	0.6	0.394
E3: postsecondary diploma excluding university degree	61.7	64.0	2.3	0.000	-1.6	-1.6	0.1	0.917
E4: university degree or equivalent	63.3	65.6	2.3	0.001	ref	ref	...	...
Income								
Men								
Q1: 1st (lowest) income quintile	49.7	52.9	3.3	0.000	-6.7	-7.7	0.9	0.001
Q2: 2nd income quintile	52.3	55.9	3.5	0.000	-4.1	-4.7	0.6	0.017
Q3: 3rd income quintile	53.8	57.8	4.0	0.000	-2.6	-2.8	0.2	0.448
Q4: 4th income quintile	54.8	59.0	4.2	0.000	-1.6	-1.6	0.0	0.916
Q5: 5th (highest) income quintile	56.4	60.6	4.2	0.000	ref	ref	...	...
Women								
Q1: 1st (lowest) income quintile	57.6	59.0	1.5	0.000	-3.7	-5.4	1.7	0.000
Q2: 2nd income quintile	59.7	61.8	2.1	0.000	-1.6	-2.6	1.0	0.006
Q3: 3rd income quintile	60.1	62.3	2.2	0.000	-1.2	-2.1	0.9	0.031
Q4: 4th income quintile	60.4	63.4	3.0	0.000	-0.9	-1.0	0.1	0.860
Q5: 5th (highest) income quintile	61.3	64.4	3.1	0.000	ref	ref	...	...

... not applicable

ref = reference category

Δ in LE₂₅ = difference between LE₂₅ in 2011 and in 1996.

LEdis₂₅ = disparities in LE between this category and the reference category.

Δ in LEdis₂₅ = difference between LEdis₂₅ in 2011 and in 1996.

Source: 1996 and 2011 Canadian Census Health and Environment Cohort with five-year mortality follow-up, Statistics Canada.

knowledge and literacy, which in turn can promote the adoption of healthier lifestyles and facilitate access to appropriate health care.^{26,29} Higher income allows access to better-quality material resources—such as food and shelter—and better, easier or faster access to services, which can have a direct (e.g., health services) or indirect (e.g., education) effect on health.²⁷ That this study found gradients in LE, HALE and HALE/LE by education or income is consistent with other studies²⁹⁻³¹ and speaks to the well-recognized role of social stratification in determining health outcomes.³² Moreover, the stepwise gradient in LE and HALE by education level within income strata underscores how multiple aspects of social disadvantage can intersect in their association with health outcomes.²⁹ This is emphasized by the finding that people in the lowest combined socioeconomic categories were at

a greater LE and HALE disadvantage than those in either a low education category or low income quintile.

Many studies have examined education-related disparities because of the availability and appeal of education as an indicator of socioeconomic status.^{11,26} Although differences in data sources, methodologies and definitions limit the direct comparability of these studies, it is possible to compare overall patterns and trends. This study found significant disparities in LE at ages 25 and 65 for both sexes between the lowest and highest education categories, and greater gaps for men than for women. These findings are consistent with what has been reported in many Organisation for Economic Co-operation and Development countries.^{11,29,30} The widening education gap in LE between 1996 and 2011 for both sexes that was reported in this study has also been reported elsewhere.^{5,9,33} This

widening has been partly attributed to the significant decline in the population size of the lowest education category, a category that is thought to be increasingly composed of individuals with characteristics that compound the risk of ill health and death.³⁴ This study found that the health status of those in the lowest education category declined between 1996 and 2011. However, it has been noted that compositional change cannot fully account for the worsening LE of those with the lowest education, particularly among women.³³

This study's finding of significant and widening income-related disparities in LE has also been reported by others,^{6,35,36} despite significant heterogeneity in the way income has been defined (e.g., career earnings versus tax data, linked at the individual level or area-based). Alcohol and smoking have been identified as contributing substantially to

Table 3
Health-adjusted life expectancy (HALE) at age 25, disparities and change over time by education categories and income quintiles, by sex, household population, Canada, 1996 and 2011 with five-year mortality follow-up

	Health-adjusted life expectancy				Disparities			
	HALE ₂₅ 1996	HALE ₂₅ 2011	Δ in HALE ₂₅	P value	HALEdisp ₂₅ 1996	HALEdisp ₂₅ 2011	Δ in HALEdisp ₂₅	P value
Education								
Men								
E1: less than secondary graduation	42.2	43.4	1.2	0.006	-8.5	-11.2	2.7	0.003
E2: secondary graduation or trades certificate	45.9	48.5	2.6	0.000	-4.8	-6.1	1.3	0.110
E3: postsecondary diploma excluding university degree	49.7	50.9	1.2	0.092	-1.0	-3.7	2.7	0.007
E4: university degree or equivalent	50.7	54.6	4.0	0.000	ref	ref	...	...
Women								
E1: less than secondary graduation	45.0	46.6	1.5	0.010	-9.1	-10.6	1.5	0.149
E2: secondary graduation or trades certificate	49.7	51.6	1.8	0.000	-4.4	-5.6	1.2	0.226
E3: postsecondary diploma excluding university degree	53.1	54.2	1.0	0.266	-1.0	-3.0	2.0	0.110
E4: university degree or equivalent	54.1	57.2	3.1	0.001	ref	ref	...	...
Income								
Men								
Q1: 1st (lowest) income quintile	39.3	42.0	2.8	0.000	-11.2	-12.3	1.1	0.202
Q2: 2nd income quintile	43.2	47.4	4.2	0.000	-7.3	-6.9	-0.4	0.603
Q3: 3rd income quintile	45.7	50.1	4.4	0.000	-4.8	-4.2	-0.6	0.498
Q4: 4th income quintile	48.0	52.1	4.1	0.000	-2.5	-2.2	-0.3	0.731
Q5: 5th (highest) income quintile	50.5	54.3	3.8	0.000	ref	ref	...	...
Women								
Q1: 1st (lowest) income quintile	44.2	46.0	1.7	0.002	-7.4	-10.0	2.6	0.030
Q2: 2nd income quintile	48.1	51.5	3.4	0.000	-3.5	-4.5	1.0	0.479
Q3: 3rd income quintile	49.9	52.8	3.0	0.000	-1.7	-3.2	1.5	0.279
Q4: 4th income quintile	49.5	54.2	4.7	0.000	-2.1	-1.8	-0.3	0.819
Q5: 5th (highest) income quintile	51.6	56.0	4.4	0.000	ref	ref	...	...

... not applicable

ref = reference category

Δ in HALE₂₅ = difference between HALE₂₅ in 2011 and in 1996.

HALEdisp₂₅ = disparities in HALE between this category and the reference category.

Δ in HALEdisp₂₅ = difference between HALEdisp₂₅ in 2011 and in 1996.

Sources: 1996 and 2011 Canadian Census Health and Environment Cohorts with five-year mortality follow-up; 1994/1995 National Population Health Survey; 2009 and 2010 Canadian Community Health Survey.

income differences in LE.^{37,38} Negative health behaviours such as these might also help explain why people in the lowest combined education and income category in this study were at the greatest LE disadvantage.

Health expectancy goes beyond LE by estimating the number of years a population may expect to live in good health.¹ Disparities in HALE—this study’s measure of health expectancy—and in HALE/LE were significantly larger at age 25 across education and income for both sexes than disparities in LE. In other words, people with the highest education and income were not only living longer than those with a lower income or less education, but were also spending a greater share of those years in good functional health. This is consistent with other published work, regardless of the measure used to estimate health expect-

ancy,^{9,39,40} and suggests that disparities may be more pervasive with respect to quality rather than quantity of remaining life.³¹ However, the disparity in HALE₆₅ was considerably smaller than the disparity in HALE₂₅. This may reflect the “age as leveller” theory, which suggests that earlier gaps in healthy life will narrow in advanced age.⁴¹

Disparities in HALE₂₅ widened between 1996 and 2011 for men across education categories and for women across income quintiles. The former partly reflects the fact that the functional health of men in the lowest education category declined over time, while it remained relatively unchanged for men in the highest education category. The reverse occurred for women. The functional health of women in the lowest income quintile remained stable, whereas it increased for the women in the highest

income quintile. These findings suggest there may be differences by sex in how the association between different components of social disadvantage and health outcomes may be evolving over time.

This study has many strengths. The CanCHECs are large, nationally representative cohorts that were created using a consistent methodology and allow for a robust examination of change over time. Two important social determinants of health—education and income—measured at the individual level for people aged 25 or older were examined. Education has the advantage of having a low risk of “reverse causality” with health,¹¹ while household income is a strong indicator of material living standards.³² Rarely have both determinants at the individual level been included in the same study of disparities in LE or HALE. HALE was estimated using HUI3, which

is a continuous scale. This makes it less sensitive to measurement error than dichotomous estimates of health status.

Several limitations should be acknowledged. The analysis did not account for other population characteristics (e.g., ethnicity, marital status) that may have changed over time within education or income categories and may have, in turn, contributed to the observed disparities. The results pertain solely to the household population since data constraints prevented the institutional population from being included in this study. Excluding the institutional population has been shown to significantly increase population estimates of HALE and HALE/LE.² Changes over time in question wording, collection mode and response rates for each census and health survey^{14,15,42,43} should be kept in mind when interpreting the results of this study. Specifically, revisions introduced in the 2006 Census to correct the under-reporting of high school completion that

had occurred previously,⁴⁴ coupled with a potential increase over time in the homogeneity of people in the lowest education category, may have complicated the interpretation of trends. Additionally, 2006 was the first census year in which respondents were given the option to allow linkage to their tax records rather than self-report their income data. This reduced the clustering around “round” dollar amounts, such as \$30,000, which then increased the variability in the income distribution compared with previous censuses.⁴⁵ However, the fact that this study derived income quintiles for each cohort separately helped circumvent the potential impact of distributional change in income groups over time.⁴⁶ Although the cohort weights were designed to help mitigate bias associated with data linkage, unknown bias might exist if people missing from the cohorts differed systematically from those who were included.

Conclusion

Education- and income-related disparities in life and health expectancy persist and may be wider than they were 15 years ago among the household population in Canada. These findings underscore the importance of ongoing data development for routine monitoring of trends in mortality and morbidity, which in turn can inform policy development and planning to advance health equity.

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Appendix

Table A
Cohort distribution and mean HUI3 scores by education categories and income quintiles by sex and age group, household population, Canada, 1996 and 2011 with five-year mortality follow-up

	1996 CanCHEC					2011 CanCHEC				
	weighted %	Age group 25 to 44		Age group 65 to 79		weighted %	Age group 25 to 44		Age group 65 to 79	
		mean HUI3	SE	mean HUI3	SE		mean HUI3	SE	mean HUI3	SE
Men										
Education										
E1: less than secondary graduation	32.1	0.868	0.014	0.791	0.013	17.1	0.836	0.012	0.811	0.007
E2: secondary graduation or trades certificate	36.6	0.892	0.006	0.814	0.016	38.1	0.899	0.003	0.844	0.005
E3: postsecondary diploma excluding university degree	14.8	0.917	0.013	0.951	0.019	21.5	0.916	0.004	0.848	0.011
E4: university degree or equivalent	16.5	0.931	0.006	0.858	0.022	23.3	0.937	0.003	0.868	0.008
Income										
Q1: 1st (lowest) income quintile	17.4	0.850	0.015	0.777	0.022	16.7	0.856	0.007	0.805	0.008
Q2: 2nd income quintile	19.6	0.881	0.011	0.785	0.020	18.7	0.903	0.005	0.830	0.007
Q3: 3rd income quintile	20.4	0.902	0.007	0.804	0.021	20.2	0.902	0.005	0.852	0.008
Q4: 4th income quintile	21.0	0.911	0.007	0.868	0.017	21.4	0.927	0.003	0.878	0.007
Q5: 5th (highest) income quintile	21.6	0.923	0.007	0.876	0.020	23.0	0.937	0.004	0.872	0.010
Women										
Education										
E1: less than secondary graduation	33.5	0.853	0.012	0.749	0.018	17.1	0.838	0.011	0.784	0.007
E2: secondary graduation or trades certificate	32.9	0.889	0.005	0.803	0.015	32.0	0.890	0.004	0.834	0.005
E3: postsecondary diploma excluding university degree	20.2	0.911	0.009	0.790	0.031	27.2	0.909	0.003	0.839	0.007
E4: university degree or equivalent	13.4	0.921	0.008	0.816	0.030	23.7	0.931	0.003	0.851	0.010
Income										
Q1: 1st (lowest) income quintile	21.5	0.847	0.011	0.741	0.017	20.1	0.850	0.006	0.772	0.008
Q2: 2nd income quintile	20.7	0.886	0.009	0.773	0.029	20.0	0.903	0.005	0.821	0.008
Q3: 3rd income quintile	19.8	0.904	0.010	0.798	0.020	19.7	0.917	0.004	0.835	0.008
Q4: 4th income quintile	19.1	0.902	0.007	0.809	0.029	19.8	0.932	0.003	0.855	0.010
Q5: 5th (highest) income quintile	18.8	0.922	0.005	0.796	0.051	20.3	0.941	0.003	0.870	0.012

CanCHEC = Canadian Census Health and Environment Cohort

HUI3 = Health Utilities Index Mark 3

SE = standard error

Sources: Statistics Canada, 1996 and 2011 Canadian Census Health and Environment Cohorts with five-year mortality follow-up; 1994/1995 National Population Health Survey; 2009 and 2010 Canadian Community Health Survey.

Table B

Change between 1996 and 2011 in life expectancy (LE), health-adjusted life expectancy (HALE), and in their disparities by education categories and income quintiles, at age 65 by sex, household population, Canada, 1996 and 2011 with five-year mortality follow-up

	Life expectancy				Health-adjusted life expectancy			
	Δ in LE ₆₅	P value	Δ in LEdisp ₆₅	P value	Δ in HALE ₆₅	P value	Δ in HALEdisp ₆₅	P value
Education								
Men								
E1: less than secondary graduation	2.4	0.000	0.7	0.024	2.1	0.000	0.8	0.112
E2: secondary graduation or trades certificate	2.6	0.000	0.5	0.131	2.4	0.000	0.6	0.296
E3: postsecondary diploma excluding university degree	3.0	0.000	0.0	0.959	0.4	0.322	2.6	0.000
E4: university degree or equivalent	3.0	0.000	...	...	2.9	0.000	...	...
Women								
E1: less than secondary graduation	1.2	0.000	1.0	0.221	2.1	0.000	0.3	0.639
E2: secondary graduation or trades certificate	1.9	0.000	0.2	0.819	2.1	0.000	0.3	0.633
E3: postsecondary diploma excluding university degree	2.1	0.000	0.0	0.980	1.2	0.087	1.2	0.189
E4: university degree or equivalent	2.1	0.004	...	...	2.4	0.000	...	...
Income								
Men								
Q1: 1st (lowest) income quintile	2.6	0.000	1.0	0.000	2.2	0.000	0.6	0.166
Q2: 2nd income quintile	3.0	0.000	0.8	0.005	3.1	0.000	-0.3	0.435
Q3: 3rd income quintile	3.4	0.000	0.3	0.306	3.5	0.000	-0.7	0.077
Q4: 4th income quintile	3.6	0.000	0.2	0.749	2.9	0.000	-0.1	0.784
Q5: 5th (highest) income quintile	3.7	0.000	...	...	2.8	0.000	...	...
Women								
Q1: 1st (lowest) income quintile	1.4	0.000	1.2	0.000	2.3	0.000	1.1	0.172
Q2: 2nd income quintile	1.9	0.000	0.7	0.027	2.3	0.000	1.0	0.215
Q3: 3rd income quintile	2.0	0.000	0.5	0.106	2.3	0.000	1.1	0.245
Q4: 4th income quintile	2.7	0.000	0.0	1.000	2.8	0.000	0.6	0.595
Q5: 5th (highest) income quintile	2.7	0.000	...	...	3.4	0.000	...	...

... not applicable

Δ in LE₆₅ = difference between LE₆₅ in 2011 and in 1996.

Δ in LEdisp₆₅ = difference between LEdisp₆₅ in 2011 and in 1996.

Δ in HALE₆₅ = difference between HALE₆₅ in 2011 and in 1996.

Δ in HALEdisp₆₅ = difference between HALEdisp₆₅ in 2011 and in 1996.

Sources: Statistics Canada, 1996 and 2011 Canadian Census Health and Environment Cohorts with five-year mortality follow-up; 1994/1995 National Population Health Survey; 2009 and 2010 Canadian Community Health Survey.

Equation 1

Calculation of variance of the ratio of HALE to LE (HALE/LE)

$$Var\left(\frac{HALE}{LE}\right) = \frac{HALE^2}{LE^2} * \left[\frac{Var(HALE)}{HALE^2} - \frac{[Var(notHALE) - Var(LE) - Var(HALE)]}{HALE * LE} + \frac{Var(LE)}{LE^2} \right]$$

where *Var* = variance and *notHALE* = the difference between LE and HALE.

Equation 2

Testing the equality of two estimates of LE, HALE or the ratio of HALE to LE (HALE/LE)

$$Z\text{-score} = \frac{(HA)LE_1 - (HA)LE_2}{\sqrt{(S^2(HA)LE_1 + S^2(HA)LE_2)}}$$

where (HA)LE = (health-adjusted) life expectancy, or HALE/LE, and $S^2(HA)LE$ = variance of the (health-adjusted) life expectancy, or HALE/LE.

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