Socio-economic Inequalities in Cause-specific Mortality: A 16-year Follow-up Study

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ABSTRACT

OBJECTIVES: To examine socio-economic inequalities in cause-specific mortality by examining the independent effects of education, occupation and income in a population-based study of working-age Canadian adults.

METHODS: This is a secondary analysis of data from the 1991-2006 Canadian Census mortality and cancer follow-up study (n=2.7 million persons). For this analysis, the cohort was restricted to 2.3 million persons aged 25 to 64 at cohort inception, of whom 164,332 died during the follow-up period. Hazard ratios were calculated by educational attainment (4 levels), occupational skill (6 categories) and income adequacy (5 quintiles) for all-cause mortality and major causes of death. Models were run separately for men and women, controlled for multiple variables simultaneously, and some were stratified by 10-year age cohorts.

RESULTS: The magnitude of socio-economic inequalities in mortality differed by indicator of socio-economic position (education, occupation, or income), age group, sex, and cause of death. Compared to age-adjusted models, hazard ratios were attenuated but remained significant in models that adjusted for both age and all three indicators of socio-economic position simultaneously. Socio-economic inequalities in mortality were evident for most of the major causes of death examined.

CONCLUSION: This study demonstrates that education, occupation and income were each independently associated with mortality and were not simply proxies for each other. When evaluating socio-economic inequalities in mortality, it is important to use different indicators of socio-economic position to provide a more complete picture.

KEY WORDS: Canada/epidemiology; socioeconomic factors; mortality

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

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Socio-economic position – an important health determinant – describes an individual's place within broad social and economic hierarchies.[1] Studies have consistently shown that mortality rates are higher among people of lower socio-economic position.[2-5] However, many studies only considered a single simple or composite indicator of socio-economic position, and were therefore unable to examine the interplay between two or more indicators.

Common indicators of socio-economic position include measures of education, occupation, and income or wealth, each of which relates to a different aspect of social stratification. Assessing the independent effects on health of each of these indicators may help us to better understand the associations among them, as well as the mechanisms through which they influence health.[6] It may also help to inform potential responses aimed at reducing disparities between those with different levels of education or income, and those in different occupational groups.[7]

The main objective of this study is to assess the independent effects of educational attainment, occupational skill level and income adequacy quintiles on mortality among working-age adults using data from a large population-based sample of Canadian adults. A secondary objective is to determine whether those effects differ by sex, age or cause of death.

METHODS

This is a secondary analysis of data from the 1991-2006 Canadian Census mortality and cancer follow-up study, which tracked mortality and cancer in a 15% sample of the adult population of Canada.[8,9] Persons were eligible for inclusion in the study cohort if they were: i) aged 25 years or older and a usual resident of Canada on the day of the Census (4 June 1991), ii) not a long-term resident of an institution such as a prison, hospital or nursing home, and iii) selected for census enumeration using the long-form questionnaire administered to one in five private households, and to all persons living in non-institutional collective dwellings and Indian reserves. Approximately 3.6 million individuals met these criteria.

The electronic 1991 Census database does not contain names, which are needed to ascertain mortality. To obtain names, census records were first linked to tax-filer data from 1990 and 1991 using probabilistic matching on the basis of dates of birth and postal codes of the individual and his or her spouse or common-law part-

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Conflict of Interest: None to declare.

Table 1. Number and Characteristics of Cohort Members

	Age Group at Cohort Inception (Years)				
	25-64	**25-34**	**35-44**	**45-54**	**55-64**
Male cohort members (N)	1,159,000	371,900	353,700	242,900	190,500
Educational attainment (%)					
University degree	16.2	15.9	19.2	16.8	10.4
Post-secondary diploma	13.5	16.2	15.1	11.5	8.0
High school diploma	39.7	43.8	41.5	36.9	31.6
Less than high school diploma	30.6	24.1	24.1	34.8	49.9
Occupational skill level (%)					
Professional	12.1	11.7	14.0	13.1	8.2
Managerial	13.2	9.8	15.4	17.0	11.0
Skilled/technical/supervisory	32.4	33.9	33.9	32.3	26.9
Semi-skilled	25.4	29.9	25.2	23.5	19.5
Unskilled	9.5	11.2	8.1	8.5	10.0
No occupation	7.3	3.4	3.4	5.6	24.5
Income adequacy quintile (%)					
Quintile 5 - highest	24.1	18.5	22.1	32.9	27.8
Quintile 4	23.5	22.8	24.1	24.8	23.3
Quintile 3	21.5	23.1	23.3	18.5	18.9
Quintile 2	17.3	20.3	18.1	12.9	15.7
Quintile 1 - lowest	13.5	15.4	12.5	10.9	15.2
Female cohort members (N)	1,153,400	400,400	364,700	226,600	161,700
Educational attainment (%)					
University degree	13.2	15.3	15.3	10.8	6.4
Post-secondary diploma	19.9	22.2	20.8	19.0	13.8
High school diploma	37.3	40.7	39.5	33.6	28.6
Less than high school diploma	29.7	21.8	24.4	36.6	51.2
Occupational skill level (%)					
Professional	13.7	13.8	16.1	14.5	7.0
Managerial	5.6	5.2	6.4	6.2	3.6
Skilled/technical/supervisory	21.9	23.1	23.4	22.2	15.1
Semi-skilled	30.6	33.6	31.0	30.3	22.6
Unskilled	8.5	8.5	8.0	9.6	8.1
No occupation	19.8	15.9	15.1	17.3	43.7
Income adequacy quintile (%)					
Quintile 5 - highest	21.8	16.3	21.3	31.4	22.7
Quintile 4	21.7	20.5	22.9	23.4	19.6
Quintile 3	21.0	22.6	22.2	17.9	18.8
Quintile 2	18.4	21.2	18.3	13.8	18.6
Quintile 1 - lowest	17.1	19.4	15.3	13.5	20.4

Source: 1991-2006 Canadian Census mortality and cancer follow-up study.

ner (if any). About three quarters of the in-scope persons were successfully linked to tax-filer data, creating a cohort of about 2.7 million people with a large sample in every socio-economic category. The cohort was then linked to the Canadian Mortality Database (4 June 1991 to 31 December 2006) using probabilistic methods previously described.[10] In the absence of a match to a death registration, follow-up status (alive, dead, emigrated, or lost to follow-up) could usually be determined from tax-filer data.[9]

For this study, the sample was restricted to persons aged 25 to 64 at cohort inception (n=2.3 million) since the majority of individuals aged 65 or older are not part of the labour force. Census data on occupation was only available for those who had been employed sometime within the year preceding the census.

Mortality data included underlying cause of death coded based on the World Health Organization's *International Classification of Diseases, Ninth Revision*[11] for deaths prior to 2000, and to the *Tenth Revision*[12] for deaths occurring in 2000 through 2006. Major causes of deaths for those aged 25 to 64 at cohort inception were examined, based on a list established in the study protocol.

Highest level of education at cohort inception was grouped into four categories: less than secondary graduation, secondary graduation (or trades certificate), post-secondary certificate or diploma (short of a university bachelor's degree), and university degree (bachelor's degree or higher).

Occupation was coded based on the kind of work an individual was doing the week prior to the 1991 Census enumeration. For persons without employment in the preceding week, the job of longest duration since 1 January 1990 was used. Respondents were asked to specify the kind of work they were doing, and the most important activities or duties they completed. This information was then coded according to the 1990 National Occupational Classification.[13] The skill level of each occupation was assigned to one of the following categories: professional, managerial, skilled/technical/supervisory, semi-skilled, and unskilled. Skill level was broadly defined as the amount and type of education and training required to enter and perform the duties of an occupation. In the National Occupational Classification, managerial occupations are not assigned a skill level because factors other than education and training (such as previous experience) are often more significant determinants of managerial employment. For the purposes of this study, managers were ranked between professional and supervisory occupations. People without an occupation were retained as a separate "no occupation" category, which included long-term unemployed, mature students, stay-at-home parents, persons unable to work, retirees and others who had not worked in the reference period.

Income adequacy quintiles were constructed as follows: First, for each economic family or unattached individual, total pre-tax, post-transfer income from all sources was combined across all family members. The ratio of total income of the economic family to the Statistics Canada low income cut-off (pre-tax, post-transfer) for the applicable family and community size group was then calculated based on the low income cut-offs shown in the 1991 Census Dictionary.[14] All members of a given family were assigned the same low income cut-off ratio. The in-scope non-institutional

Table 2. Adjusted Hazard Ratios for All-cause Mortality by Socio-economic Indicators, for Cohort Members Aged 25 to 64 Years at Baseline, 1991-2006

	Men				Women			
	Age-adjusted		Fully adjusted		Age-adjusted		Fully adjusted	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Educational attainment								
University degree*	1.00	–	1.00	–	1.00	–	1.00	–
Post-secondary diploma	1.32	1.29-1.36	1.23	1.19-1.27	1.22	1.17-1.26	1.15	1.11-1.20
High school diploma	1.66	1.62-1.70	1.45	1.42-1.49	1.43	1.38-1.48	1.27	1.23-1.32
Less than high school diploma	2.14	2.09-2.19	1.68	1.63-1.72	1.89	1.83-1.96	1.50	1.44-1.56
Occupational skill level								
Professional*	1.00	–	1.00	–	1.00	–	1.00	–
Managerial	1.17	1.14-1.21	0.96	0.93-1.00	1.24	1.18-1.30	1.06	1.01-1.12
Skilled/technical/supervisory	1.43	1.39-1.47	1.04	1.01-1.07	1.25	1.20-1.29	1.03	0.99-1.07
Semi-skilled	1.67	1.63-1.72	1.15	1.11-1.19	1.34	1.30-1.39	1.03	1.00-1.07
Unskilled	1.89	1.83-1.94	1.22	1.18-1.27	1.56	1.50-1.62	1.09	1.04-1.14
No occupation	2.85	2.77-2.93	1.75	1.69-1.80	2.12	2.05-2.19	1.43	1.37-1.48
Income adequacy quintile								
Quintile 5 - highest*	1.00	–	1.00	–	1.00	–	1.00	–
Quintile 4	1.18	1.16-1.20	1.05	1.03-1.07	1.14	1.11-1.17	1.06	1.04-1.09
Quintile 3	1.33	1.30-1.35	1.11	1.09-1.13	1.28	1.25-1.32	1.14	1.11-1.17
Quintile 2	1.54	1.51-1.57	1.21	1.18-1.23	1.50	1.46-1.54	1.27	1.24-1.31
Quintile 1 - lowest	2.22	2.18-2.26	1.56	1.53-1.59	2.10	2.05-2.15	1.66	1.62-1.71

Note: The age-adjusted model controls for age (continuous); the fully-adjusted model controls for age (continuous), educational attainment, occupational skill level and income adequacy quintile.
HR=hazard ratio; CI=confidence interval.
* Reference group (HR=1.00).
– Not applicable.
Source: 1991-2006 Canadian Census mortality and cancer follow-up study.

population was then ranked according to the low income cut-off ratio, and quintiles of population were constructed within each census metropolitan area, census agglomeration, or rural and small town area (outside any census metropolitan area or census agglomeration, by province). The purpose of constructing the quintiles within each area was to take account of regional differences in housing costs which are not reflected in the low income cut-offs. The percentage of the cohort in each income quintile did not always equal 20% because the quintiles were constructed based on the in-scope population (n=3.6 million) rather than the cohort (n=2.7 million).

For each member of the cohort, person-days of follow-up were calculated from the day of the Census (4 June 1991) to the date of death, date of emigration or the last day of the study period (31 December 2006), whichever occurred first. Person-days of follow-up were divided by 365.25 to obtain person-years at risk.

Cox proportional mortality hazard ratios were used to estimate the effect of education, occupation and income on mortality. The reference groups, from which the hazard ratios were calculated, were as follows: university degree, professional occupation, highest income adequacy quintile. All models were sex-specific. The age-adjusted model controlled for age at baseline in years. The fully-adjusted hazard models controlled for age, educational attainment, occupational skill level, and income adequacy quintile. The proportional hazards assumption was verified by visual inspection of log (-log) survival curves. Age cohort-specific models were also constructed, as were cause of death-specific models. We did not test for interactions among the socio-economic variables.

Polychoric correlations were used to measure the linear association between two ordinal variables, namely education (4 levels), occupational skill level (6 levels) and income adequacy quintiles (5 levels). Correlation values can range from -1 (negative correlation) to +1 (positive correlation). A value of 0 indicates that there is no correlation between the two variables.

RESULTS

The study cohort consisted of 2.3 million Census respondents aged 25 to 64 years at cohort inception, of whom 164,332 (7%) died during the 16-year follow-up period. Among the cohort members, 16% of men and 13% of women had a university degree, 12% of men and 14% of women were employed in professional occupations, while 24% of men and 22% of women were in the highest income adequacy quintile. Compared to younger cohort members (aged 25 to 34 and 35 to 44 at cohort inception), older cohort members (aged 45 to 54 and 55 to 64) were less likely to have a university degree or post-secondary diploma, and more likely to have no occupation or to be in the highest income quintile (Table 1).

Education, occupation and income were each associated with all-cause mortality in the age-adjusted models for both men and women (Table 2). The associations persisted for each indicator in the fully-adjusted models (controlled for age, educational attainment, occupational skill level, and income adequacy quintile), although the hazard ratios were attenuated. In the following summary, all findings reported were significantly ($p<0.05$) different from the reference groups (university degree; professional occupations; highest income adequacy quintile), except as noted.

Compared to men with a university degree, fully-adjusted hazard ratios were 1.23 for post-secondary diploma, 1.45 for secondary graduation and 1.68 for less than secondary graduation. Compared to men in the professional category, hazard ratios were 0.96 for managerial, 1.04 for skilled/technical/supervisory, 1.15 for semi-skilled, 1.22 for unskilled, and 1.75 for no occupation. Compared to men in the highest income adequacy quintile (quintile 5), hazard ratios were 1.05, 1.11, 1.21, and 1.56 in quintiles 4, 3, 2 and 1, respectively.

Compared to women with a university degree, fully-adjusted hazard ratios were 1.15 for post-secondary diploma, 1.27 for secondary graduation, and 1.50 for less than secondary graduation. Compared to women in professional occupations, the hazard ratio for women with no occupation was 1.43. All other hazard ratios by occupational skill level ranged from 1.03 to 1.09. Compared to women in

Table 3. Adjusted Hazard Ratios for All-cause Mortality, by Socio-economic Indicators, by Sex and Age Group at Baseline, for Cohort Members Aged 25 to 64 Years at Baseline, 1991-2006

	Age Group at Cohort Inception (Years)							
	25-34		35-44		45-54		55-64	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
Men								
Educational attainment								
University degree*	1.00	–	1.00	–	1.00	–	1.00	–
Post-secondary diploma	1.25	1.12-1.40	1.26	1.18-1.36	1.28	1.21-1.36	1.18	1.13-1.24
High school diploma	1.67	1.52-1.85	1.54	1.45-1.64	1.48	1.40-1.55	1.33	1.27-1.38
Less than high school diploma	2.16	1.95-2.39	1.79	1.67-1.91	1.63	1.54-1.71	1.52	1.46-1.59
Occupational skill level								
Professional*	1.00	–	1.00	–	1.00	–	1.00	–
Managerial	0.87	0.76-0.99	0.96	0.89-1.04	0.93	0.87-0.98	1.01	0.96-1.06
Skilled/technical/supervisory	1.02	0.91-1.14	1.08	1.01-1.16	1.03	0.97-1.08	1.03	0.98-1.08
Semi-skilled	1.17	1.04-1.31	1.26	1.17-1.36	1.16	1.10-1.23	1.10	1.05-1.15
Unskilled	1.38	1.22-1.56	1.36	1.25-1.47	1.23	1.15-1.31	1.14	1.08-1.20
No occupation	2.83	2.49-3.22	3.14	2.88-3.42	2.41	2.26-2.57	1.50	1.43-1.57
Income adequacy quintile								
Quintile 5 - highest*	1.00	–	1.00	–	1.00	–	1.00	–
Quintile 4	1.03	0.95-1.12	1.06	1.01-1.12	1.05	1.01-1.08	1.08	1.05-1.11
Quintile 3	1.08	1.00-1.17	1.06	1.00-1.12	1.13	1.09-1.18	1.16	1.13-1.19
Quintile 2	1.19	1.10-1.29	1.11	1.05-1.17	1.23	1.18-1.28	1.28	1.24-1.31
Quintile 1 - lowest	1.52	1.40-1.64	1.42	1.34-1.51	1.53	1.47-1.60	1.57	1.52-1.61
Women								
Educational attainment								
University degree*	1.00	–	1.00	–	1.00	–	1.00	–
Post-secondary diploma	1.20	1.07-1.36	1.20	1.11-1.30	1.12	1.04-1.20	1.11	1.03-1.18
High school diploma	1.45	1.29-1.63	1.30	1.20-1.40	1.22	1.14-1.31	1.21	1.14-1.29
Less than high school diploma	1.91	1.69-2.16	1.63	1.50-1.76	1.37	1.27-1.47	1.40	1.31-1.49
Occupational skill level								
Professional*	1.00	–	1.00	–	1.00	–	1.00	–
Managerial	0.98	0.83-1.16	1.01	0.91-1.11	1.07	0.98-1.17	1.12	1.02-1.23
Skilled/technical/supervisory	0.98	0.87-1.11	1.01	0.93-1.09	1.05	0.98-1.12	1.04	0.97-1.11
Semi-skilled	1.06	0.94-1.20	1.03	0.95-1.11	1.07	1.00-1.14	1.01	0.94-1.08
Unskilled	1.11	0.96-1.29	1.09	0.99-1.20	1.08	1.00-1.17	1.09	1.01-1.17
No occupation	1.53	1.35-1.74	1.55	1.43-1.68	1.58	1.48-1.70	1.37	1.29-1.46
Income adequacy quintile								
Quintile 5 - highest*	1.00	–	1.00	–	1.00	–	1.00	–
Quintile 4	1.04	0.93-1.16	0.97	0.91-1.04	1.10	1.05-1.16	1.10	1.05-1.14
Quintile 3	0.99	0.89-1.10	1.07	1.00-1.14	1.21	1.15-1.27	1.19	1.14-1.24
Quintile 2	1.10	0.99-1.23	1.19	1.11-1.27	1.34	1.28-1.42	1.33	1.28-1.39
Quintile 1 - lowest	1.54	1.38-1.71	1.61	1.51-1.72	1.80	1.71-1.89	1.66	1.59-1.72

Note: The fully-adjusted model controls for age (continuous), educational attainment, occupational skill level and income adequacy quintile.
HR=hazard ratio; CI=confidence interval.
* Reference group (HR=1.00).
– Not applicable.
Source: 1991-2006 Canadian Census mortality and cancer follow-up study.

the highest income adequacy quintile, hazard ratios were progressively elevated across income adequacy quintiles, ranging from 1.06 in the second-highest quintile to the strongest association in the lowest quintile (HR=1.66).

Table 3 shows fully-adjusted hazard ratios for each level of educational attainment, occupational skill level, and income adequacy quintile, by sex and by 10-year age cohort at baseline. A clear gradient in mortality by educational attainment was evident in each age cohort for men and women. There was a slight attenuation of the hazard ratios in the older age groups compared to the younger age groups. With the exception of persons without an occupation which showed a strong association, especially among men the mortality gradient by occupational skill level was modest to absent. For example, compared to persons with a professional occupation, hazard ratios for men were only significantly elevated for those in semi-skilled and unskilled occupations in each age group. Across income adequacy quintiles, hazard ratios were highest in the lowest income quintile for both men and women. Although hazard ratios, for the most part, were significantly elevated in the other income quintiles, they were considerably more modest, especially in the 25 to 34 and 35 to 44 year-old age categories.

Among men, the association between socio-economic indicators and mortality varied by both cause of death and indicator of socio-economic position (education, occupation or income) (Table 4). The fully-adjusted hazard ratios were most often largest by education level compared to either occupation or income. By cause of death, fully-adjusted hazard ratios were largest for deaths due to lung cancer, chronic obstructive pulmonary disease (COPD), cirrhosis of the liver, unintentional injuries and diabetes. The socio-economic gradient was modest or absent (depending on the specific indicator) for colorectal, pancreatic and prostate cancers.

Among women, with some exceptions, a socio-economic gradient was evident by education and income level, but not by occupational skill level, when cause of death groupings were examined (Table 5). For education and income, fully-adjusted hazard ratios were largest for deaths due to COPD, diabetes, ischemic heart disease, and cirrhosis of the liver, lung cancer (education) and unintentional injuries (income). For breast and ovarian cancers, there was no significant association by income, while by education the gradient was reversed.

DISCUSSION

Results from this population-based cohort study demonstrate that each indicator of socio-economic position – educational attainment, occupational skill level and income adequacy quintile – was independently associated with mortality. These findings support

Table 4. Adjusted Hazard Ratios by Cause of Death and Socio-economic Indicators, for Male Cohort Members Aged 25 to 64 Years at Baseline, 1991-2006

	Ischaemic Heart Disease	Lung Cancer	Unintentional Injury	Colorectal Cancer	Suicide	Stroke	Diabetes	COPD	Prostate Cancer	Cirrhosis of Liver	Pancreatic Cancer
Number of deaths	20,340	12,680	5207	4170	3811	3735	3001	2763	2342	2153	2027
Educational attainment											
University degree*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Post-secondary diploma	**1.33**	**1.52**	**1.32**	**1.28**	1.14	1.11	**1.54**	**1.62**	1.10	**1.51**	1.13
High school diploma	**1.52**	**2.03**	**1.74**	**1.42**	**1.44**	**1.34**	**1.57**	**2.24**	1.17	**2.24**	**1.23**
Less than high school diploma	**1.75**	**2.61**	**2.24**	**1.53**	**1.69**	**1.56**	**1.97**	**3.21**	**1.20**	**2.29**	**1.23**
Occupational skill level											
Professional*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Managerial	1.00	1.01	0.87	1.04	0.81	0.98	0.90	0.84	**1.27**	0.72	1.26
Skilled/technical/supervisory	1.04	**1.13**	**1.21**	0.98	1.09	1.15	0.88	1.00	**1.35**	0.86	1.05
Semi-skilled	**1.19**	**1.28**	**1.23**	1.00	**1.20**	**1.26**	1.13	**1.34**	**1.25**	1.06	1.14
Unskilled	**1.21**	**1.32**	**1.50**	0.98	**1.35**	**1.30**	**1.25**	**1.09**	**1.23**	1.25	1.11
No occupation	**1.79**	**1.44**	**2.03**	1.17	**2.15**	**1.90**	**1.97**	**2.28**	**1.33**	**1.89**	1.06
Income adequacy quintile											
Quintile 5 - highest*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Quintile 4	**1.08**	**1.05**	0.95	1.05	**1.15**	0.98	**1.28**	**1.48**	0.99	0.90	1.10
Quintile 3	**1.12**	**1.18**	0.94	1.03	1.06	**1.16**	**1.38**	**1.68**	1.01	0.96	1.02
Quintile 2	**1.24**	**1.23**	1.04	1.01	**1.17**	**1.24**	**1.51**	**2.00**	1.01	**1.15**	1.01
Quintile 1 - lowest	**1.53**	**1.53**	**1.52**	1.11	**1.43**	**1.71**	**2.24**	**2.99**	1.10	**1.73**	1.15

Note: The fully-adjusted model controls for age (continuous), educational attainment, occupational skill level and income adequacy quintile.
* Reference group (HR=1.00).
Bolded hazard ratio indicates significantly different (p<0.05) from reference group.
Source: 1991-2006 Canadian Census mortality and cancer follow-up study.

Table 5. Adjusted Hazard Ratios by Cause of Death and Socio-economic Indicators, for Female Cohort Members Aged 25 to 64 Years at Baseline, 1991-2006

	Lung Cancer	Breast Cancer	Ischaemic Heart Disease	Stroke	Colorectal Cancer	Unintentional Injury	Ovarian Cancer	COPD	Diabetes	Pancreatic Cancer	Suicide	Cirrhosis of Liver
Number of deaths	7453	5979	5843	2490	2453	1964	1710	1661	1629	1309	1096	931
Educational attainment												
University degree*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Post-secondary diploma	**1.67**	0.93	**1.61**	1.19	1.12	1.11	0.93	**2.58**	**1.70**	1.09	**1.45**	1.16
High school diploma	**2.18**	0.93	**2.03**	**1.33**	**1.20**	1.01	**0.81**	**2.61**	**2.02**	**1.34**	**1.37**	**1.69**
Less than high school diploma	**2.81**	**0.82**	**2.56**	**1.62**	**1.29**	**1.22**	0.84	**4.36**	**3.20**	**1.31**	1.26	**2.06**
Occupational skill level												
Professional*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Managerial	**1.25**	1.08	1.06	0.85	1.18	1.01	0.89	0.98	0.82	**1.48**	0.84	1.06
Skilled/technical/supervisory	**1.17**	1.02	0.94	0.89	0.98	1.02	1.09	1.14	0.89	1.11	0.84	1.01
Semi-skilled	**1.22**	0.95	1.09	0.94	0.94	1.10	1.05	1.11	0.88	1.00	1.05	0.97
Unskilled	**1.19**	0.93	**1.24**	0.98	0.94	**1.28**	0.98	1.02	1.17	1.14	1.31	1.16
No occupation	**1.24**	1.06	**1.64**	1.22	1.13	**1.65**	1.10	**1.92**	**1.83**	1.00	**1.57**	**1.91**
Income adequacy quintile												
Quintile 5 - highest*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Quintile 4	1.05	0.97	**1.16**	0.98	**1.14**	0.98	0.95	**1.25**	**1.41**	1.21	0.88	1.16
Quintile 3	**1.14**	1.00	**1.34**	1.07	**1.13**	1.06	0.92	**1.49**	**1.84**	1.12	0.99	1.07
Quintile 2	**1.17**	1.00	**1.56**	**1.16**	**1.22**	**1.33**	0.98	**1.76**	**2.00**	**1.26**	1.00	**1.32**
Quintile 1 - lowest	**1.53**	1.03	**2.23**	**1.69**	**1.15**	**2.26**	0.93	**2.96**	**3.23**	**1.23**	**1.78**	**2.44**

Note: The fully-adjusted model controls for age (continuous), educational aattainment, occupational skill level and income adequacy quintile.
* Reference group (HR=1.00).
Bolded hazard ratio indicates significantly different (p <0.05) from reference group.
Source: 1991-2006 Canadian Census mortality and cancer follow-up study.

the hypothesis that each indicator of socio-economic position measures different aspects of social stratification. They are not simply proxies for each other.[1,6]

At the same time, education, occupation and income are closely related: a specific level of education typically qualifies a person for an occupation, and that occupation produces a stream of income. However, there are examples of "status inconsistency" in which this general pattern does not hold. For example, some people with little formal education may become highly successful in occupations without strict entry requirements, and thus end up with higher incomes. Conversely, some people with university degrees may have jobs that generate a lower level of income than is typical. Nevertheless, in the cohort for this study, education, occupation, and income were linearly correlated. The polychoric correlation between education and occupation was strongest (0.53), followed by that between occupation and income (0.38), and that between education and income (0.30). The magnitude of those correlations indicates that education, income and occupation were not simply proxies of each other but do reflect different aspects of socio-economic position.

By controlling for different dimensions of socio-economic position, this study shows the independent effects on mortality of education, occupational skill level, and income. The mechanisms through which each of these three indicators influence health are discussed in existing literature. Education is related to the intra- and interpersonal skills that are needed to produce and maintain good health. People with higher levels of education may be better able to access and use health information and to change their

behaviours in response to prevention messages.[15-17] Income may influence health most directly through access to material resources, such as better-quality food and shelter.[18] However, income is also related to exposure to health-promoting (or risky) environments at home and in the workplace, and to the affordability of services that directly or indirectly influence health, including leisure activities, education, and health services delivered outside Canada's publicly-insured health care system.[6,19] Occupation can directly affect health through exposures to hazardous materials in the workplace.[3,18,20-22] Positive or negative influences on health may also arise as a result of the particular demands and rewards associated with different types of work, such as social networks, work-based stress, and the level of autonomy and degree of control over work conditions.[18,22,23]

Other research has also shown that persons in lower socio-economic categories are more likely to smoke, and to drink heavily.[19,24-26] Among the causes of death examined in this study, relative inequalities were greatest for those causes for which smoking or heavy drinking is an important risk factor, such as lung cancer, chronic obstructive pulmonary disease, and cirrhosis of the liver. Although this study did not control for smoking status or alcohol consumption, other studies have shown that socio-economic gradients in mortality are not eliminated by controlling for those risk factors.[27-29]

This study has certain limitations. Education, occupation and income were all self-reported and only assessed at cohort inception. Any changes in these three measures of socio-economic position during the follow-up period were not accounted for in this study. Changes in income quintile or occupational skill level are likely to be non-differential – sometimes increasing, sometimes decreasing. This should result in an attenuation of the hazard ratios, assuming that the relative risks remained unchanged. Information on risk factors such as smoking, lack of exercise or poor diet was also lacking. As such, the results may overstate somewhat the direct effects of socio-economic position on mortality. Due to the large sample size, even slight differences in hazard ratios may be statistically significant, so the practical importance of those differences should also be considered. We did not test for interactions among the three indicators of socio-economic position; that might be an interesting avenue to explore in future work.

CONCLUSION

This study demonstrates that education, occupation and income were each independently associated with mortality and were not simply proxies for each other. Examining all three indicators of socio-economic position simultaneously provides a more complete picture of socio-economic inequalities in mortality in Canada, which in turn may help to build a fuller understanding of the mechanisms underlying these associations.

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RÉSUMÉ

OBJECTIFS : Étudier les inégalités socioéconomiques influant sur la mortalité selon la cause en examinant les effets indépendants du niveau de scolarité, de la profession et du revenu dans le cadre d'une étude basée sur la population d'adultes canadiens en âge de travailler.

MÉTHODES : Il s'agit d'une analyse secondaire des données de l'étude canadienne de suivi de la mortalité et du cancer selon le recensement, 1991-2006 (n=2,7 millions de personnes). Pour cette analyse, on a créé une cohorte limitée à 2,3 millions de personnes âgées de 25 à 64 ans, dont 164 332 sont décédées durant la période de suivi. Les rapports des risques ont été calculés pour toutes les causes confondues et les causes principales de décès, selon le niveau de scolarité (4 niveaux), les compétences professionnelles (6 catégories) et la suffisance du revenu (5 quintiles). On a exécuté des modèles séparément pour les hommes et les femmes, en tenant compte de variables multiples simultanément, et certains ont été stratifiés par cohortes d'âge de 10 ans.

RÉSULTATS : L'ampleur des inégalités socioéconomiques influant sur la mortalité variait selon l'indicateur de la situation socioéconomique (niveau de scolarité, profession ou revenu), le groupe d'âge, le sexe et la cause de décès. Comparativement aux modèles ajustés en fonction de l'âge, les rapports des risques étaient atténués, mais demeuraient importants dans les modèles ajustés en fonction de l'âge et des trois indicateurs de la situation socioéconomique simultanément. Des inégalités socioéconomiques influant sur la mortalité ont été observées pour la plupart des causes principales de décès examinées.

CONCLUSION : Cette étude démontre que le niveau de scolarité, la profession et le revenu étaient tous associés de manière indépendante à la mortalité et n'étaient pas simplement des variables de substitution l'une pour l'autre. Dans le cadre de l'étude des inégalités socioéconomiques influant sur la mortalité, il est important d'utiliser différents indicateurs de la situation socioéconomique afin de brosser un tableau plus complet.

MOTS CLÉS : Canada/épidémiologie; facteurs socioéconomiques; mortalité