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Regional and socioeconomic disparities in cardiovascular disease in Canada during 2005–2016: evidence from repeated nationwide cross-sectional surveys

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ABSTRACT

Introduction The objective of this study is to examine the temporal trends and patterns of regional and socioeconomic disparities in cardiovascular disease (CVD) in Canada during 2005–2016.

Methods A total of 670 000 adults aged ≥20 years who participated in the Canadian Community Health Surveys between 2005 and 2016 were enrolled for this study. CVD referred to heart disease and stroke in this study. Equivalised household income was used as a proxy of socioeconomic status. Absolute and relative socioeconomic inequalities were measured by slope index of inequality (SII) and relative index of inequality (RII), respectively.

Results In 2015/2016, the overall age-adjusted and sex-adjusted prevalence of heart disease and stroke was 4.80% (95% CI 4.61% to 4.98%) and 1.25% (95% CI 1.13% to 1.36%), respectively. Trend analyses suggested a significant decline in the age-adjusted and sex-adjusted prevalence of heart disease (P for trend <0.001) and a non-significant decline in the age-adjusted and sex-adjusted prevalence of stroke (P for trend=0.058) from 2005 to 2016. Nevertheless, the total number of adults suffering from heart disease and stroke increased by 8.9% and 20.2% over the study period, respectively. Moreover, the age-adjusted and sex-adjusted prevalence of heart disease and stroke varied widely across all health regions, and both of them tended be higher among those with lower income. The SII and RII indicated that there were persistent absolute and relative socioeconomic inequalities in heart disease and stroke across all surveys (eg, SII for heart disease in both sexes, 2005: 0.04 (95% CI 0.03 to 0.04); 2015/2016: 0.03 (95% CI, 0.02 to 0.04); RII for heart disease in both sexes, 2005: 1.99 (95% CI 1.75 to 2.27); 2015/2016: 1.77 (95% CI 1.52 to 2.08).

Conclusion Geographical and socioeconomic disparities should be taken into account during the further efforts to strengthen preventive measures and optimise healthcare resources for heart disease and stroke in Canada.

Key questions

What is already known?

- Cardiovascular disease (CVD) remains a major cause of mortality and rising healthcare costs in Canada, and poses a huge challenge to Canadian health system.
- There are currently no studies examining the temporal trends in CVD at the health region level in Canada.
- Socioeconomic status plays an important role in the occurrence of CVD. However, it is still unclear about the changing pattern of socioeconomic disparities in CVD in Canada.

What are the new findings?

- Between 2005 and 2016, there was a significant decline in the age-adjusted and sex-adjusted prevalence of heart disease, while a non-significant decline was observed for stroke among all Canadian adults.
- Geographically, the prevalence and temporal changes of heart disease and stroke varied widely across different health regions.
- There were persistent socioeconomic inequalities in heart disease and stroke from 2005 to 2016, and the narrowing socioeconomic inequalities were only observed for heart disease among men.

What do the new findings imply?

- Current intervention strategies failed or even neglected to address the regional and socioeconomic disparities in CVD in Canada.
- Further efforts to strengthen preventive measures and optimise healthcare resources for heart disease and stroke should take into account the geographical and socioeconomic disparities in Canada.

INTRODUCTION

Cardiovascular disease (CVD) refers to a class of diseases involving the heart and/or blood vessels, and the mortality burden attributable to CVD mainly comes from ischaemic heart disease, stroke and hypertensive heart disease.[1] Despite consistent declines in mortality over the past few decades, CVD

remains a major cause of mortality, disability and rising healthcare costs in developed countries.[2–4] In Canada, CVD accounted for 29.8% of all Canadian deaths in 2016, killing over 81 300 people per year.[5] The estimated direct costs of CVD in Canada have reached $C13 billion in 2010.[6] Therefore, developing and deploying evidence-based health strategies is crucial in order to effectively prevent and manage CVD in Canada.

A successful response to the challenge of CVD requires an accurate understanding of its epidemiological and demographic characteristics among Canadian population. However, although the overall prevalence of CVD within Canada has been estimated by some studies, they were failed to distinguish the regional variation within the country.[3 7] Moreover, recent studies suggest that socioeconomic status plays an important role in the incidence, treatment and outcomes of CVD.[8 9] Previous studies conducted among Canadian populations have assessed socioeconomic disparities in health, but most of them focused on the overall health status.[10–12] It remains unclear about the secular trends in socioeconomic disparities with regard to CVD in Canada. To address the gaps, we used data from repeated nationwide cross-sectional surveys to investigate the temporal trends in the prevalence of heart disease and stroke at the national and regional levels, and to examine the socioeconomic disparities in heart disease and stroke in Canada between 2005 and 2016.

METHODS

Data sources

The Canadian Community Health Survey (CCHS) programme of Statistics Canada includes a series of cross-sectional nationally representative surveys beginning in 2000 that designed to provide reliable health estimates of Canadians. Using a consistent, multistage, stratified cluster sampling strategy, a nationally representative sample is selected for each survey in 1-year or 2-year cycles. Individuals who lived on Indian Reserves, Crown Lands, institutions, certain remote regions or were full-time members of the Canadian Forces were excluded from each survey. Statistics Canada estimated that the CCHS covers about approximately 98% of the Canadian population aged ≥12 years. More details about the CCHS can be found elsewhere.[13] In this study, we included adults aged ≥20 years from the latest six cycles (done in 2005, 2007/2008, 2009/2010, 2011/2012, 2013/2014, 2015/2016) of the CCHS.

Measures

To identify the prevalence of CVD, information on heart disease and stroke was collected in the CCHS through the questions: 'Do you have heart disease?' and 'Do you suffer from the effects of a stroke?' The questions were prefaced with a statement: 'Remember, we're interested in conditions diagnosed by a health professional and that are expected to last or have already lasted 6 months or more.'

Health regions are legislated administrative areas defined by Canadian provincial government to administer and deliver healthcare services to all Canadian residents. Given the boundary changes between 2005 and 2016, health regions were combined to ensure stable units of analysis over time, reducing the number of areas analysed from 112 to 105 (online supplemental table 1). In addition, according to the recommendations of Statistics Canada,[14] three neighbouring health regions with a small population in Saskatchewan were combined to avoid potential poor data quality (online supplemental table 1). For simplicity, combined areas were still named as 'health regions' throughout.

We used equivalised household income, which is defined as total annual household income divided by the square root of household size, as the proxy of socioeconomic status.[15 16] Equivalised household income is an important and frequently used measure that takes account of the differences in household sizes because the larger the household, the more the income that will be needed to keep the same standard of living. In order to achieve consistent comparisons from 2005 to 2016, we stratified equivalised household income into quartiles for each survey cycle.

Statistical analyses

Statistical analyses were conducted using Stata (V.15.0; StataCorp) and R software (V.3.6.1; R Foundation for Statistical Computing). Sampling weights provided by Statistics Canada were used to extrapolate the results to the general population covered by the CCHS. Replicate bootstrap weights provided by Statistics Canada were used to account for the complex survey design. Two-sided $p<0.05$ was considered statistically significant. The age-adjusted and sex-adjusted prevalence of CVD was calculated by direct standardisation to the 2006 Canada Census population using the joint age (10-year interval) and sex groups. Temporal trends in prevalence of CVD were evaluated by multivariable Poisson regression analysis, adjusting for age and sex.[17 18] P values for trend were then calculated by the contrast postestimation command in Stata.

Socioeconomic inequalities were assessed using two well-recognised indices: the slope index of inequality (SII) and the relative index of inequality (RII).[19–21] The SII represents an absolute difference in prevalence of CVD between the most and least socioeconomic groups. The RII can be interpreted as relative inequality in prevalence between the most and least socioeconomic groups. A SII greater than 0 and an RII greater than 1 would indicate that individuals with lower socioeconomic status would be more likely to have the disease.[22] To calculate the two indices, socioeconomic status was first transformed into cumulative rank probabilities (ridit scores) ranging from 0 (highest) to 1 (lowest).[20] Then, we used multivariable Poisson regression models, adjusting for

age and sex, to estimate the association between the ridit scores and CVD prevalence, and the RII could be derived directly from the models. We further obtained the SII through marginal effects and the nlcom postestimation commands in Stata. Temporal trends in the SII and RII were assessed by adding the interaction term between the ridit scores and survey circles into the regression models.[23] P values for trend were then calculated using orthogonal polynomial contrasts generated by the contrast postestimation command in Stata.

Patient and public involvement

Patients or the public were not involved in the design, conduct or interpretation of this research as this was a secondary analysis of nationally representative data.

RESULTS

Overall, our study included 670 000 participants (49.1% men and 50.9% women) aged ≥20 years from six survey cycles. The sample size and distribution of study sample by age group and sex for each survey cycle were presented in online supplemental table 2. The percentage of missing values for heart disease (<0.30%) and stroke (<0.15%) in each survey cycle was also shown in online supplemental table 2. Participants who had missing values for heart disease and stroke were excluded from the respective analysis.

Heart disease and stroke prevalence in 2015/2016

The overall crude prevalence of heart disease and stroke in 2015/2016 was 5.04% (95% CI 4.85% to 5.24%) and 1.29% (95% CI 1.18% to 1.41%), respectively. This equates to an estimated 1.39 million adults with heart disease and 0.36 million adults with stroke. The age-adjusted and sex-adjusted prevalence of heart disease and stroke in 2015/2016 overall and by age group and sex was shown in table 1. The overall age-adjusted and sex-adjusted prevalence of heart disease and stroke was 4.80% (95% CI 4.61% to 4.98%) and 1.25% (95% CI, 1.13% to 1.36%), respectively; and both of them tended to be higher among men. Furthermore, the adjusted prevalence of heart disease and stroke increased substantially with age group; among participants aged ≥80 years, it upped to 23.49% (95% CI 21.84% to 25.15%) for heart disease and upped to 6.43% (95% CI 5.44% to 7.42%) for stroke (table 1).

Trend analysis

From 2005 to 2016, there was a statistically significant decline in the age-adjusted and sex-adjusted prevalence of heart disease from 5.75% (95% CI 5.57% to 5.94%) to 4.80% (95% CI 4.61% to 4.98%) (P for trend <0.001) and a non-significant decline in the age-adjusted and sex-adjusted prevalence of stroke (P for trend=0.058; table 1). Temporal trends in the age-adjusted and sex-adjusted prevalence of heart disease and stroke by age group and sex were also shown in table 1. Notably, despite the declining prevalence rates from 2005 to 2016, the estimated total number of adults suffering from heart disease and stroke increased by 114 000 (8.9%) and 60 000 (20.2%), respectively.

Regional variations

In 2015/2016, the health region-level age-adjusted and sex-adjusted prevalence of heart disease varied widely from 2.52% (95% CI 0.79% to 4.25%) in Prairie North Regional Health Authority to 9.27% (95% CI 3.12% to 15.43%) in Mamawetan/Keewatin/Athabasca Regional Health Authorities (figure 1). Even though the national age-adjusted and sex-adjusted prevalence of heart disease declined between 2005 and 2016, 21 health regions experienced an increase in the prevalence rate over this period. Health regions with most rapid increase in age-adjusted and sex-adjusted prevalence of heart disease were in Nunavut (192.0%), Mamawetan/Keewatin/Athabasca Regional Health Authorities (48.9%) and the Eastern Ontario Health Unit (38.5%). In contrast, health regions with most rapid decline in age-adjusted and sex-adjusted prevalence of heart disease were in Northwestern Health Unit (−52.2%), Prairie North Regional Health Authority (−51.2%) and Porcupine Health Unit (−46.8%).

The health region-level age-adjusted and sex-adjusted prevalence of stroke in 2015/2016 ranged from 0.33% (95% CI -0.19% to 0.85%) in Five Hills Regional Health Authority to 3.50% (95% CI 1.02% to 5.97%) in Bathurst Area (figure 2). Between 2005 and 2016, health regions with most rapid increase were in Northern Interior Health Service Delivery Area (356.5%), Région de l'Abitibi-Témiscamingue (188.2%) and Lambton Health Unit (187.4%), whereas health regions with most rapid decline in age-adjusted and sex-adjusted prevalence of stroke were in Five Hills Regional Health Authority (−87.2%), Brant County Health Unit (−78.4%), and Elgin-St Thomas Health Unit (−68.3%). The health region-level age-adjusted and sex-adjusted prevalence of heart disease and stroke in 2005 was presented in online supplemental table 3. More details about health regions with the most rapid increase or decline in age-adjusted and sex-adjusted prevalence of heart disease and stroke was presented in online supplemental table 4.

Socioeconomic inequalities

The distribution of age-adjusted and sex-adjusted prevalence of heart disease and stroke by income quartiles was presented in table 2. In all survey cycles, both heart disease and stroke tended to be more common among those with lower income. The SII and RII presented in table 2 suggested consistent absolute and relative socioeconomic inequalities in heart disease and stroke across all survey cycles. Trend analyses in the SII and RII indicated that the absolute and relative socioeconomic inequalities in heart disease were narrowing among men from 2005 to 2016 (P for trend <0.001 and=0.006, respectively), but the inequalities were stable among women over this period (P for trend=0.502 and 0.096, respectively). For stroke, trend

Table 1 Age-adjusted and sex-adjusted prevalence of heart disease and stroke, overall and by age group and sex

Age groups, years	2005	2007/2008	2009/2010	2011/2012	2013/2014	2015/2016	P value	Direction of trend
Heart disease								
Both sexes								
20–39	0.70 (0.59 to 0.81)	0.62 (0.51 to 0.74)	0.62 (0.49 to 0.74)	0.68 (0.54 to 0.82)	0.70 (0.56 to 0.84)	0.65 (0.52 to 0.77)	0.942	—
40–59	3.30 (3.04 to 3.57)	3.40 (3.09 to 3.71)	3.13 (2.86 to 3.41)	3.30 (2.93 to 3.66)	3.15 (2.80 to 3.51)	2.81 (2.52 to 3.09)	0.012	Decrease
60–79	14.75 (14.15 to 15.35)	14.37 (13.78 to 14.95)	13.85 (13.27 to 14.43)	13.01 (12.45 to 13.58)	12.65 (12.16 to 13.15)	11.49 (10.91 to 12.06)	<0.001	Decrease
≥80	25.36 (23.84 to 26.89)	25.00 (23.59 to 26.42)	25.09 (23.46 to 26.72)	25.21 (23.70 to 26.72)	23.71 (22.26 to 25.15)	23.49 (21.84 to 25.15)	0.029	Decrease
All ages	5.75 (5.57 to 5.94)	5.67 (5.48 to 5.86)	5.47 (5.28 to 5.65)	5.39 (5.19 to 5.60)	5.20 (5.00 to 5.39)	4.80 (4.61 to 4.98)	<0.001	Decrease
Men								
20–39	0.71 (0.54 to 0.89)	0.64 (0.48 to 0.80)	0.62 (0.43 to 0.81)	0.70 (0.49 to 0.90)	0.63 (0.44 to 0.82)	0.54 (0.37 to 0.70)	0.267	—
40–59	4.34 (3.91 to 4.78)	3.97 (3.50 to 4.44)	4.07 (3.58 to 4.55)	3.87 (3.31 to 4.42)	3.84 (3.31 to 4.38)	3.42 (2.97 to 3.87)	0.005	Decrease
60–79	17.96 (17.04 to 18.88)	16.95 (16.02 to 17.87)	17.67 (16.73 to 18.61)	16.91 (15.97 to 17.85)	16.33 (15.50 to 17.16)	14.87 (13.90 to 15.84)	<0.001	Decrease
≥80	28.61 (26.10 to 31.11)	29.02 (26.52 to 31.51)	27.91 (25.44 to 30.38)	29.23 (26.69 to 31.77)	26.30 (23.83 to 28.77)	24.38 (21.75 to 27.00)	0.009	Decrease
All ages	6.98 (6.68 to 7.28)	6.62 (6.33 to 6.91)	6.74 (6.44 to 7.05)	6.60 (6.26 to 6.94)	6.31 (6.00 to 6.62)	5.72 (5.43 to 6.01)	<0.001	Decrease
Women								
20–39	0.69 (0.54 to 0.83)	0.61 (0.44 to 0.77)	0.61 (0.44 to 0.78)	0.67 (0.47 to 0.86)	0.76 (0.56 to 0.96)	0.75 (0.57 to 0.94)	0.258	—
40–59	2.29 (1.98 to 2.60)	2.84 (2.45 to 3.23)	2.23 (1.94 to 2.52)	2.74 (2.23 to 3.26)	2.49 (2.04 to 2.93)	2.21 (1.88 to 2.54)	0.607	—
60–79	11.88 (11.19 to 12.58)	12.04 (11.26 to 12.81)	10.43 (9.79 to 11.07)	9.53 (8.88 to 10.18)	9.37 (8.77 to 9.96)	8.49 (7.78 to 9.20)	<0.001	Decrease
≥80	23.58 (21.76 to 25.41)	22.80 (21.08 to 24.52)	23.55 (21.44 to 25.65)	23.00 (21.10 to 24.91)	22.28 (20.50 to 24.06)	23.01 (20.92 to 25.10)	0.543	—
All ages	4.69 (4.46 to 4.91)	4.87 (4.62 to 5.12)	4.34 (4.13 to 4.55)	4.36 (4.10 to 4.63)	4.22 (3.98 to 4.47)	3.97 (3.74 to 4.20)	<0.001	Decrease
Stroke								
Both sexes								
20–39	0.21 (0.14 to 0.27)	0.12 (0.08 to 0.16)	0.15 (0.09 to 0.21)	0.26 (0.17 to 0.36)	0.12 (0.07 to 0.17)	0.28 (0.14 to 0.42)	0.244	—
40–59	0.77 (0.66 to 0.89)	0.70 (0.60 to 0.81)	0.70 (0.58 to 0.82)	0.57 (0.47 to 0.68)	0.78 (0.60 to 0.96)	0.72 (0.56 to 0.88)	0.707	—
60–79	3.04 (2.74 to 3.34)	3.09 (2.83 to 3.36)	2.95 (2.69 to 3.22)	3.18 (2.78 to 3.57)	2.71 (2.44 to 2.99)	2.74 (2.44 to 3.04)	0.055	—
≥80	7.43 (6.49 to 8.37)	7.45 (6.51 to 8.40)	6.90 (6.05 to 7.75)	6.17 (5.32 to 7.02)	6.33 (5.46 to 7.20)	6.43 (5.44 to 7.42)	0.027	Decrease
All ages	1.35 (1.25 to 1.45)	1.31 (1.22 to 1.39)	1.26 (1.17 to 1.35)	1.26 (1.15 to 1.36)	1.21 (1.11 to 1.31)	1.25 (1.13 to 1.36)	0.058	—
Men								
20–39	0.24 (0.13 to 0.34)	0.12 (0.05 to 0.19)	0.17 (0.08 to 0.27)	0.21 (0.10 to 0.32)	0.10 (0.03 to 0.17)	0.24 (0.06 to 0.41)	0.888	—
40–59	0.80 (0.64 to 0.96)	0.79 (0.62 to 0.95)	0.63 (0.48 to 0.78)	0.57 (0.41 to 0.74)	0.73 (0.52 to 0.94)	0.84 (0.54 to 1.14)	0.844	—
60–79	3.63 (3.15 to 4.11)	3.63 (3.20 to 4.05)	3.29 (2.86 to 3.73)	3.52 (2.99 to 4.05)	3.27 (2.84 to 3.70)	3.37 (2.84 to 3.91)	0.277	—
≥80	8.53 (6.83 to 10.23)	8.77 (7.23 to 10.32)	8.21 (6.80 to 9.63)	6.93 (5.49 to 8.36)	5.88 (4.71 to 7.04)	7.76 (5.63 to 9.89)	0.065	—
All ages	1.55 (1.40 to 1.70)	1.51 (1.38 to 1.64)	1.37 (1.24 to 1.50)	1.34 (1.20 to 1.49)	1.27 (1.14 to 1.40)	1.47 (1.27 to 1.68)	0.106	—
Women								

Continued

Table 1 Continued

Age groups, years	2005	2007/2008	2009/2010	2011/2012	2013/2014	2015/2016	P value	Direction of trend
20–39	0.18 (0.11 to 0.24)	0.12 (0.07 to 0.16)	0.13 (0.07 to 0.20)	0.32 (0.17 to 0.46)	0.15 (0.08 to 0.22)	0.32 (0.10 to 0.53)	0.055	—
40–59	0.74 (0.58 to 0.91)	0.62 (0.48 to 0.76)	0.76 (0.58 to 0.95)	0.57 (0.43 to 0.71)	0.83 (0.55 to 1.12)	0.60 (0.42 to 0.78)	0.666	—
60–79	2.51 (2.15 to 2.87)	2.63 (2.28 to 2.98)	2.67 (2.31 to 3.03)	2.88 (2.31 to 3.46)	2.23 (1.87 to 2.58)	2.21 (1.88 to 2.53)	0.104	—
≥80	6.83 (5.64 to 8.02)	6.72 (5.57 to 7.88)	6.18 (5.13 to 7.22)	5.76 (4.79 to 6.72)	6.58 (5.31 to 7.84)	5.70 (4.67 to 6.73)	0.181	—
All ages	1.19 (1.07 to 1.32)	1.14 (1.04 to 1.25)	1.19 (1.06 to 1.31)	1.20 (1.05 to 1.34)	1.15 (1.00 to 1.31)	1.07 (0.94 to 1.21)	0.267	—

Numbers in the table are percentage (95% CI).

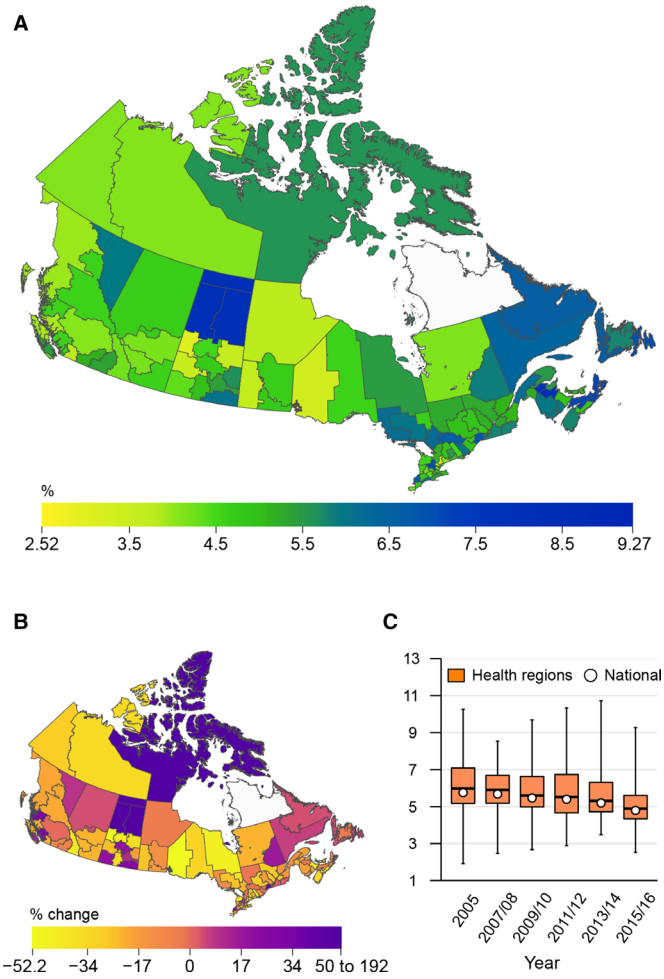

Figure 1 Health region-level age-adjusted and sex-adjusted prevalence of heart disease. (A) Age-adjusted and sex-adjusted prevalence of heart disease for both sexes combined in 2015/2016. (B) Percent change in the age-adjusted and sex-adjusted prevalence of heart disease for both sexes combined from 2005 to 2016. In (A, B), two health regions (ie, Région Du Nunavik, and Région des Terres-Cries-de-la-Baie-James) were filled with blank because of missing data. (C) Age-adjusted and sex-adjusted prevalence of heart disease in each survey cycle. The bottom border, middle line and top border of the boxes indicate the 25th, 50th and 75th percentiles, respectively, across all health regions; the whiskers indicate the full range across all health regions; and the circles indicate the national-level prevalence rate.

analyses in the SII and RII suggested that the absolute and relative socioeconomic inequalities were stable among both men and women from 2005 to 2016 (all P for trend >0.05).

DISCUSSION

This study investigated the temporal trends, regional variation and socioeconomic inequalities in CVD among Canadian adults between 2005 and 2016. Over the study period, there was a significant decline in the age-adjusted and sex-adjusted prevalence of heart disease from 5.75% to 4.80%, but a non-significant decline was observed for stroke (P for trend=0.058). Geographically, striking differences between health regions in the age-adjusted and sex-adjusted

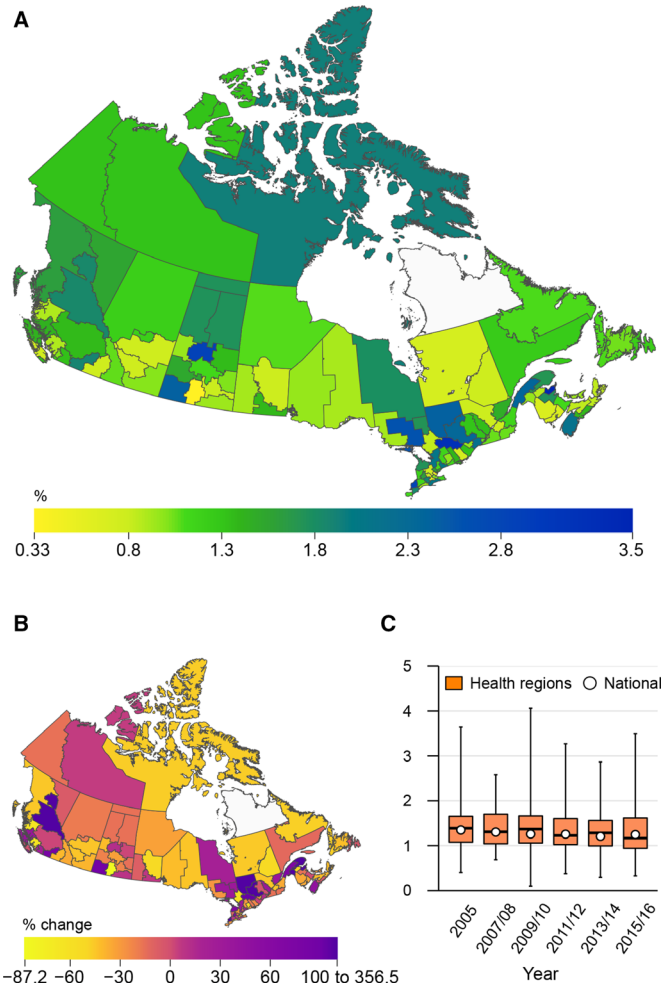

Figure 2 Health region-level age-adjusted and sex-adjusted prevalence of stroke. (A) Age-adjusted and sex-adjusted prevalence of stroke for both sexes combined in 2015/2016. (B) Percent change in the age-adjusted and sex-adjusted prevalence of stroke for both sexes combined from 2005 to 2016. In (A, B), two health regions (ie, Région Du Nunavik, and Région des Terres-Cries-de-la-Baie-James) were filled with blank because of missing data. (C) Age-adjusted and sex-adjusted prevalence of stroke in each survey cycle. The bottom border, middle line and top border of the boxes indicate the 25th, 50th and 75th percentiles, respectively, across all health regions; the whiskers indicate the full range across all health regions; and the circles indicate the national-level prevalence rate.

prevalence rates was observed for heart disease and stroke, although the patterns of change over time in most regions followed the national trends. Moreover, persistent absolute and relative socioeconomic inequalities in heart disease and stroke were found across all surveys.

Similar to other developed countries such as the United States and Australia, the adjusted prevalence of heart disease and stroke tended to decline in Canada.[3] Nevertheless, from 2005 to 2016, the total number of adults suffering from heart disease and stroke increased by 8.9% and 20.2%, respectively. This phenomenon was partly due to the growth and ageing of the Canadian population. On one hand, the trends in this analysis reflected efforts in prevention and treatment of CVD in Canada, especially for heart disease. On the other hand, more and high-quality healthcare services should still be required as the overall amount of population with CVD was increasing. As expected, we found that men were more likely than women to have heart disease and stroke, which was largely owing to higher exposure to cardiovascular risk factors in men, such as smoking, high blood glucose and dyslipidaemia.[3 24] For example, for those aged ≥25 years in Canada, men have a higher smoking prevalence rate (18.5% vs 14.0%) and heavier cigarette consumption (17.4 vs 12.9 cigarettes per day) than women in 2012.[25]

Our study confirmed considerable variations between health regions in the age-adjusted and sex-adjusted prevalence of heart disease and stroke in Canada. The findings are particularly useful for local health units to evaluate existing cardiovascular programmes and to design new ones suited to their regions. Notably, the regional prevalence of heart disease was higher in most eastern health regions. The reasons for the disparities are complex and multifactorial, which could be partly explained by difference in risk factor exposures. Using the CCHS data, Maclagan *et al*[26] found that the prevalence of heart disease in Canada was correlated with the Cardiovascular Health in Ambulatory Care Research Team (CANHEART) health index generated by smoking, physical activity, fruit and vegetable consumption, overweight/obesity, diabetes and hypertension. Considering the uneven distributions of cardiovascular risk factors, more researches are warranted to identify the key risk factors of CVD for each health region, especially for regions with high or increasing prevalence rates.

The association between socioeconomic status and CVD has been well documented in previous studies.[27–29] However, to the best of our knowledge, the changing pattern of socioeconomic disparities in CVD in Canada over the past decade remains unclear. In this study, we found persistent absolute and relative socioeconomic inequalities in heart disease and stroke in Canada from 2005 to 2016, and the narrowing socioeconomic inequalities were only observed for heart disease among men, suggesting a failure to achieve an equitable improvement in CVD prevalence. To date, the underlying causes linking the association between socioeconomic status and CVD are still unknown. In a population-based cohort study, Zhang *et al*[27] found that unhealthy lifestyles mediated a small proportion of the socioeconomic inequality in incident CVD in both US and UK adults. Therefore, promoting healthy lifestyles alone could not substantially reduce the socioeconomic inequity in CVD. Further study is required to explore the mechanism of socioeconomic status on CVD to help inform valuable interventions targeted at improving the situation in both Canada and other countries.

Limitations

Several limitations of this study should be properly acknowledged. First, data on heart disease and stroke were collected through self-report questionnaires. Although clinical registries or health administrative data can provide more credible estimates of the diseases, they cannot provide health information at the health

Table 2 Age-adjusted and sex-adjusted prevalence of heart disease and stroke by income quartile and sex, and changes in absolute and relative socioeconomic inequalities

Income quartiles	2005	2007/2008	2009/2010	2011/2012	2013/2014	2015/2016	P value	Direction of trend
Heart disease								
Both sexes*								
1st (poorest)	7.13 (6.75 to 7.51)	7.23 (6.74 to 7.72)	6.81 (6.41 to 7.20)	6.82 (6.32 to 7.33)	6.54 (6.04 to 7.03)	5.98 (5.58 to 6.38)	<0.001	Decrease
2nd	5.90 (5.51 to 6.30)	5.52 (5.19 to 5.85)	5.30 (4.87 to 5.74)	5.31 (4.92 to 5.70)	5.16 (4.76 to 5.56)	4.82 (4.43 to 5.22)	<0.001	Decrease
3rd	5.06 (4.70 to 5.42)	5.33 (4.95 to 5.72)	4.88 (4.50 to 5.26)	4.75 (4.34 to 5.15)	4.49 (4.13 to 4.86)	4.38 (3.99 to 4.77)	<0.001	Decrease
4th (richest)	4.53 (4.01 to 5.04)	4.63 (4.15 to 5.10)	4.88 (4.37 to 5.39)	4.48 (4.02 to 4.95)	4.49 (4.02 to 4.96)	4.12 (3.69 to 4.56)	0.102	—
SII	0.04 (0.03 to 0.04)	0.03 (0.03 to 0.04)	0.03 (0.02 to 0.04)	0.03 (0.02 to 0.04)	0.03 (0.02 to 0.04)	0.03 (0.02 to 0.04)	0.010	Decrease
RII	1.99 (1.75 to 2.27)	1.94 (1.68 to 2.25)	1.73 (1.50 to 2.00)	1.84 (1.57 to 2.15)	1.85 (1.59 to 2.14)	1.77 (1.52 to 2.08)	0.225	—
Men†								
1st (poorest)	8.55 (7.93 to 9.17)	8.68 (7.83 to 9.52)	8.09 (7.45 to 8.73)	7.88 (7.17 to 8.59)	7.65 (6.88 to 8.43)	6.83 (6.22 to 7.44)	<0.001	Decrease
2nd	7.48 (6.83 to 8.13)	6.45 (5.91 to 7.00)	6.89 (6.11 to 7.67)	6.54 (5.86 to 7.21)	6.28 (5.72 to 6.85)	5.65 (5.00 to 6.30)	<0.001	Decrease
3rd	6.52 (5.90 to 7.13)	6.37 (5.74 to 7.00)	6.24 (5.63 to 6.85)	6.38 (5.68 to 7.08)	6.09 (5.48 to 6.69)	5.63 (5.03 to 6.23)	0.018	Decrease
4th (richest)	5.07 (4.39 to 5.74)	5.26 (4.58 to 5.93)	6.02 (5.33 to 6.71)	6.21 (5.42 to 7.01)	5.29 (4.65 to 5.93)	5.14 (4.56 to 5.72)	0.875	—
SII	0.04 (0.03 to 0.05)	0.04 (0.03 to 0.05)	0.03 (0.02 to 0.04)	0.02 (0.01 to 0.04)	0.03 (0.01 to 0.04)	0.02 (0.01 to 0.03)	<0.001	Decrease
RII	2.01 (1.69 to 2.38)	2.04 (1.67 to 2.48)	1.58 (1.31 to 1.90)	1.45 (1.19 to 1.77)	1.54 (1.27 to 1.86)	1.49 (1.22 to 1.81)	0.006	Decrease
Women†								
1st (poorest)	5.90 (5.48 to 6.32)	5.95 (5.43 to 6.47)	5.68 (5.23 to 6.13)	5.89 (5.12 to 6.66)	5.54 (4.96 to 6.12)	5.22 (4.68 to 5.77)	0.002	Decrease
2nd	4.52 (4.10 to 4.94)	4.72 (4.29 to 5.16)	3.92 (3.54 to 4.30)	4.24 (3.80 to 4.68)	4.26 (3.65 to 4.86)	4.10 (3.65 to 4.55)	0.052	—
3rd	3.78 (3.34 to 4.22)	4.48 (3.96 to 5.01)	3.70 (3.27 to 4.13)	3.43 (2.96 to 3.90)	3.10 (2.66 to 3.53)	3.32 (2.85 to 3.79)	<0.001	Decrease
4th (richest)	3.98 (3.25 to 4.70)	4.07 (3.39 to 4.75)	3.78 (3.09 to 4.47)	3.07 (2.52 to 3.62)	3.68 (3.03 to 4.33)	3.14 (2.56 to 3.72)	0.008	Decrease
SII	0.03 (0.02 to 0.04)	0.03 (0.02 to 0.04)	0.03 (0.02 to 0.04)	0.04 (0.03 to 0.05)	0.04 (0.03 to 0.05)	0.03 (0.02 to 0.04)	0.502	—
RII	1.98 (1.61 to 2.44)	1.84 (1.46 to 2.31)	2.03 (1.60 to 2.57)	2.72 (2.08 to 3.57)	2.49 (1.96 to 3.17)	2.31 (1.78 to 3.01)	0.096	—
Stroke								
Both sexes*								
1st (poorest)	2.12 (1.89 to 2.34)	1.87 (1.69 to 2.06)	1.85 (1.64 to 2.06)	1.94 (1.70 to 2.18)	1.72 (1.49 to 1.94)	1.87 (1.64 to 2.10)	0.210	—
2nd	1.43 (1.26 to 1.61)	1.25 (1.08 to 1.42)	1.11 (0.96 to 1.26)	1.16 (0.98 to 1.34)	1.24 (1.01 to 1.47)	1.36 (1.10 to 1.62)	0.617	—
3rd	1.01 (0.83 to 1.19)	1.12 (0.93 to 1.32)	1.04 (0.87 to 1.22)	1.11 (0.82 to 1.41)	1.05 (0.80 to 1.29)	1.06 (0.82 to 1.30)	0.924	—
4th (richest)	0.77 (0.58 to 0.97)	0.82 (0.63 to 1.01)	0.98 (0.72 to 1.23)	0.79 (0.58 to 1.00)	0.87 (0.63 to 1.11)	0.60 (0.45 to 0.76)	0.136	—
SII	0.02 (0.01 to 0.02)	0.01 (0.01 to 0.02)	0.01 (0.01 to 0.02)	0.02 (0.01 to 0.02)	0.01 (0.01 to 0.02)	0.02 (0.02 to 0.02)	0.752	—
RII	4.78 (3.53 to 6.48)	3.00 (2.25 to 4.02)	2.76 (1.99 to 3.84)	3.78 (2.52 to 5.67)	3.18 (2.24 to 4.51)	4.70 (3.48 to 6.33)	0.828	—
Men†								
1st (poorest)	2.68 (2.31 to 3.06)	2.23 (1.91 to 2.55)	2.07 (1.76 to 2.37)	2.22 (1.85 to 2.58)	1.78 (1.50 to 2.06)	2.12 (1.78 to 2.46)	0.040	Decrease

Continued

Table 2 Continued

Income quartiles	2005	2007/2008	2009/2010	2011/2012	2013/2014	2015/2016	P value	Direction of trend
2nd	1.51 (1.27 to 1.75)	1.61 (1.36 to 1.85)	1.20 (0.97 to 1.44)	1.19 (0.95 to 1.43)	1.33 (1.10 to 1.55)	1.67 (1.21 to 2.13)	0.952	—
3rd	1.09 (0.84 to 1.33)	1.16 (0.90 to 1.42)	1.21 (0.95 to 1.48)	1.08 (0.77 to 1.40)	0.95 (0.66 to 1.24)	1.42 (0.98 to 1.87)	0.638	—
4th (richest)	0.93 (0.58 to 1.28)	0.96 (0.70 to 1.21)	0.87 (0.60 to 1.14)	1.19 (0.77 to 1.61)	0.96 (0.67 to 1.24)	0.65 (0.43 to 0.87)	0.132	—
SII	0.02 (0.02 to 0.03)	0.02 (0.01 to 0.02)	0.01 (0.01 to 0.02)	0.02 (0.01 to 0.02)	0.01 (0.01 to 0.02)	0.02 (0.02 to 0.03)	0.246	—
RII	5.85 (3.81 to 8.96)	3.50 (2.40 to 5.09)	3.06 (1.98 to 4.73)	3.87 (2.34 to 6.40)	2.85 (1.86 to 4.38)	4.68 (3.09 to 7.08)	0.459	—
Women†								
1st (poorest)	1.64 (1.38 to 1.89)	1.56 (1.35 to 1.78)	1.73 (1.42 to 2.04)	1.68 (1.40 to 1.97)	1.67 (1.32 to 2.03)	1.68 (1.34 to 2.02)	0.823	—
2nd	1.36 (1.12 to 1.61)	0.96 (0.75 to 1.17)	1.03 (0.83 to 1.22)	1.15 (0.89 to 1.40)	1.18 (0.76 to 1.60)	1.11 (0.84 to 1.38)	0.535	—
3rd	0.94 (0.69 to 1.18)	1.12 (0.84 to 1.39)	0.89 (0.67 to 1.12)	1.15 (0.67 to 1.63)	1.08 (0.75 to 1.41)	0.76 (0.55 to 0.96)	0.314	—
4th (richest)	0.67 (0.41 to 0.93)	0.71 (0.43 to 0.99)	1.02 (0.66 to 1.39)	0.54 (0.32 to 0.75)	0.74 (0.41 to 1.07)	0.58 (0.37 to 0.79)	0.630	—
SII	0.01 (0.01 to 0.02)	0.01 (0.01 to 0.01)	0.01 (0.00 to 0.02)	0.01 (0.01 to 0.02)	0.01 (0.01 to 0.02)	0.02 (0.01 to 0.02)	0.425	—
RII	3.77 (2.48 to 5.73)	2.46 (1.57 to 3.85)	2.50 (1.52 to 4.10)	3.66 (1.93 to 6.94)	3.59 (2.06 to 6.26)	4.74 (3.02 to 7.43)	0.264	—

Numbers in the table are percentage (95% CI) or predicted mean (95% CI).
*The prevalence, SII and RII are adjusted for age and sex.
†The prevalence, SII and RII are only adjusted for age.
RII, relative index of inequality; SII, slope index of inequality.

region level. Moreover, our prevalence estimates of heart disease and stroke for Canada were close to the results of Global Burden of Disease Study.[3] Second, our study did not include all CVD, such as peripheral arterial disease and aortic aneurysm. Additionally, data on the types and severity of heart disease and stroke were not available in this study. Third, this was a study of adults aged ≥20 years who participated in the CCHS, so our estimates could not be extrapolated to the excluded populations (ie, individuals who lived on Indian Reserves, Crown Lands, institutions, certain remote regions or were full-time members of the Canadian Forces). Fourth, our study measured socioeconomic inequality based on equivalised household income, which is just one aspect of socioeconomic status. The impact of educational attainment, employment status, and neighbourhood environment on CVD prevalence and its temporal changes in Canada require further study.[9] Fifth, the predicted value of SII ranged from 0.01 to 0.04 in this study and the huge sample size may reject the null hypothesis for the analyses. However, we believe that our assessment of socioeconomic inequalities was reliable as both RII and the distribution of disease prevalence by income quartiles also supported the results.

CONCLUSION

During the study period, there was a significant decline in the age- and sex-adjusted prevalence of heart disease, while a non-significant decline was observed for stroke among all Canadian adults. Geographically, the prevalence and temporal changes of heart disease and stroke varied widely across different health regions. Moreover, there were persistent socioeconomic inequalities in heart disease and stroke from 2005 to 2016, and the narrowing socioeconomic inequalities were only observed for heart disease among men. Geographical and socioeconomic disparities should be taken into account during the further efforts to strengthen preventive measures and optimise healthcare resources for heart disease and stroke in Canada.

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