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Trajectories of health-related quality of life by socio-economic status in a nationally representative Canadian cohort

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Abstract

Background—Mortality and morbidity have been shown to follow a 'social gradient' in Canada and many other countries around the world. Comparatively little, however, is known about whether ageing amplifies, diminishes or sustains socio-economic inequalities in health.

Methods—Growth curve analysis of seven cycles of the Canadian National Population Health Survey (n=13 682) for adults aged 20 and older at baseline (1994/95). The outcome of interest is the Health Utilities Index Mark 3, a measure of health-related quality of life (HRQL). Models include the deceased so as not to present overly optimistic HRQL values. Socio-economic position is measured separately by household-size-adjusted income and highest level of education attained.

Results—HRQL is consistently highest for the most affluent and the most highly educated men and women, and is lower, in turn, for middle and lower income and education groups. HRQL declines with age for both men and women. The rate of the decline in HRQL, however, was related neither to income nor to education for men, suggesting stability in the social gradient in HRQL over time for men. There was a sharper decline in HRQL for upper-middle and highest-income groups for women than for the poorest women.

Conclusion—HRQL is graded by both income and education in Canadian men and women. The grading of HRQL by social position appears to be 'set' in early adulthood and is stable through mid- and later life.

INTRODUCTION

This paper examines the differences in health-related quality of life (HRQL) trajectories of a large cohort of Canadians by socio-economic status. Canada has historically been a more

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Competing interests It should be noted that DF has a proprietary interest in Health Utilities Incorporated, Dundas, Ontario, Canada. Health Utilities Incorporated distributes copyrighted Health Utilities Index (HUI) materials and provides methodological advice on the use of HUI. It should also be noted that Health Utilities Incorporated received no payments for the use of the Health Utilities Index Mark 3 in the Statistics Canada National Population Health Survey reported in the paper.

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equal society than its large neighbour to the south, and this relative equality has been linked to its more favourable population health status record.[1] That said, inequality in household earnings has increased dramatically in the past 10 years in Canada, and poverty rates have increased across all age groups.[2] Public spending as a percentage of gross domestic product is similar in Canada and the USA at 16%, while it is much higher in many European (eg, France at over 29%) and Scandinavian (eg, Sweden at over 29%; Norway at over 21%) countries. Thus, the overall context of our study is a country with growing inequality, intermediate poverty levels among its Organisation for Economic Co-operation and Development (OECD) peers and lower public spending on social programmes.

Social gradients in health have been documented across most countries in the world and through recent history, at least postindustrial revolution. Rudolf Virchow's report of the typhus epidemic in Upper Silesia (see Azar[3]) and Friedrich Engels' *Condition of the Working Class in England* are both commonly cited as works that introduced the medical community to the idea that health is strongly patterned by social conditions. In Canada, our understanding of the social gradient in health has come largely from work led by Russell Wilkins,[4,5] which has shown, by linking death records to small geographic areas, that Canadians living in the poorest communities in Canada have much higher mortalities from most causes of death than those from the most affluent communities, and that every step up in the community income hierarchy seems to be protective of mortality. More recently, Wilkins and colleagues have demonstrated, through a linkage of census and mortality records for a large sample of Canadians, that both individual income and education levels are strongly predictive of mortality 10 years later.

The social gradient in mortality is thus well established in Canada. Having a low income or low education, however, is likely to affect the quality of an individual's life long before death. In this study, we are interested in how socio-economic circumstances of Canadians influence their HRQL as they age. Our methodology then differs from most past research in that we follow a large cohort of individual Canadians over 12 years to determine the trajectory of HRQL by socio-economic characteristics. This builds on our previous work which examined the 'natural history' of HRQL in the same cohort.[6] There, we reviewed previous studies of health trajectories, and we showed that HRQL is high in the Canadian population until about age 70, when it begins to decline for both sexes, but more sharply for males, owing mainly to their lower life expectancies. The study included groups normally left out of large population-based cohort studies—Canadians who died and who entered long-term care facilities—and so we were able to demonstrate very accurate (less optimistic) depictions of gender differences in HRQL through time.

The longitudinal methodology directs us to thinking about the development of social gradients in health from a lifecourse perspective. In general, lifecourse approaches consider that events in early life and cumulative exposures throughout adolescence and adult life influence the way health is graded by social circumstances. Some models emphasise the powerful role of events in utero or very early life conditions for example,[7] over subsequent life experiences, but most lifecourse approaches recognise the interplay between early life and adult exposures.[8]

Few published studies have used a longitudinal multilevel approach where multiple observations from individuals are nested within persons. There are, however, two studies from the USA that have examined changes in the inequality gap among social groups that occurs with the ageing process. The more recent of these[9] assesses trajectories of self-assessed health of 49–65-year-old African–Americans over a 4-year period. They find that factors such as pre-existing conditions at baseline and socio-economic status influence the starting-points (intercepts) of the trajectories of self-rated health. Over time, however, the

inequalities at the starting-point are sustained such that the decline that occurs with ageing in self-reported health status is modest, and the authors point out that the decline is similar to that of White Americans. Similar findings were reported in an earlier study assessing the role of ageing in the 'disability gap' between black and white Americans.[10] In their 6-year trajectory analysis of disability (respondents' reports of their ability to perform multiple activities of daily living), Kelly-Moore and Ferraro found that the gap in disability rates between black and white Americans neither increases nor diminishes over time.

Of additional interest in our of analysis is whether high income and education are associated with the compression of morbidity into older age groups, compared with a more steady and linear decline in health of less affluent and less educated groups. House and colleagues[11] state:

> the now-15-year longitudinal follow-up on our nationally representative ACL [American's Changing Lives Study] sample indicates that there is a genuine social stratification by both education and income of the way health changes with age, with much greater compression of functional limitation achieved at higher levels of education and income and the greatest socio-economic disparities in health at middle and early old ages. (p 22)

Thus, in the analyses presented here, we examine the role of income and education in the compression of morbidity in Canadians.

METHODS

This analysis is based on longitudinal data from the first seven cycles (1994/1995 through 2006/2007) of the National Population Health Survey (NPHS). The target population of the NPHS Household component includes household residents (adults and children) in the 10 Canadian provinces in 1994/1995 excluding persons living on Indian Reserves and Crown Lands, residents of health institutions, Canadian Forces Bases and some remote areas in Ontario and Quebec. We examine trajectories for the sample aged 20 and older at baseline.

In 1994/1995, 20 095 households were selected for the NPHS longitudinal panel. Of these, 86% completed the general component of the NPHS questionnaire (17 276), and 83.6% of selected respondents provided responses to the in-depth health questionnaire. Response rates in subsequent cycles based on the 17 276 selected respondents were 92.8% in 1996/1997; 88.3% in 1998/1999; 84.9% in 2000/2002; 80.8% in 2002/2003; and 77.6% in 2004/2005. More detailed descriptions of the NPHS design, sample and interview procedures are available elsewhere.[12] Data were collected primarily through computer-assisted personal interviews in 1994/1995 and primarily through computer assisted-telephone interviews thereafter. Respondent confidentiality is strictly maintained under the Statistics Canada Act, and further ethical approval is not required for analyses of these data.

Measures

HRQL—The HUI3 is a composite measure of health status across eight attributes: vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain and discomfort.[13] Each attribute has five or six levels that range from severely impaired (for instance, blind for vision) to no impairment. HUI3 health states are scored using utility functions based on preference scores obtained from a Canadian sample. This random sample of community-dwelling subjects (16+) was asked to provide preference scores for sets of HUI3 health states. Their responses were used to estimate a multiplicative multiattribute utility function for the HUI3 system. Thus, each individual has an HUI3 score for each measurement time, which reflects an overall level of HRQL based on the combination of attribute levels they experience. HUI3 scores can range from −0.36 to 1.00. A score of 1.00 is considered perfect

health, while a score of 0 represents the state of being dead, and a score less than 0, a state 'worse than dead.' For analyses including participants for the first cycle after their death, an HUI3 score of 0 was imputed for that cycle. We tested for differences in modelling results if the dead were included in the analyses beyond their death (ie, we tested for the possibility of survivor effects) and found there to be no difference in models with multiple death codes and those with a singleton death code in the first cycle following the recorded death. We use a transformed version of the HUI3 in the analysis here given that initial longitudinal modelling of the variable in its raw form revealed non-normal residuals and variance estimation problems. An empirical assessment of an arcsine transformation arcsine [{2× {(HUI3+0.36)/(1+0.36)}}−1] showed improvement in the distribution of the residuals and limited the conditional mean to plausible scores in the interval −0.36, 1.00 (Feng and Bernier, unpublished analyses). Among possible choices for the transformation (eg, log, log-log, square root) it was the arcsine that showed the best improvement in the distribution of residuals. This is a monotonic transformation that ensures the same ordering in the transformed as in the original values of the HUI3.

Time—Time is proxied by the individual's age and was centred at 47 (the mean of the distribution of the sample at baseline).

Education level—Education level represented the highest level of education received over the study period. For many, this was the education level reported at baseline: however, if respondents reported achieving a higher level of education during the study period, the highest reported level was adopted. Education was treated as a time-invariant predictor and was measured in four categories: less than secondary school graduation, secondary school graduation, some postsecondary education and postsecondary graduation.

Household income level—Household income level was treated as a time-varying predictor owing to the changing nature of income throughout the life-course. Household income was measured contemporaneously with HRQL, given that the adoption of a lagged household income variable, while tempting from the standpoint of reciprocal causation, resulted in excessive loss of data points for individuals who did not respond to a given cycle of data collection. We adopted a household size adjustment to household income as follows: lowest income=less than $10 000 for one to four persons or less than $15 000 for five or more persons; lower-middle income=$10 000–14 999 for one or two persons, $10 000–19 999 for three or four persons, or $15 000–29 999 for five or more persons; middle income= $15 000–29 999 for one or two persons, $20 000–39 999 for three or four persons, $30 000–59 999 for five or more persons; upper-middle income= $30 000–59 999 for one or two persons, $40 000–79 999 for three or four persons, $60 000–79 999 for five or more persons; highest=$60 000 or more for one or two persons, $80 000 or more for three or more persons. We retained those respondents who did not answer the income question in the modelling by using a dummy variable to indicate income missing.

Modelling

Random coefficient growth curve models are applied to account for correlations in the longitudinal data from the NPHS. We created sex-specific models owing to the fundamental differences between men and women in longevity and HRQL.[6] The order of the polynomial of the individual change trajectory (cubic) was determined iteratively by assessing fit (deviance statistic) of higher-order models. The linear and quadratic terms for the age variable were entered as random effects, as these specifications improved model fit. All other variables were considered fixed effects. Education and income were modelled separately for both men and women for ease of interpretation. We present the final models with the non-backtransformed results owing to the complexity of the backtransformation of

the models that include covariates. We calculated inflection points (where the second derivative of the function is zero) for each of the curves to estimate the age at which accelerated decline in HRQL occurs for men and women by income and education levels. All analyses were performed with SAS (data preparation and manipulation) and MLwiN (multilevel modelling). In order to account for the complex survey design of the NPHS, we used the normalised sample weights and bootstrap weights to produce all estimates. Inflection points were calculated using Maple software.

RESULTS

Descriptives

Of the 13 682 adults (age 20 and older) at baseline, the vast majority (n=13 577, 99%) had valid HUI3 scores at baseline. The mean HUI3 scores at baseline were typically higher for males than females and declined with age for both sexes (tables 1 and 2). HRQL at baseline followed a social gradient whereby HUI3 scores were generally lower for those with lower education and income levels for both men and women (table 3). Evidence for a step-like gradient in HRQL was more pronounced for income than for education for this cohort.

Modelling trajectories of HRQL

The models treat individual change in HUI for both men and women over time as though the change follows a cubic trajectory (tables 4 and 5). For both sexes, HUI decreases nonlinearly with age. Trajectory starting-points at age 20 were significantly higher for higher levels of education and income for men, but the absence of any statistically significant interaction terms (ie, age×education and age×income) suggests that the shape of the decline in HUI3 over time is similar for all male groups (table 4; figures 1 and 2). For women, there are similar differences in trajectory starting-points at age 20 (although there is no difference in the starting HUI3 scores for women in the lowest income group and those in the lower-middle income adequacy group) (table 5; figures 3 and 4). There were accelerated declines in HUI3 in women with high school education (compared with those with less than high school). Although higher-order interactions were examined (ie, interactions between education levels and quadratic age), these terms did not improve model fit significantly. There were also accelerated declines in the HUI3 in the most affluent groups compared with the poorest women. Indeed, the final model for income groups for women includes a cubic model with interactions with all age terms (age, age^2, age^3). For men, the inflection points in HRQL occurred at age 49 for men in the lowest education groups and at age 51 for men with the highest level of education. The results were similar for income for men. For women, the inflection points were the same across education levels (age 53), while for income, the inflection points for the lowest income groups were age 54 and age 53 for the highest groups.

DISCUSSION

HRQL is lower for Canadian men and women of lower education and income levels compared with those with a high education and increased affluence. The ‘social gradient’ in HRQL is evident in early adulthood and continues through mid and later life, diminishing slightly for women over time. For men, the trajectories of HRQL are similar across the social spectrum, suggesting that rates of decline in HRQL over time, expected with the ageing process, do not differ across social groups. That said, there was evidence that the decline in HRQL happens earlier for men of lower social standing, giving higher-status men a delay of 2 years in the decline of HRQL. For women, there was evidence of modest acceleration in decline in HRQL for those who were more highly educated and more

affluent relative to their more poorly educated and less affluent peers, suggesting a modest narrowing of the social gradient in HRQL for women over time.

Our findings are similar to past work on the disability gap between white and black Americans which has been shown to remain stable over time.[10] We also see, like House and colleagues,[12] that the social gap in HRQL tends to decrease with age, but only for women in Canada. This decrease is the result of a slightly more accelerated decline in HRQL for more highly educated and more affluent women. Some of this effect, however, may be an artefact of declining numbers of women remaining in the high-income categories over time, or it may be a result of a survivor effect for poorer women in the older age groups. Unlike the findings from House *et al*'s American's Changing Lives Study, however, Canadians overall of lower socio-economic status do not appear to have a linear decline in functional health over time. The shape of the decline is nonlinear for all social groups in Canada, suggesting that the compression of morbidity phenomenon is not limited only to the highest SES groups in Canada.

Age-related declines in quality of life do not appear to be vastly different across the social spectrum in Canada. This may suggest that policies such as universal health insurance and comparatively generous old age benefits have helped to reduce the disparities in life circumstances as Canadians age. Indeed, publicly funded old-age income safety nets in Canada are among the highest in the OECD, and this, in turn, has meant that the rate of senior citizen poverty in Canada is among the lowest in the world (eg, the rate of senior poverty in the USA is estimated at 23.6% compared with 4.4% in Canada).[14]

Overall, trajectories of HRQL are set early in life and remain stable over time. Put another way, socio-economic status appears to be strongly related to health status in Canada but not necessarily to the way health changes with age. Our findings support claims for the importance of early life experiences in setting up one's lifetime health trajectory.[15] These experiences of socio-economic disadvantage in early life may encompass a wide variety of both material (eg, poverty and poor nutrition, poor quality housing) and psychosocial (eg, stressful life events, shame from stigma, social isolation) exposures that collectively limit life chances and set up health-related quality of life deficits in early life that are never overcome at older ages for Canadians.

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What is already known on this subject

- Health-related quality of life tends to decline with age, but we know little about whether socio-economic status affects health-related quality of life trajectories.

What this study adds

- The decline in health-related quality of life in Canada, a setting with universal health insurance, is very similar across income and education groups.
- The 'gap' in health-related quality of life by socio-economic status present in early adulthood remains throughout the life course.

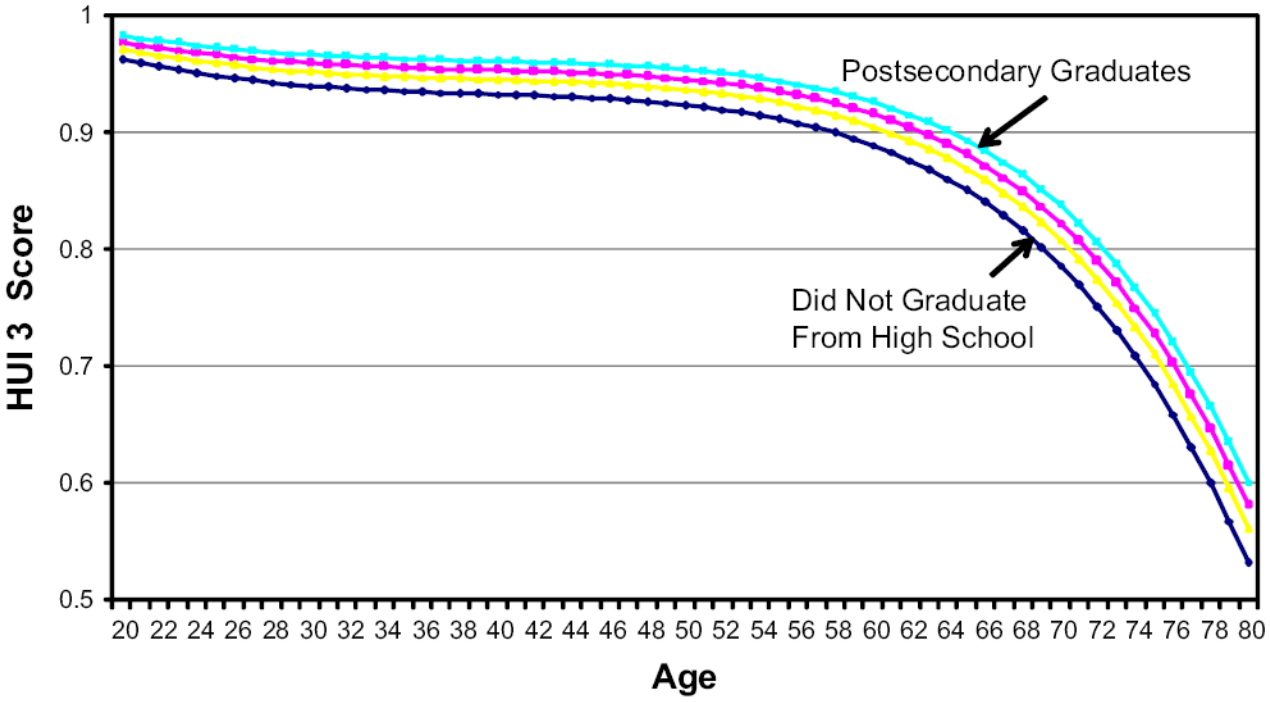

Figure 1.
Health-related quality of life (measured by the Health Utilities Index 3 (HUI3)) by highest educational attainment, Canadian males, ages 20+ in 1994/1995 (followed to 2006/2007).

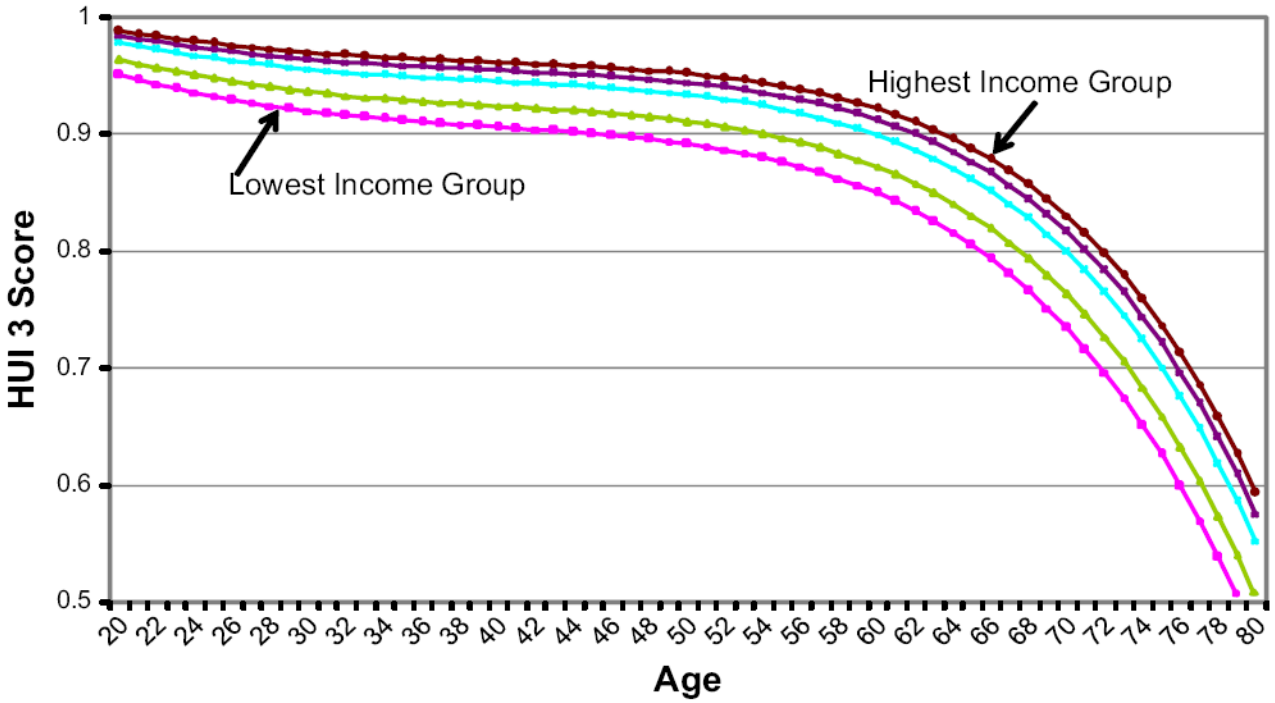

Figure 2.
Health-related quality of life (measured by the Health Utilities Index 3 (HUI3)) by household size-adjusted income, Canadian males, ages 20+ in 1994/1995 (followed to 2006/2007).

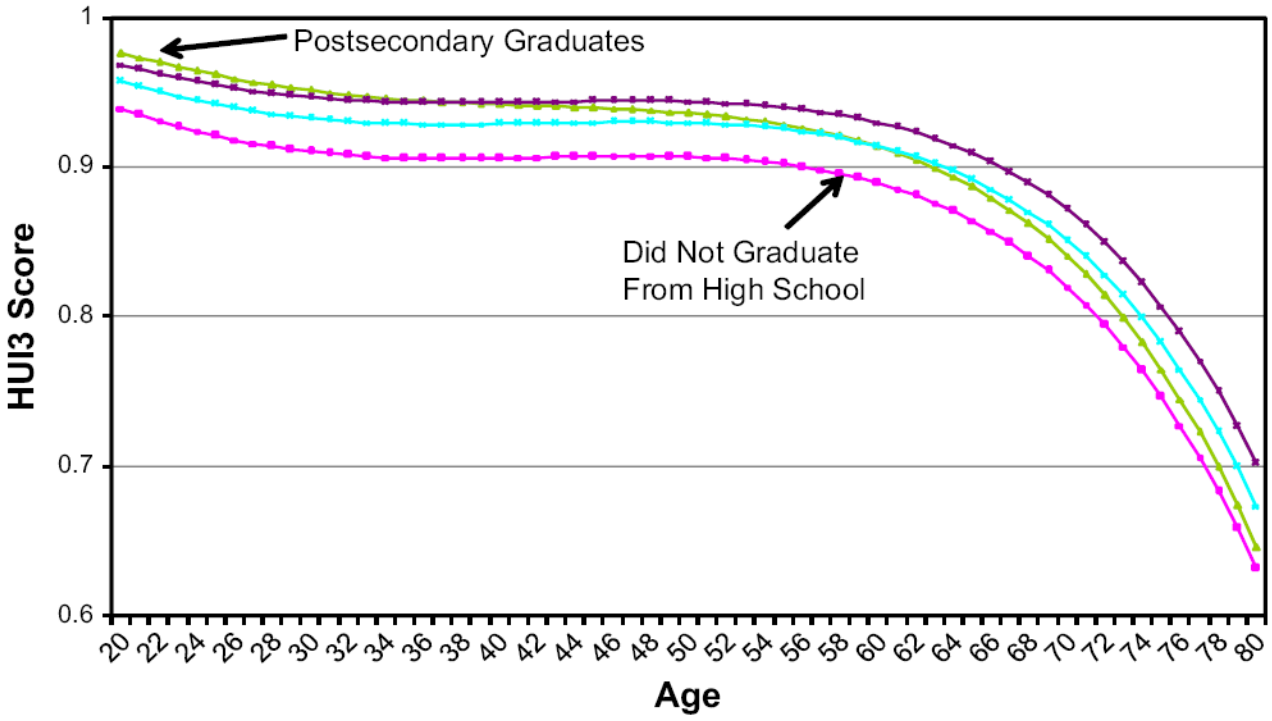

Figure 3.
Health-related quality of life (measured by the Health Utilities Index 3 (HUI3)) by highest educational attainment, Canadian females, ages 20+ in 1994/1995 (followed to 2006/2007).

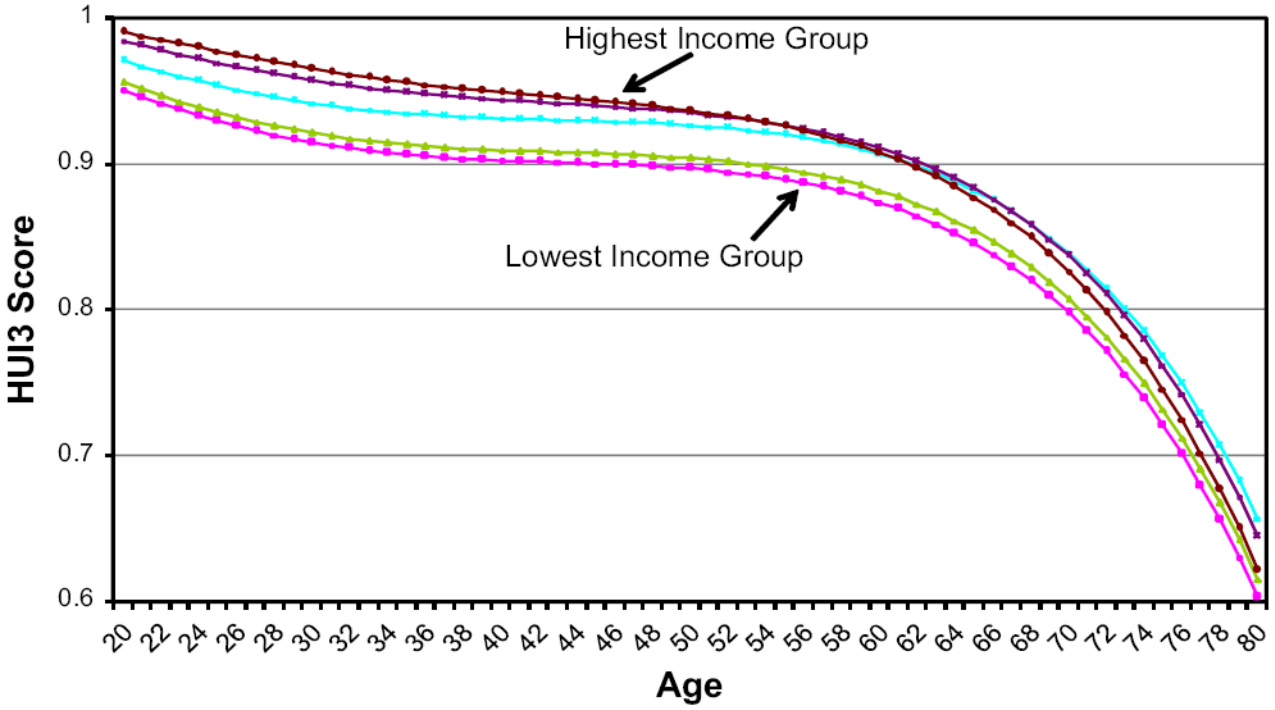

Figure 4.
Health-related quality of life (measured by the Health Utilities Index 3 (HUI3)) by household size-adjusted income, Canadian females, ages 20+ in 1994/1995 (followed to 2006/2007).

Table 1

Characteristics of sample at baseline (1994/1995) and over the study period: males

Age	N at baseline	Observations over study period	Mean Health Utilities Index 3 at Baseline
20–40	2786	15 467	0.90
41–60	2020	11 456	0.87
61–80	1195	6097	0.81
Over 80	158	588	0.65

Table 2

Characteristics of sample at baseline (1994/1995) and over study period: females

Age	N at baseline	Observations over study period	Mean Health Utilities Index 3 at baseline
20–40	3200	18 408	0.89
41–60	2173	12 694	0.85
61–80	1709	9341	0.79
Over 80	336	1469	0.60

Table 3

Mean health-related quality of life at baseline (1994/1995) by education and household income levels

	Males	Females
Education level *		
Less than secondary-school graduation	0.82	0.77
Secondary school graduation	0.89	0.86
Some postsecondary	0.86	0.86
Postsecondary graduation	0.90	0.89
Household income level †		
Lowest income	0.80	0.80
Lower middle	0.81	0.79
Middle income	0.85	0.84
Upper middle	0.88	0.88
Highest	0.91	0.90

* Highest level of education obtained by the individual respondent.

† Adjusted for household size as follows: lowest income=less than $10 000 for one to four persons or less than $15 000 for five or more persons; lower-middle income=$10 000–$14 999 for one or two persons, $10 000–19 999 for three or four persons, or $15 000–29 999 for five or more persons; middle income=$15 000–29 999 for one or two persons, $20 000–39 999 for three or four persons, $30 000–59 999 for five or more persons; upper-middle income=$30 000–59 999 for one or two persons, $40 000–79 999 for three or four persons, $60 000–79 999 for five or more persons; highest=$60 000 or more for one or two persons, $80 000 or more for three or more persons.

Table 4

Growth-curve model results for men

Education		Income adequacy	
Variable	**Estimate**	**Variable**	**Estimate**
Baseline		Baseline	
Intercept	1.11*	Intercept	1.01*
Less than high school education	Reference	Low income adequacy	Reference
High school graduation	0.08*	Lower-middle income adequacy	0.05*
Some postsecondary education	0.04*	Middle income adequacy	0.13*
Postsecondary graduate	0.11*	Upper-middle income adequacy	0.16*
		Upper income adequacy	0.19*
		Income adequacy missing	0.20*
Rate of change		Rate of change	
Age	−0.004*	Age	−0.005*
Age squared	−0.0003*	Age squared	−0.0002*
Age cubed	−0.00001*	Age cubed	−0.00001*

*Statistically significant at p=0.05.

Table 5

Growth-curve model results for women

Education		Income adequacy	
Variable	**Estimate**	**Variable**	**Estimate**
Baseline		Baseline	
Intercept	1.04*	Intercept	1.05*
Less than high-school education	Reference	Low income adequacy	Reference
High-school graduation	0.10*	Lower-middle income adequacy	0.06*
Some postsecondary education	0.07*	Middle income adequacy	0.10*
Postsecondary graduate	0.12*	Upper-middle income adequacy	0.10*
		Upper income adequacy	0.11*
		Income adequacy missing	−0.008*
Rate of change (interactions with age)		Rate of change (interactions with age)	
Less than high-school education	Reference	Low income adequacy	Reference
High-school graduation	−0.002*	Lower-middle income adequacy	−0.002*
Some postsecondary education	−0.002	Middle income adequacy	−0.005*
Postsecondary graduate	−0.001	Upper-middle income adequacy	−0.004*
		Upper income adequacy	−0.006*
		Income adequacy missing	−0.01*
Age	−0.001	Age	−0.0005
Age squared	−0.0002*	Age squared	−0.00006*
Age cubed	−0.00001*	Age cubed	−0.00001*
		Rate of change (interactions with age^2)	
		Low income adequacy	Reference
		Lower-middle income adequacy	−0.0003
		Middle income adequacy	−0.0001*
		Upper-middle income adequacy	−0.00009
		Upper income adequacy	−0.00009
		Income adequacy missing	−0.0001*
		Rate of change (interactions with age^3)	
		Low income adequacy	Reference
		Lower-middle income adequacy	0.000003*
		Middle income adequacy	0.000007*
		Upper-middle income adequacy	0.000004*
		Upper income adequacy	0.000007*
		Income adequacy missing	0.000005*

*Statistically significant at p=0.05.