

Trends in socioeconomic inequalities in premature and avoidable mortality in Canada, 1991–2016

Faraz Vahid Shahidi PhD, Abtin Parnia MPH, Arjumand Siddiqi ScD

■ Cite as: *CMAJ* 2020 September 28;192:E1114-28. doi: 10.1503/cmaj.191723

ABSTRACT

BACKGROUND: Recent epidemiologic findings suggest that socioeconomic inequalities in health may be widening over time. We examined trends in socioeconomic inequalities in premature and avoidable mortality in Canada.

METHODS: We conducted a population-based repeated cohort study using the 1991, 1996, 2001, 2006 and 2011 Canadian Census Health and Environment Cohorts. We linked individual-level Census records for adults aged 25–74 years to register-based mortality data. We defined premature mortality as death before age 75 years. For each census cohort, we estimated age-standardized rates, risk differences and risk ratios for premature and

avoidable mortality by level of household income and education.

RESULTS: We identified 16284045 Census records. Between 1991 and 2016, premature mortality rates declined in all socioeconomic groups except for women without a high school diploma. Absolute income-related inequalities narrowed among men (from 2478 to 1915 deaths per 100 000) and widened among women (from 1008 to 1085 deaths per 100 000). Absolute education-related inequalities widened among men and women. Relative socioeconomic inequalities in premature mortality widened progressively over the study period. For example, the relative risk of premature mortality associated

with the lowest income quintile increased from 2.10 (95% confidence interval [CI] 2.02–2.17) to 2.79 (95% CI 2.66–2.91) among men and from 1.72 (95% CI 1.63–1.81) to 2.50 (95% CI 2.36–2.64) among women. Similar overall trends were observed for avoidable mortality.

INTERPRETATION: Socioeconomically disadvantaged groups have not benefited equally from recent declines in premature and avoidable mortality in Canada. Efforts to reduce socioeconomic inequalities and associated patterns of disadvantage are necessary to prevent this pattern of widening health inequalities from persisting or worsening over time.

A decade after the release of the World Health Organization's final report on the social determinants of health,¹ governments around the world appear to have made relatively little progress toward the goal of reducing health inequalities. In fact, recent epidemiologic findings suggest that socioeconomic inequalities in mortality and related indicators of population health are widening over time.^{2–7} Such trends are well established in the United States and Europe, yet analogous trends in Canada remain poorly characterized. Efforts to monitor the evolution of socioeconomic inequalities in mortality in Canada have been hampered by the fact that official death records lack information on the socioeconomic status of deceased people.⁸ In the absence of this information, some investigators relied on area-based measures of socioeconomic deprivation to monitor change in mortality inequalities in Canada.^{9–13} More recently, however, researchers have overcome this methodologic barrier by linking vital statistics records to individual Census data that contain relevant indicators of socioeconomic status.^{14,15}

Notably, existing analyses of individual-level trends in the mortality gradient in Canada have focused on the adult population as a whole and, in so doing, have obscured from view an important source of survivorship bias.^{14,15} Prior research has shown that those who survive into older adulthood represent a highly selected group and that positive selection for the most robust people is particularly strong at the lower end of the socioeconomic spectrum.^{16–20} This pattern of selective survival leads to the gradual convergence of average health levels over time, which, in turn, attenuates the association between socioeconomic status and mortality in older age groups. A common approach to dealing with this form of downward selection bias involves excluding the “oldest old” and focusing attention on socioeconomic inequalities in premature and avoidable mortality among adults younger than age 75 years.^{21–25}

In the present study, we aimed to examine trends in socioeconomic inequalities in premature and avoidable mortality between 1991 and 2016 in Canada using linked Census and vital registration data.

Methods

Data and sample

We conducted a population-based repeated cohort study using data from the 1991, 1996, 2001, 2006 and 2011 Canadian Census Health and Environment Cohorts.²⁶ Each cohort consists of adults among the 20% of Canadian households selected to complete the mandatory long-form Census or, in the case of the 2011 cohort, the 30% of Canadian households invited to complete the voluntary National Household Survey.²⁷ Census records were probabilistically linked to the Canadian Mortality Database covering the period 1991–2016. Our population of interest consisted of community-dwelling adults aged 25–74. We did not include adults younger than 25 owing to their exclusion from the sampling frame of the 1991 Canadian Census Health and Environment Cohort. We identified a relevant analytic sample of 16 284 045 Census records that were successfully linked to the Canadian Mortality Database.

Measures

Our exposure of interest was socioeconomic status, measured in terms of household income and education. We included both indicators as they capture different dimensions of socioeconomic inequality.^{2,28–33} We constructed household income by calculating the sum of all self-reported sources of income during the preceding calendar year. Following recent Statistics Canada and Organisation for Economic Co-operation and Development reports,^{34–38} we adjusted for household size by dividing total household income by the square root of the number of household members. Respondents were grouped into 5 equalized household income quintiles. Education was measured by means of a series of questions asking respondents to identify their highest level of educational attainment. Respondents were grouped into 1 of the following 4 categories: postsecondary degree, some postsecondary education, high school diploma or less than high school. A complete list of survey questions used to create these variables is included in Appendix 1 (available at www.cmaj.ca/lookup/doi/10.1503/cmaj.191723/tab-related-content).

Our primary outcome of interest was premature mortality, defined as death before age 75 years.³⁹ We also examined 2 components of avoidable mortality: preventable mortality, referring to causes of premature death that are potentially avoidable through primary prevention efforts (e.g., lung cancer, suicide and unintentional injuries); and amenable mortality, referring to causes of premature death that are potentially avoidable through secondary and tertiary prevention efforts (e.g., breast cancer, respiratory infections and neurologic disorders).³⁹ We coded preventable and amenable causes of death according to an established classification scheme.³⁹ We measured mortality over the 5-year period between Censuses, resulting in 5 nonoverlapping periods: June 1991–May 1996, June 1996–May 2001, June 2001–May 2006, June 2006–May 2011 and June 2011–May 2016.

Statistical analysis

We calculated age-standardized mortality rates for each socioeconomic group, stratified by sex and cohort. We used the direct method of standardization using 5-year age groups, taking the 1991

Canadian population as the reference. We quantified change in mortality rates, measured in both absolute and relative terms, by comparing the first and last time periods. We evaluated trends in the magnitude of absolute and relative inequalities in mortality across socioeconomic groups by calculating risk differences and risk ratios (RRs). We estimated RRs and corresponding 95% confidence intervals (CIs) by fitting Poisson regression models, with death as a dependent variable, socioeconomic status (i.e., household income quintile or level of educational attainment) as a categorical independent variable, and age measured in continuous years as an adjustment variable. In each model, we treated the highest socioeconomic category as the reference group.

Census respondents whose records were successfully integrated with the Canadian Mortality Database tended to be younger and more socioeconomically advantaged than the larger pool of eligible respondents. To adjust for any resulting error and account for the complex survey design, we applied sampling weights and bootstrap replicate weights provided by Statistics Canada.

We conducted all statistical analyses using Stata 16.0 (StataCorp).

Ethics approval

Data accessed through the Statistics Canada Research Data Centre Program are subject to strict confidentiality and disclosure protocols, as set out in the *Statistics Act* of Canada. These data are exempt from formal ethics review and approval, as stipulated in Article 2.2(a) of the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*.⁴⁰

Results

A description of the study population is provided in Table 1. Trends in premature and avoidable (preventable and amenable) mortality rates are presented in Table 2, Table 3 and Table 4. The figures show trends in premature (Figure 1 and Figure 2), preventable (Figure 3 and Figure 4) and amenable (Figure 5 and Figure 6) mortality inequalities by income and educational levels, respectively. Supporting data for the figures are presented in Appendix 1, Supplementary Tables S1–S6.

Premature mortality rates declined progressively over the study period in all socioeconomic groups, except for women without a high school diploma. Among men, premature mortality rates declined more steeply at the lower end of the income distribution than at the higher end. Consequently, absolute inequalities between higher- and lower-income men decreased over time. For example, the absolute risk difference (per 100 000) between men in the highest and lowest income quintiles decreased considerably over the study period, from 2478 deaths to 1915 deaths (Figure 1). This favourable pattern was somewhat reversed across levels of educational attainment, with the absolute gap between the most- and least-educated men increasing over the study period, from 1713 deaths to 1843 deaths (Figure 2). Among women, absolute inequalities widened more consistently. Absolute risk differences (per 100 000) between women in the highest and lowest income quintiles increased over time, from 1008 deaths to 1085 deaths. The absolute gap between the most- and least-educated women widened over the study period, from 792 deaths to 1119 deaths per 100 000.

Table 1: Descriptive characteristics of the Canadian Census Health and Environment Cohorts

Characteristic	Cohort; no. (%) of events/respondents*				
	1991	1996	2001	2006	2011
Men					
Observations	1 237 675	1 466 165	1 445 040	1 797 805	2 018 405
Premature deaths	38 215	41 125	37 245	45 110	45 205
Preventable deaths (avoidable)	19 702	20 495	18 465	22 900	22 410
Amenable deaths (avoidable)	9055	9570	8395	10 115	9795
Age, yr					
25–34	355 490 (28.7)	349 235 (23.8)	278 065 (19.2)	358 855 (20.0)	402 275 (19.9)
35–44	339 215 (27.4)	413 165 (28.2)	399 530 (27.6)	440 440 (24.5)	428 990 (21.3)
45–54	231 770 (18.7)	325 785 (22.2)	358 960 (24.8)	457 960 (25.5)	508 575 (25.2)
55–64	181 515 (14.7)	215 370 (14.7)	237 565 (16.4)	338 950 (18.9)	425 365 (21.1)
65–74	129 695 (10.5)	162 605 (11.1)	170 920 (11.8)	201 595 (11.2)	253 205 (12.5)
Income quintile					
Q5 (highest)	256 895 (20.8)	305 520 (20.8)	301 285 (20.8)	376 570 (20.9)	420 910 (20.9)
Q4	255 880 (20.7)	304 545 (20.8)	299 740 (20.7)	371 770 (20.7)	417 520 (20.7)
Q3	255 555 (20.6)	302 230 (20.6)	297 400 (20.6)	367 485 (20.4)	410 740 (20.3)
Q2	249 270 (20.1)	290 490 (19.8)	287 480 (19.9)	352 795 (19.6)	395 230 (19.6)
Q1 (lowest)	220 080 (17.8)	263 385 (18.0)	259 130 (17.9)	329 185 (18.3)	374 000 (18.5)
Education					
Postsecondary degree	192 635 (15.6)	243 945 (16.6)	270 030 (18.7)	379 620 (21.1)	507 690 (25.2)
Some postsecondary	375 615 (30.3)	469 780 (32.0)	483 565 (33.5)	675 970 (37.6)	782 545 (38.8)
High school diploma	229 055 (18.5)	276 665 (18.9)	277 255 (19.2)	389 480 (21.7)	426 085 (21.1)
Less than high school	440 375 (35.6)	475 775 (32.5)	414 195 (28.7)	352 735 (19.6)	302 090 (15.0)
Women					
Observations	1 240 085	1 541 860	1 513 855	1 876 300	2 146 855
Premature deaths	19 729	24 815	23 800	30 370	31 645
Preventable deaths (avoidable)	7655	9770	9240	12 525	13 015
Amenable deaths (avoidable)	6580	7675	7190	8825	9045
Age, yr					
25–34	387 760 (31.3)	376 285 (24.4)	309 465 (20.4)	378 680 (20.2)	428 915 (20.0)
35–44	352 615 (28.4)	433 165 (28.1)	427 955 (28.3)	458 110 (24.4)	458 085 (21.3)
45–54	217 060 (17.5)	330 210 (21.4)	366 010 (24.2)	473 160 (25.2)	539 380 (25.1)
55–64	154 180 (12.4)	219 330 (14.2)	230 295 (15.2)	346 965 (18.5)	450 790 (21.0)
65–74	128 465 (10.4)	182 875 (11.9)	180 130 (11.9)	219 390 (11.7)	269 690 (12.6)
Income quintile					
Q5 (highest)	238 660 (19.2)	296 090 (19.2)	290 465 (19.2)	358 230 (19.1)	412 130 (19.2)
Q4	239 690 (19.3)	297 070 (19.3)	292 075 (19.3)	363 095 (19.4)	415 550 (19.4)
Q3	239 990 (19.4)	299 370 (19.4)	294 390 (19.4)	367 320 (19.6)	422 305 (19.7)
Q2	246 285 (19.9)	311 135 (20.2)	304 290 (20.1)	382 040 (20.4)	437 845 (20.4)
Q1 (lowest)	275 465 (22.2)	338 200 (21.9)	332 640 (22.0)	405 615 (21.6)	459 030 (21.4)
Education					
Postsecondary degree	152 195 (12.3)	215 775 (14.0)	262 125 (17.3)	396 465 (21.1)	567 460 (26.4)
Some postsecondary	348 560 (28.1)	460 680 (29.9)	487 680 (32.2)	671 925 (35.8)	791 080 (36.8)
High school diploma	303 375 (24.5)	360 080 (23.4)	344 320 (22.7)	462 080 (24.6)	495 630 (23.1)
Less than high school	435 955 (35.2)	505 335 (32.8)	419 740 (27.7)	345 835 (18.5)	292 680 (13.6)

*Reported frequencies are randomly rounded to the nearest 5, as per Statistics Canada requirements.

Among both men and women, we observed a secular increase in relative inequalities in premature mortality by income. The Q1/Q5 RR grew progressively larger over the study period, from 2.10 (95% CI 2.02–2.17) to 2.79 (95% CI 2.66–2.91) among men and from 1.72 (95% CI 1.63–1.81) to 2.50 (95% CI 2.36–2.64) among women (Figure 1). Risk ratios associated with the remaining quintiles of the income distribution showed similar, though less pronounced, trends over time. Relative educational inequalities in premature mortality also widened gradually over the study period. For example, among men and women without a high school diploma, the relative risk of premature mortality increased from 1.98 (95% CI 1.90–2.07) to 2.60 (95% CI 2.48–2.72) and from 1.82 (95% CI 1.69–1.95) to 2.31 (95% CI 2.18–2.44), respectively (Figure 2).

Similar overall trends were observed for avoidable (i.e., preventable and amenable) mortality. We observed some distinguishable cause-specific trends, however, and these trends were patterned by sex. For example, in contrast to large secular declines among men in all socioeconomic groups, women with a high

school diploma or less experienced little to no improvements in preventable mortality over the study period. Among men, there were larger absolute reductions in preventable mortality inequalities over time. In contrast, women experienced larger absolute reductions in amenable mortality inequalities over the study period. Relative inequalities in preventable and amenable mortality increased at a comparable pace among men, whereas relative inequalities in preventable mortality rose more steeply than corresponding inequalities in amenable mortality among women.

Interpretation

We found that premature and avoidable mortality rates declined in most socioeconomic groups in Canada between 1991 and 2016. However, socioeconomically disadvantaged groups did not benefit equally from these overall decreases in mortality. Among women without a high school diploma, premature mortality rates persisted, and, more strikingly, avoidable mortality attributable to preventable causes of death increased. Owing to the

Table 2: Trends in premature mortality across socioeconomic groups in Canada, 1991–2016

Characteristic	Period; age-standardized mortality rate (per 100 000)					Change, 1991 to 2016	
	1991–1996	1996–2001	2001–2006	2006–2011	2011–2016	Absolute	Relative, %
Men							
Overall	2922	2478	2131	1945	1735	–1187	–40.6
Income quintile							
Q5 (highest)	2055	1640	1347	1233	1064	–991	–48.2
Q4	2430	1995	1694	1486	1287	–1143	–47.0
Q3	2689	2278	1946	1768	1521	–1168	–43.4
Q2	3137	2767	2343	2123	1970	–1167	–37.2
Q1 (lowest)	4533	3921	3524	3282	2979	–1554	–34.3
Education							
Postsecondary degree	1873	1478	1285	1114	988	–885	–47.2
Some postsecondary	2632	2218	1955	1862	1688	–944	–35.9
High school diploma	2835	2467	2134	2111	2006	–829	–29.2
Less than high school	3586	3203	2922	2876	2831	–755	–21.0
Women							
Overall	1569	1405	1316	1250	1126	–443	–28.2
Income quintile							
Q5 (highest)	1206	1059	972	807	717	–489	–40.5
Q4	1328	1207	1051	953	844	–484	–36.4
Q3	1441	1288	1212	1136	996	–445	–30.9
Q2	1557	1413	1315	1296	1195	–362	–23.2
Q1 (lowest)	2214	1979	1942	1967	1802	–412	–18.6
Education							
Postsecondary degree	1086	942	871	788	723	–363	–33.4
Some postsecondary	1332	1186	1121	1111	1029	–303	–22.7
High school diploma	1450	1298	1275	1298	1289	–161	–11.1
Less than high school	1878	1752	1766	1928	1842	–36	–1.9

uneven distribution patterning of recent decreases in mortality, relative socioeconomic inequalities in premature and avoidable mortality increased substantially among men and women between 1991 and 2016. Absolute education-related inequalities also widened consistently over the study period, whereas absolute income-related inequalities narrowed among men and widened among women.

Our results are similar to those reported in previous studies examining trends in socioeconomic inequalities in mortality in Canada.^{9–15} However, our findings indicate that socioeconomic inequalities in premature and avoidable mortality are substantially wider than corresponding inequalities in overall mortality. More important, perhaps, they show that recent adverse trends in the relative magnitude of premature and avoidable mortality inequalities are also more pronounced. For example, whereas a previous study using the same data to examine trends in overall mortality showed that relative inequalities between the highest and lowest income quintiles increased by 12% among men and by 21% among women between 1991 and 2011,¹⁵ we found that,

over the same period, relative inequalities in premature mortality increased by 33% among men and by 47% among women. Our findings are also consistent with the broader international literature on this topic. For example, recent studies have shown that relative socioeconomic inequalities in overall and premature mortality have widened substantially in most European countries, whereas absolute inequalities have declined in some cases and increased in others.^{3,24,41,42} Widening overall and premature mortality inequalities have also been reported in the US, where, in absolute terms at least, adverse trends have been more pronounced.^{2,4–6,43–45} Indeed, after several decades of secular gains in life expectancy among all socioeconomic groups in the US, mortality rates have started to rise among the lowest-earning and least-educated Americans. Similarly, in the present study, we observed a startling lack of decline in mortality rates among women with lower educational attainment, particularly for causes of death that are potentially avoidable through primary intervention strategies. In fact, contrary to the generally declining mortality rates observed in all other socioeconomic groups,

Table 3: Trends in preventable (avoidable) mortality across socioeconomic groups in Canada, 1991–2016

Characteristic	Period; age-standardized mortality rate (per 100 000)					Change, 1991 to 2016	
	1991–1996	1996–2001	2001–2006	2006–2011	2011–2016	Absolute	Relative, %
Men							
Overall	1523	1241	1070	996	896	–627	–41.2
Income quintile							
Q5 (highest)	1026	769	631	590	536	–490	–47.8
Q4	1201	962	816	734	608	–593	–49.4
Q3	1376	1111	967	896	781	–595	–43.2
Q2	1657	1390	1193	1102	1024	–633	–38.2
Q1 (lowest)	2494	2096	1854	1757	1616	–878	–35.2
Education							
Postsecondary degree	910	652	560	504	442	–468	–51.4
Some postsecondary	1323	1074	949	944	876	–447	–33.8
High school diploma	1436	1238	1045	1070	1015	–421	–29.3
Less than high school	1929	1672	1561	1564	1577	–352	–18.2
Women							
Overall	606	546	511	512	468	–138	–22.8
Income quintile							
Q5 (highest)	428	365	327	294	258	–170	–39.7
Q4	474	445	366	350	317	–157	–33.1
Q3	526	461	442	432	393	–133	–25.3
Q2	604	567	530	535	500	–104	–17.2
Q1 (lowest)	945	847	842	901	830	–115	–12.2
Education							
Postsecondary degree	316	288	278	256	235	–81	–25.6
Some postsecondary	485	448	406	437	426	–59	–12.2
High school diploma	523	470	488	540	537	14	2.7
Less than high school	780	735	752	878	874	94	12.0

our results suggest that preventable mortality has increased among women without a high school diploma. Thus, although our results suggest that mortality rates have evolved more favourably among socioeconomically disadvantaged groups in Canada than among their counterparts in the US, the fact that declines in premature mortality have stalled or, for some causes, even reversed among the most socioeconomically disadvantaged women raises pressing concerns with respect to the pursuit of health and gender equity in Canada.⁴⁷

There are numerous possible explanations for our findings. First, and perhaps most important, inequalities in mortality may be widening owing to contemporaneous trends in social determinants of health.^{48–51} Over the past 3 decades, large-scale policy shifts in Canada have contributed to rising levels of income inequality and a weakened social safety net (e.g., as indicated by the declining generosity and coverage of key social programs, such as employment insurance and social assistance).^{52–54} These societal trends are not unique to Canada and may, in turn, explain why the health of socioeconomically disadvantaged groups is lag-

ging further and further behind that of their more advantaged counterparts in numerous jurisdictions, including the US and peer countries in Europe.^{4,55–60} Changing social and economic conditions may also explain why mortality rates have stalled or increased among women with lower levels of education. Evidence suggests, for example, that women rely more heavily than men on government transfers as a source of income and that declines in the generosity and coverage of these programs have disproportionately affected the most socioeconomically disadvantaged women.^{61,62} Furthermore, although participation in the labour market has increased substantially among women with lower education levels, they face major barriers to gainful and secure employment — barriers that are potentially compounded by persisting gender inequities in caregiving responsibilities.^{63,64}

Second, socioeconomic lags in the diffusion of new technologies (e.g., in medical care) and interventions (e.g., in health promotion) are well established.^{65–67} In Canada, for example, higher socioeconomic groups have benefited more from the implementation of routine public health interventions aimed at reducing

Table 4: Trends in amenable (avoidable) mortality across socioeconomic groups in Canada, 1991–2016

Characteristic	Period; age-standardized mortality rate (per 100 000)					Change, 1991 to 2016	
	1991–1996	1996–2001	2001–2006	2006–2011	2011–2016	Absolute	Relative, %
Men							
Overall	677	564	465	420	359	–318	–47.0
Income quintile							
Q5 (highest)	469	373	296	270	202	–267	–56.9
Q4	593	459	355	317	278	–315	–53.1
Q3	634	514	417	374	307	–327	–51.6
Q2	722	641	515	455	397	–325	–45.0
Q1 (lowest)	1017	878	786	721	641	–376	–37.0
Education							
Postsecondary degree	414	346	280	236	213	–201	–48.6
Some postsecondary	638	509	429	403	343	–295	–46.2
High school diploma	683	565	474	469	430	–253	–37.0
Less than high school	816	721	638	605	566	–250	–30.6
Women							
Overall	520	435	395	364	317	–203	–39.0
Income quintile							
Q5 (highest)	413	366	309	254	225	–188	–45.5
Q4	454	391	343	296	259	–195	–43.0
Q3	479	420	377	345	263	–216	–45.1
Q2	529	406	377	365	335	–194	–36.7
Q1 (lowest)	698	574	549	539	486	–212	–30.4
Education							
Postsecondary degree	414	324	294	266	233	–181	–43.7
Some postsecondary	462	366	347	331	288	–174	–37.7
High school diploma	507	426	392	373	360	–147	–29.0
Less than high school	599	514	495	517	481	–118	–19.7

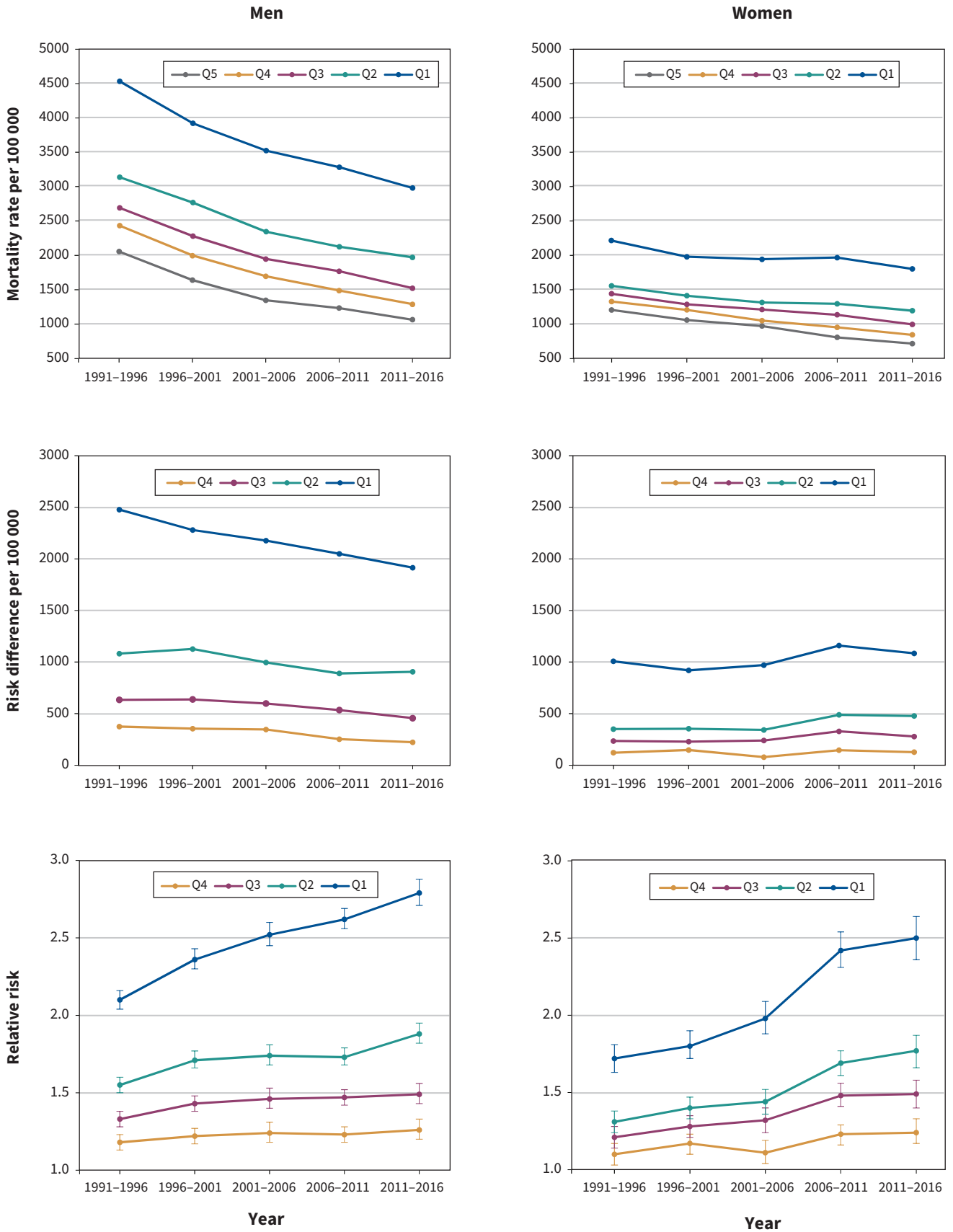


Figure 1: Trends in inequalities in premature mortality by income quintile in Canada, 1991–2016. Q5 = highest quintile, Q1 = lowest quintile. Q1 to Q4 were compared to Q5. Error bars represent 95% confidence interval.

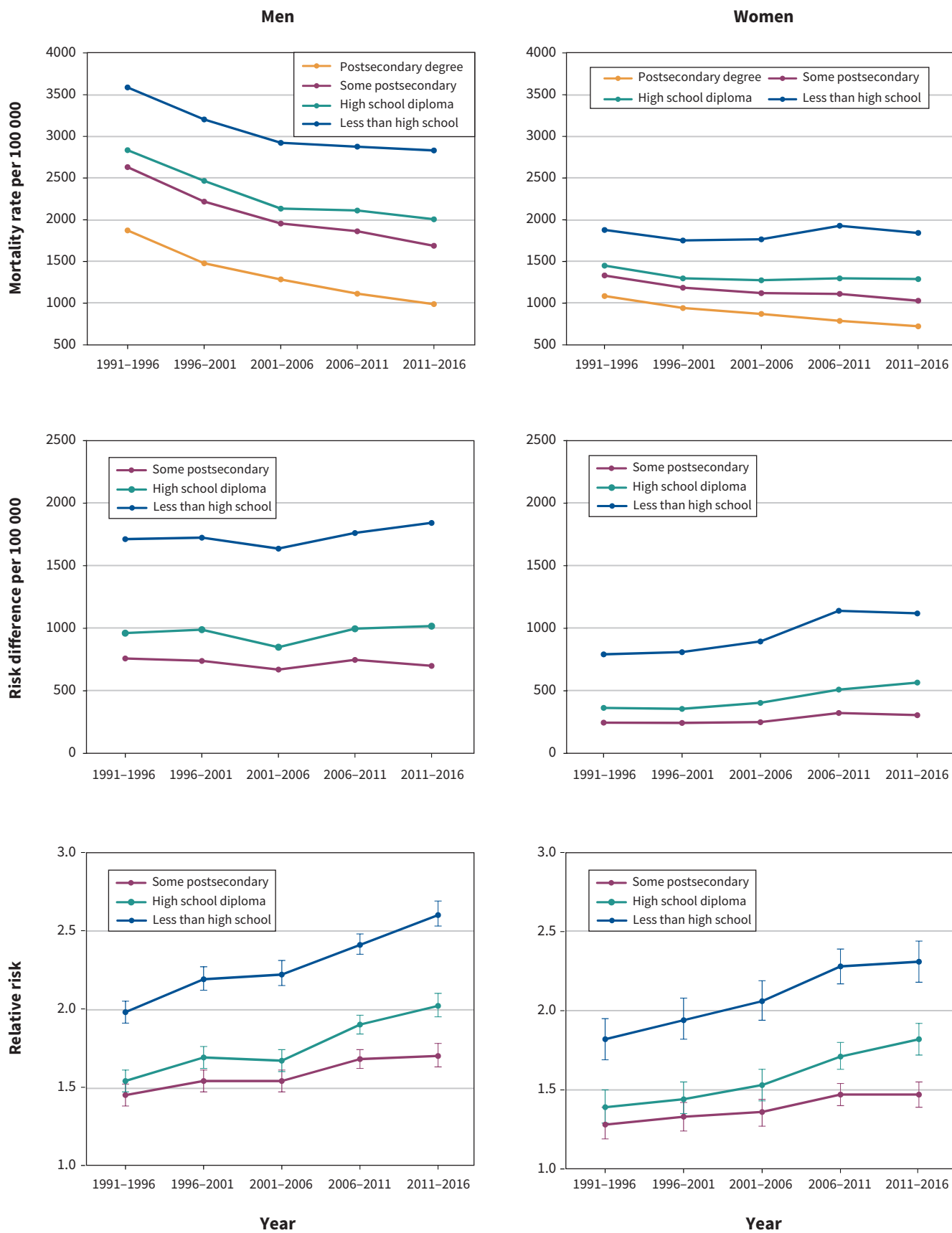


Figure 2: Trends in inequalities in premature mortality by education level in Canada, 1991–2016. The comparator was postsecondary degree. Error bars represent 95% confidence interval.

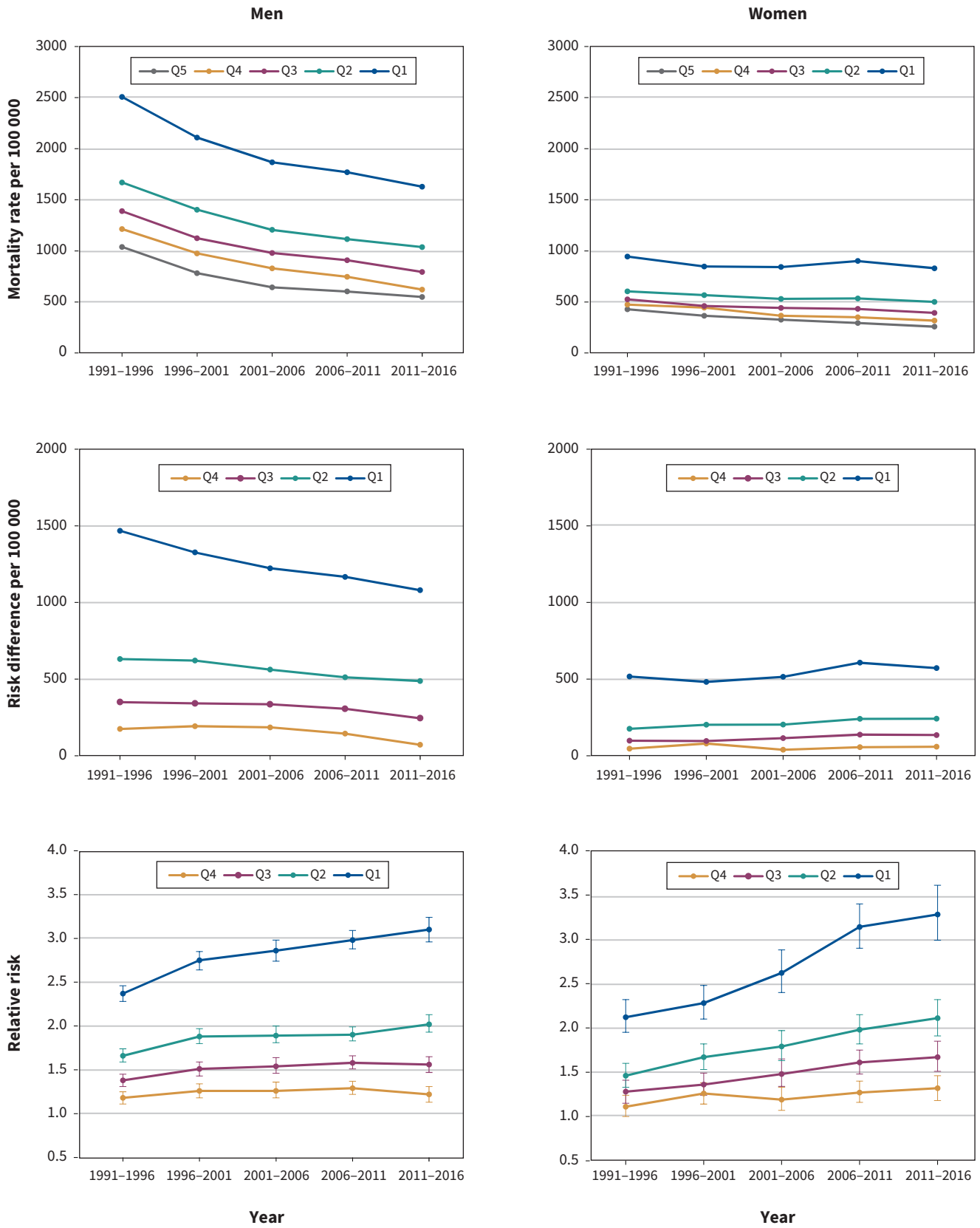


Figure 3: Trends in inequalities in preventable (avoidable) mortality by income quintile in Canada, 1991-2016. Q5 = highest quintile, Q1 = lowest quintile. Q1 to Q4 were compared to Q5. Error bars represent 95% confidence interval.

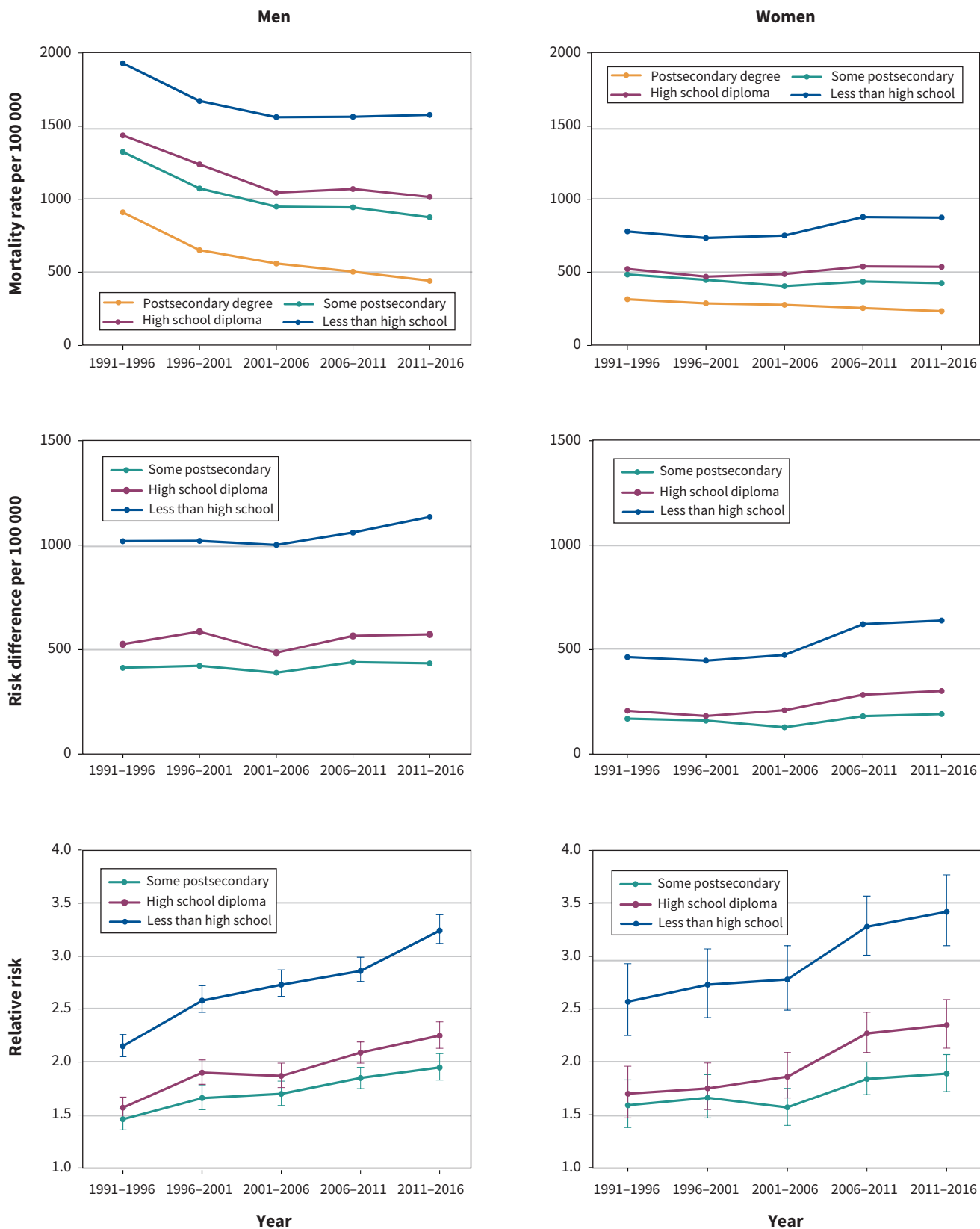


Figure 4: Trends in inequalities in preventable (avoidable) mortality by education level in Canada, 1991–2016. The comparator was postsecondary degree. Error bars represent 95% confidence interval.

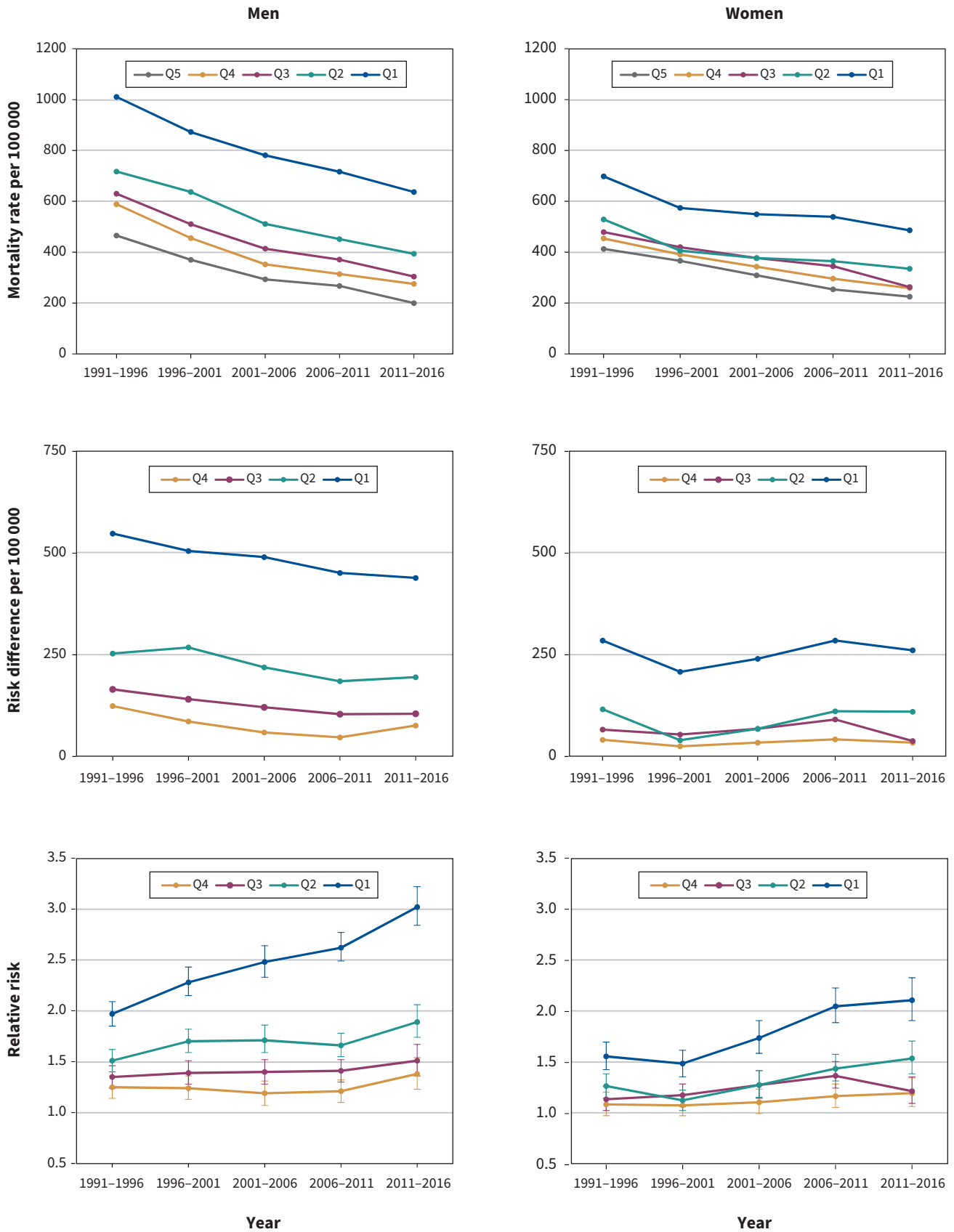


Figure 5: Trends in inequalities in amenable (avoidable) mortality by income quintile in Canada, 1991–2016. Q5 = highest quintile, Q1 = lowest quintile. Q1 to Q4 were compared to Q5. Error bars represent 95% confidence interval.

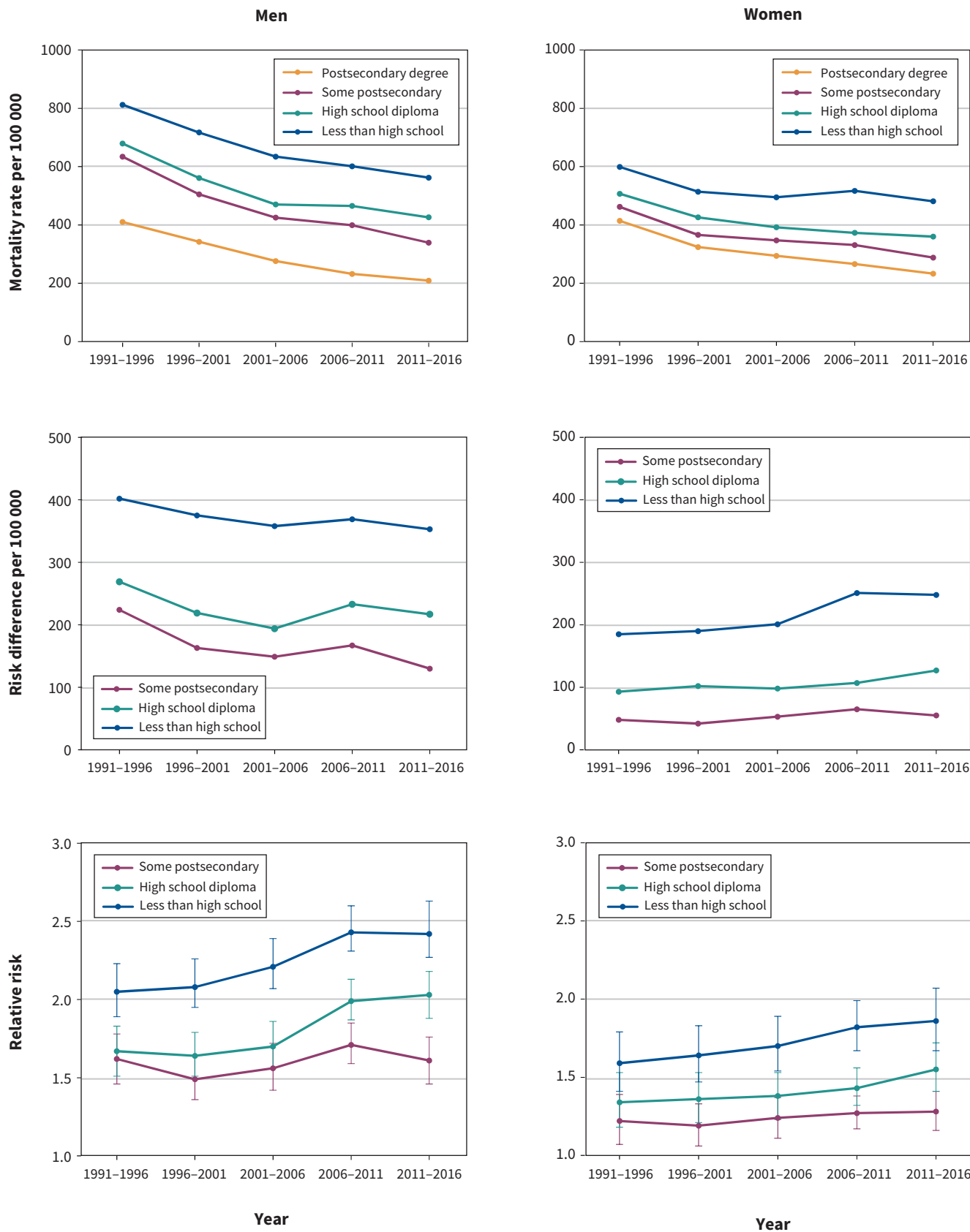


Figure 6: Trends in inequalities in amenable (avoidable) mortality by education level in Canada, 1991–2016. The comparator was postsecondary degree. Error bars represent 95% confidence interval.

risk factors such as smoking and physical inactivity.^{68,69} Differential access and uptake between socioeconomic groups may, in turn, give rise to increasing mortality inequalities over time. Given that, historically, the prevalence of these risk factors has been higher among men, it is perhaps not surprising to find, as we have in this study, that recent improvements in preventable and avoidable mortality are also more heavily concentrated in men, particularly at the lower end of the socioeconomic spectrum. This finding is consistent, for example, with evidence that lower-educated men have experienced larger absolute and relative declines in smoking prevalence than lower-educated women over the last several decades.^{69,70}

Third, as socioeconomic circumstances improve within a population (e.g., owing to increasing levels of educational attainment), those who fall in the lowest categories of socioeconomic status may represent a more negatively selected group of people.^{71,72} For example, the composition of these groups may change over time such that they are more heavily composed of people with chronic diseases and disabilities.^{73,74} Given that educational expansion has progressed more rapidly for women than men,⁷⁵ resulting selection effects may also be stronger among women, and, accordingly, this may be an important factor contributing to the overall more negative mortality trends observed among lower-educated women in Canada.^{76–78}

Finally, research has shown that relative inequalities in mortality have a tendency to increase as absolute mortality rates decrease.^{79–81} Larger absolute reductions in mortality among men may also explain why the absolute income-related gradient narrowed in men but not in women. Indeed, our findings suggest that improvements in public health and health care have contributed substantially toward mitigating premature mortality among men, particularly at the lower end of the socioeconomic spectrum, but much less so among women.

Limitations

We relied on self-reported measures of income and education, which may have been subject to response biases. Second, although we attempted to correct for differential probabilities of Census response and record linkage using sampling weights provided by Statistics Canada, we have no way of evaluating the extent to which our analyses are affected by any resulting selection bias. Third, owing to the voluntary nature of the National Household Survey, it is likely that estimates based on the 2011 survey (response rate 68.6%) are less representative than findings from the earlier cohorts, which were based on the mandatory long-form Census. However, to assess the resulting impact on data quality, Statistics Canada conducted extensive sensitivity analyses and determined that the National Household Survey data are of sufficient high quality to produce precise and comparable estimates in population-based studies.⁸² Fourth, our study did not consider the impact of the changing demographic composition of the Canadian population (e.g., due to urbanization and immigration) on differential mortality trends across socioeconomic groups, and future research could explore this. Finally, our study provides only a broad view of trends in cause-specific (i.e., preventable and amenable) inequalities in mortality. Further research involving a

deeper analysis of specific causes of death — and for men and women separately — may be useful for highlighting where Canada has made the most (and the least) progress toward health equity. Such work may also reveal the underlying mechanisms contributing to the trends observed in this study, including the discernible differences between men and women.⁸³ In particular, more detailed cause-specific analyses are needed to better understand why premature mortality rates have stalled (and for some causes even risen) among lower-educated women.

Conclusion

Our findings indicate that Canada has made no overall progress toward the goal of reducing socioeconomic inequalities in premature and avoidable mortality. In fact, the strength of the association between socioeconomic status and mortality appears to have increased substantially between 1991 and 2016. Efforts to reduce socioeconomic inequalities and associated patterns of disadvantage are necessary to prevent this pattern of widening health inequalities from persisting or worsening over time.

References

1. Commission on Social Determinants of Health. *Closing the gap in a generation: health equity through action on the social determinants of health. Final report of the Commission on Social Determinants of Health.* Geneva: World Health Organization; 2008.
2. Bosworth B. Increasing disparities in mortality by socioeconomic status. *Annu Rev Public Health* 2018;39:237-51.
3. Mackenbach JP, Valverde JR, Artnik B, et al. Trends in health inequalities in 27 European countries. *Proc Natl Acad Sci U S A* 2018;115:6440-5.
4. Bor J, Cohen GH, Galea S. Population health in an era of rising income inequality: USA, 1980–2015. *Lancet* 2017;389:1475-90.
5. Case A, Deaton A. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proc Natl Acad Sci U S A* 2015;112:15078-83.
6. Chetty R, Stepner M, Abraham S, et al. The association between income and life expectancy in the United States, 2001–2014. *JAMA* 2016;315:1750-66.
7. Hajizadeh M, Mitnitski A, Rockwood K. Socioeconomic gradient in health in Canada: Is the gap widening or narrowing? *Health Policy* 2016;120:1040-50.
8. Tjepkema M, Wilkins R, Long A. Socio-economic inequalities in cause-specific mortality: a 16-year follow-up study. *Can J Public Health* 2013;104:e472-8.
9. Baker M, Currie J, Schwandt H. Mortality inequality in Canada and the United States: Divergent or convergent trends? *J Labor Econ* 2019;37(Suppl 2):S325-53.
10. Buajitti E, Watson T, Kornas K, et al. *Ontario atlas of adult mortality 1992–2015: trends in Local Health Integration Networks.* Toronto: Population Health Analytics Lab; 2018.
11. Buajitti E, Frank J, Watson T, et al. Changing relative and absolute socioeconomic health inequalities in Ontario, Canada: a population-based cohort study of adult premature mortality, 1992 to 2017. *PLoS One* 2020;15:e0230684.
12. Pampalon R, Hamel D, Gamache P. Recent changes in the geography of social disparities in premature mortality in Quebec. *Soc Sci Med* 2008;67:1269-81.
13. Zygmunt A, Kendall CE, James P, et al. Avoidable mortality rates decrease but inequity gaps widen for marginalized neighborhoods: a population-based analysis in Ontario, Canada from 1993 to 2014. *J Community Health* 2020;45:579-97.
14. Bushnik T, Tjepkema M, Martel L. Socioeconomic disparities in life and health expectancy among the household population in Canada. *Health Rep* 2020;31:3-14.
15. Marshall-Catlin E, Bushnik T, Tjepkema M. Trends in mortality inequalities among the adult household population. *Health Rep* 2019;30:11-7.
16. Baeten S, Van Ourti T, Van Doorslaer E. The socioeconomic health gradient across the life cycle: What role for selective mortality and institutionalization? *Soc Sci Med* 2013;97:66-74.
17. Hoffmann R. Illness, not age, is the leveler of social mortality differences in old age. *J Gerontol B Psychol Sci Soc Sci* 2011;66:374-9.
18. Ma J, Altekruse S, Cosgrove C, et al. Educational disparities in mortality between adults aged 50–64 and 66–79 years, U.S. *Am J Prev Med* 2017;52:728-34.

19. Rehnberg J, Fors S, Fritzell J. Divergence and convergence: How do income inequalities in mortality change over the life course? *Gerontology* 2019;65:313-22.
20. Zajacova A, Burgard SA. Healthier, wealthier, and wiser: a demonstration of compositional changes in aging cohorts due to selective mortality. *Popul Res Policy Rev* 2013;32:311-24.
21. Blakely T, Disney G, Atkinson J, et al. A typology for charting socioeconomic mortality gradients: “go southwest. *Epidemiology* 2017;28:594-603.
22. Lewer D, Jayatunga W, Aldridge RW, et al. Premature mortality attributable to socioeconomic inequality in England between 2003 and 2018: an observational study. *Lancet Public Health* 2020;5:e33-41.
23. Ma J, Siegel RL, Ward EM, et al. State-level educational disparities in mortality in the United States, 2010–2014. *Prev Med* 2018;106:53-9.
24. Mackenbach JP, Kulháňová I, Menvielle G, et al.; Eurothine and EURO-GBD-SE consortiums. Trends in inequalities in premature mortality: a study of 3.2 million deaths in 13 European countries. *J Epidemiol Community Health* 2015;69:207-17, discussion 205-6.
25. Zygumant A, Tanuseputro P, James P, et al. Neighbourhood-level marginalization and avoidable mortality in Ontario, Canada: a population-based study. *Can J Public Health* 2020;111:169-81.
26. Tjepkema M, Christidis T, Bushnik T, et al. Cohort profile: the Canadian Census Health and Environment Cohorts (CanCHECs). *Health Rep* 2019;30:18-26.
27. National Household Survey (NHS). Ottawa: Statistics Canada; 2013. Available: www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5178 (accessed 2020 Sept. 14).
28. Bleich SN, Jarlenski MP, Bell CN, et al. Health inequalities: trends, progress, and policy. *Annu Rev Public Health* 2012;33:7-40.
29. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic status in health research: one size does not fit all. *JAMA* 2005;294:2879-88.
30. Geyer S, Hemström Ö, Peter R, et al. Education, income, and occupational class cannot be used interchangeably in social epidemiology. Empirical evidence against a common practice. *J Epidemiol Community Health* 2006;60:804-10.
31. Green MJ, Popham F. Interpreting mutual adjustment for multiple indicators of socioeconomic position without committing mutual adjustment fallacies. *BMC Public Health* 2019;19:10.
32. Kino S, Kawachi I. How much do preventive health behaviors explain education- and income-related inequalities in health? Results of a Oaxaca–Blinder decomposition analysis. *Ann Epidemiol* 2020;43:44-50.
33. Oakes JM, Andrade KE. The measurement of socioeconomic status. In: Oakes JM, Kaufman JS, editors. *Methods in social epidemiology*. San Francisco: Jossey-Bass; 2017:23-42.
34. *What are equivalence scales?* Paris: Organisation for Economic Co-operation and Development; 2011.
35. Organisation for Economic Co-operation and Development. *In it together: why less inequality benefits all — overview of inequality trends, key findings and policy directions*. Paris: OECD Publishing; 2015.
36. Organisation for Economic Co-operation and Development. *Divided we stand: why inequality keeps rising*. Paris: OECD Publishing; 2011.
37. Sanmartin C, Hennessy D, Lu Y, et al. Trends in out-of-pocket health care expenditures in Canada, by household income, 1997 to 2009. *Health Rep* 2014; 25:13-7.
38. Canadian Income Survey, 2018. Ottawa: Statistics Canada; 2020. Available: www150.statcan.gc.ca/n1/daily-quotidien/200224/dq200224a-eng.htm (accessed 2020 Apr. 10).
39. *Health indicators 2012*. Ottawa: Canadian Institute for Health Information; 2012.
40. *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*. Ottawa: Interagency Secretariat on Research Ethics; 2014.
41. Mackenbach JP, Kulháňová I, Artnik B, et al. Changes in mortality inequalities over two decades: register based study of European countries. *BMJ* 2016;353: i1732.
42. Mackenbach JP, Hu Y, Artnik B, et al. Trends in inequalities in mortality amenable to health care in 17 European countries. *Health Aff (Millwood)* 2017;36:1110-8.
43. Krieger N, Rehkopf D, Chen JT, et al. The fall and rise of US inequities in premature mortality: 1960–2002. *PLoS Med* 2008;5:e46.
44. Meara ER, Richards S, Cutler DM. The gap gets bigger: changes in mortality and life expectancy, by education, 1981–2000. *Health Aff (Millwood)* 2008;27:350-60.
45. Montez JK, Zajacova A, Hayward MD, et al. Educational disparities in adult mortality across US states: How do they differ, and have they changed since the mid-1980s? *Demography* 2019;56:621-44.
46. Olshansky SJ, Antonucci T, Berkman L, et al. Differences in life expectancy due to race and educational differences are widening, and many may not catch up. *Health Aff (Millwood)* 2012;31:1803-13.
47. Stewart M, Kushner KE, Gray J, et al. Promoting gender equity through health research: impacts and insights from a Canadian initiative. *Glob Health Promot* 2013;20:25-38.
48. Adler NE, Newman K. Socioeconomic disparities in health: pathways and policies. *Health Aff (Millwood)* 2002;21:60-76.
49. Braveman P, Gottlieb L. The social determinants of health: it’s time to consider the causes of the causes. *Public Health Rep* 2014;129(Suppl 2):19-31.
50. Marmot M, Friel S, Bell R, et al.; Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet* 2008;372:1661-9.
51. Raphael D, editor. *Social determinants of health: Canadian perspectives*. 2nd ed. Toronto: Canadian Scholars’ Press; 2009.
52. Banting K, Myles J, editors. *Inequality and the fading of redistributive politics*. Vancouver: UBC Press; 2013.
53. Green DA, Riddell WC, St. Hilaire F, editors. *Income inequality: the Canadian story*. Montréal: Institute for Research on Public Policy; 2016.
54. Bryant T, Raphael D, Schrecker T, et al. Canada: a land of missed opportunity for addressing the social determinants of health. *Health Policy* 2011;101:44-58.
55. Dutton DJ, Forest PG, Kneebone RD, et al. Effect of provincial spending on social services and health care on health outcomes in Canada: an observational longitudinal study. *CMAJ* 2018;190:E66-71.
56. McCartney G, Collins C, Mackenzie M. What (or who) causes health inequalities: theories, evidence and implications. *Health Policy* 2013;113:221-7.
57. Raphael D, Bryant T. Maintaining population health in a period of welfare state decline: political economy as the missing dimension in health promotion theory and practice. *Promot Educ* 2006;13:236-42.
58. Siddiqi A, Kawachi I, Keating DP, et al. A comparative study of population health in the United States and Canada during the neoliberal era, 1980–2008. *Int J Health Serv* 2013;43:193-216.
59. Keeley B. *Income inequality: the gap between rich and poor*. Paris: OECD Publishing; 2015.
60. Mackenbach JP, Valverde JR, Bopp M, et al. Progress against inequalities in mortality: register-based study of 15 European countries between 1990 and 2015. *Eur J Epidemiol* 2019;34:1131-42.
61. Fox D, Moser M. Women in Canada: a gender-based statistical report — the economic well-being of women in Canada. Ottawa: Statistics Canada; 2018. Available: www150.statcan.gc.ca/n1/pub/89-503-x/2015001/article/54930-eng.htm (accessed 2020 May 22).
62. Davis M. *Workers left outside the El umbrella: explanations and a simple solution*. Toronto: Mowat Centre for Policy Innovation; 2012.
63. Jenson J. The fading goal of gender equality: three policy directions that underpin the resilience of gendered socio-economic inequalities. *Soc Polit* 2015;22:539-60.
64. Vosko LF, Clark LF. Canada: gendered precariousness and social reproduction. In: Vosko LF, MacDonald M, Campbell I, editors. *Gender and the contours of precarious employment*. London (UK), New York: Routledge Press; 2009:26-42.
65. Capewell S, Graham H. Will cardiovascular disease prevention widen health inequalities? *PLoS Med* 2010;7:e1000320.
66. Weiss D, Rydland HT, Øversveen E, et al. Innovative technologies and social inequalities in health: a scoping review of the literature. *PLoS One* 2018;13: e0195447.
67. White M, Adams J, Heywood P. How and why do interventions that increase health overall widen inequalities within populations. In: Babones S, editor. *Social inequality and public health*. Bristol (UK): Polity Press; 2009:65-82.
68. Smoke-Free Ontario Scientific Advisory Committee; Ontario Agency for Health Protection and Promotion (Public Health Ontario). Smoke-Free Ontario Scientific Advisory Committee 2010 report. In: *Evidence to guide action: comprehensive tobacco control in Ontario (2016)*. Toronto: Queen’s Printer for Ontario; 2017:18.
69. Smith P, Frank J, Mustard C. Trends in educational inequalities in smoking and physical activity in Canada: 1974–2005. *J Epidemiol Community Health* 2009;63: 17-23.
70. Corsi DJ, Boyle MH, Lear SA, et al. Trends in smoking in Canada from 1950 to 2011: progression of the tobacco epidemic according to socioeconomic status and geography. *Cancer Causes Control* 2014;25:45-57.
71. Bound J, Geronimus AT, Rodriguez JM, et al. Measuring recent apparent declines in longevity: the role of increasing educational attainment. *Health Aff (Millwood)* 2015;34:2167-73.

72. Montez JK, Zajacova A, Hayward MD, et al. Educational disparities in adult mortality across US states: How do they differ, and have they changed since the mid-1980s? *Demography* 2019;56:621-44.
73. Hoffman R, Kröger H, Pakpahan E. Pathways between socioeconomic status and health: Does health selection or social causation dominate in Europe? *Adv Life Course Res* 2018;36:23-36.
74. Mackenbach JP. The persistence of health inequalities in modern welfare states: the explanation of a paradox. *Soc Sci Med* 2012;75:761-9.
75. Turcotte M. *Women and education*. Ottawa: Statistics Canada; 2011, modified 2015 Oct. 30. Available: www150.statcan.gc.ca/n1/pub/89-503-x/2010001/article/11542-eng.htm (accessed 2020 May 22).
76. Dowd JB, Hamoudi A. Is life expectancy really falling for groups of low socioeconomic status? Lagged selection bias and artefactual trends in mortality. *Int J Epidemiol* 2014;43:983-8.
77. Montez JK, Hummer RA, Hayward MD, et al. Trends in the educational gradient of U.S. adult mortality from 1986 to 2006 by race, gender, and age group. *Res Aging* 2011;33:145-71.
78. Östergren O, Lundberg O, Artnik B, et al. Educational expansion and inequalities in mortality — a fixed-effects analysis using longitudinal data from 18 European populations. *PLoS One* 2017;12:e0182526.
79. Eikemo TA, Skalická V, Avendano M. Variations in relative health inequalities: Are they a mathematical artefact? *Int J Equity Health* 2009;8:32.
80. Houweling TA, Kunst AE, Huisman M, et al. Using relative and absolute measures for monitoring health inequalities: experiences from cross-national analyses on maternal and child health. *Int J Equity Health* 2007;6:15.
81. Mackenbach JP. Should we aim to reduce relative or absolute inequalities in mortality? *Eur J Public Health* 2015;25:185.
82. Smith WR. The 2011 National Household Survey — the complete statistical story. Ottawa: Statistics Canada; 2015. Available: www.statcan.gc.ca//eng/blog-blogue/cs-sc/2011NHSstory (accessed 2020 Apr. 10).
83. Stein EM, Gennuso KP, Ugboaja D, et al. The epidemic of despair among white Americans: trends in the leading causes of premature death, 1999–2015. *Am J Public Health* 2017;107:1541-7.

Competing interests: None declared.

This article has been peer reviewed.

Affiliations: Institute for Work & Health (Shahidi); Dalla Lana School of Public Health (Parnia, Siddiqi), University of Toronto, Toronto, Ont.; Gillings School of Public Health (Siddiqi), University of North Carolina, Chapel Hill, NC

Contributors: Faraz Shahidi and Abtin Parnia acquired and analyzed the data. All of the authors conceptualized and designed the study, interpreted the data, drafted the manuscript and revised it critically for important intellectual context, approved the

final version to be published and agreed to be accountable for all aspects of the work.

Funding: Faraz Shahidi is supported by the Canadian Institutes of Health Research and the Institute for Work & Health. Arjumand Siddiqi is supported by the Canada Research Chair in Population Health Equity.

Disclaimer: The funders played no role in the study design, data collection and analysis, decision to publish or preparation of the manuscript.

Data sharing: The data used in this study are held securely by Statistics Canada. As the Canadian Census Health and Environment

Cohorts contain potentially identifiable information, Statistics Canada is prohibited by law from making the data available to the general public. Researchers may request access to the data by submitting an application to the Canadian Research Data Centre Network: info@crdcn.org or nancy.hofmann@canada.ca (director, Microdata Access Division). Information about the application procedure can be found at the following link: <https://crdcn.org/research>.

Accepted: June 2, 2020

Correspondence to: Faraz Shahidi, fshahidi@iwh.on.ca