



Clinical Research

Recent Temporal Changes in Atherosclerotic Cardiovascular Diseases in Ontario: Clinical and Health Systems Impact

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See editorial by Waters, pages 295–297 of this issue.

ABSTRACT

Background: It is unknown how the contemporary burden of atherosclerotic cardiovascular disease (ASCVD) compares with historical trends.

Methods: As part of the Cardiovascular Health in Ambulatory Care Research Team “big data” initiative, we used information from multiple population-based databases to study 20-year temporal trends in hospitalizations and deaths from ASCVD. We calculated hospitalization rates for 6 ASCVD events (acute myocardial infarction, unstable angina, stroke, transient ischemic attack, peripheral arterial disease, and congestive heart failure) and death rates resulting from ischemic heart disease, cerebrovascular disease and circulatory and non-circulatory causes in adults aged 20–105 years in Ontario, Canada from 1994–2014 (to 2012 for deaths).

Results: The overall age-standardized composite rate of hospitalization for the 6 conditions or circulatory deaths declined 49.2% in men (from 1533.4 per 100,000 in 1994 to 778.3 per 100,000 in 2012)

RÉSUMÉ

Introduction : On ignore quel est le fardeau actuel de la maladie cardiovasculaire athérosclérotique (MCVAS) par rapport aux tendances historiques.

Méthodes : Dans le cadre de l’initiative « big data » de CANHEART (Cardiovascular Health in Ambulatory Care Research Team), nous avons fait appel aux données de diverses bases de données représentatives de populations afin d’établir la tendance au chapitre des hospitalisations et des décès associés à la MCVAS sur 20 ans. Nous avons calculé le taux d’hospitalisation pour six événements de la MCVAS (infarctus aigu du myocarde, angine instable, accident vasculaire cérébral (AVC), ischémie cérébrale transitoire, maladie artérielle périphérique et insuffisance cardiaque congestive) ainsi que le taux de mortalité associé à la cardiopathie ischémique, la maladie vasculaire cérébrale ainsi que les causes circulatoires et non circulatoires chez les adultes âgés entre 20 et 105 ans en Ontario, au Canada, entre 1994 et 2014 (2012 pour les décès).

Atherosclerotic cardiovascular disease (ASCVD) is a leading cause of morbidity and mortality in Canada. Although a 30.0% decline in the age- and sex-standardized cardiovascular disease (CVD) mortality rate in Canada between 1994 and 2004 has been reported,¹ recently observed increases in some cardiac risk factors, such as diabetes and obesity, have raised concerns that improvements in ASCVD incidence and mortality may be plateauing or even reversing.^{2,3} The potentially large economic and societal burden that ASCVD poses makes ascertaining and understanding temporal trends in hospitalization and death rates from ASCVD important for health

system planners, policy makers, and clinicians to evaluate progress in combatting ASCVD and make decisions about allocation of limited health system resources.

In the present study, we examined temporal trends in hospitalization rates for 6 major ASCVD conditions (acute myocardial infarction [AMI], unstable angina, stroke, transient ischemic attack [TIA], peripheral arterial disease, and congestive heart failure [CHF]) in Ontario, Canada among those aged 20–105 years between 1994 and 2014, as well as trends in mortality rates from ischemic heart disease (IHD), cerebrovascular disease (CBVD), circulatory diseases, and noncirculatory diseases (comprises all noncardiovascular deaths) between 1994 and 2012. The aforementioned conditions are among the most frequent causes of hospitalization and deaths in Canada. This study is part of the Cardiovascular Health in Ambulatory Care Research Team (CANHEART) “big data” initiative (<http://www.canheart.ca>). The CANHEART initiative uses large population-based health

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See page 383 for disclosure information.

and 49.9% in women (from 1191.2 per 100,000 in 1994 to 596.2 per 100,000 in 2012). The annual rates of decline were least evident among those aged 20-49 years for both sexes. The overall self-reported prevalence of Ontarians living with heart disease or stroke, or both, declined nonsignificantly (P for trend = 0.19), from 7.7% to 7.1% for men, and significantly (P for trend = 0.01), from 7.3% to 5.8% for women, from 2001-2012.

Conclusions: Striking declines in hospitalizations and deaths from ASCVD were observed in Ontario from 1994-2014. However, the limited progress observed in younger Canadians highlights the need for ongoing efforts aimed at preventing and treating ASCVDs and their associated risk factors.

databases in Ontario in an effort to measure and improve the quality of cardiovascular care in Ontario.⁴

Methods

Data sources

We used several population-based health administrative and vital statistic databases to conduct this study. Hospitalization rates for the 6 ASCVD conditions of interest as the most responsible diagnosis were determined using records in the Canadian Institute for Health Information (CIHI) hospital Discharge Abstract Database (DAD). Mortality and cause of death data up to 2012 were identified using the Registrar General of Ontario's vital statistic database. Later data were not available at the time of this study. Revascularization procedures, namely, percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) were identified from the CIHI DAD and Same Day Surgery databases. International Classification of Diseases, Ninth Revision (ICD-9) and International Classification of Diseases, Tenth Revision (ICD-10) codes used to identify hospitalization diagnoses and death causes and the Canadian Classification of Procedure and Canadian Classification of Health Interventions codes used to identify revascularization procedures, are shown in [Supplemental Table S1](#).^{5,6} Ontario population counts were obtained from Statistics Canada census data.

To obtain information on the self-reported prevalence of stroke and heart disease, we used the Canadian Community Health Survey (CCHS) cycles 2001, 2003, 2005, 2007-2008, 2009-2010, and 2011-2012. The CCHS is conducted by Statistics Canada and is a large, ongoing, population-based survey of approximately 130,000 Canadians in the general population in every 2-year cycle.⁷ It uses a complex, multistage, dual-frame sampling technique to obtain reliable estimates of population health at the provincial and health region level.⁷ For this study, we focused on 2 survey questions—whether the respondent self-reported heart disease and if he/she reported suffering from the effects of a stroke.

Résultats : Le taux composite global normalisé en fonction de l'âge pour les six événements ou les décès de causes circulatoires a diminué de 49,2 % chez les hommes (de 1533,4 pour 100 000 personnes en 1994 à 778,3 pour 100 000 personnes en 2012) et de 49,9 % chez les femmes (de 1191,2 par 100 000 personnes en 1994 à 596,2 par 100 000 personnes en 2012). Le taux de diminution annuel de tels événements était cependant moins important pour la tranche des 20 à 49 ans des deux sexes. Entre 2001 et 2012, la prévalence globale auto rapportée des Ontariens disant vivre avec une maladie du coeur ou un AVC ou les deux a aussi diminué, mais pas de manière significative (p pour la tendance = 0,19), soit de 7,7 % à 7,1 % chez les hommes, tandis qu'elle a diminué de manière significative chez les femmes (p pour la tendance = 0,01), soit de 7,3 % à 5,8 %.

Conclusions : En Ontario, on a observé une diminution remarquable du taux d'hospitalisation et du taux de décès des suites de la MCVAS entre 1994 et 2014. Cependant, les progrès limités à ce chapitre relevés chez les Canadiens plus jeunes indiquent qu'il faut poursuivre les efforts visant à prévenir et à traiter la MCVAS et les facteurs de risque qui y sont associés.

Statistical analyses

We calculated yearly sex-specific, age-standardized rates of hospitalizations and deaths for each ASCVD condition and revascularization procedure among Ontarians 20-105 years of age (20-102 years for the CCHS). Rates were calculated as the sex- and year-specific total counts identified from the appropriate databases divided by the sex- and year-specific population counts reported in Statistics Canada's census data and standardized to the 2006 Ontario census population to allow for comparisons across years. If an individual had multiple hospitalizations for the same condition in a given year, each hospitalization was counted. However, transfers between hospitals were counted as 1 hospitalization. Sex-stratified, age-specific rates of hospitalizations for AMI, stroke, CHF, and a composite measure of hospitalization for 1 of the 6 ASCVD events or death from circulatory diseases was also computed for 4 age strata: 20-49, 50-64, 65-74, and 75+ years. For the composite measure, only 1 event per year for each individual was counted. Self-reported prevalence of outcomes using CCHS data were weighted using Statistics Canada survey weights to obtain weighted estimates representative of the population.

The average annual rate of change and the relative and absolute change in rates between the first and last years were also determined, with their confidence intervals (CIs) obtained using bootstrapping techniques. Testing for time trends in rates was conducted by computing Kendall's tau-b correlation coefficient and associated P value.⁸ Trend differences by sex were examined using linear regression including year and sex interaction terms as predictors. Similarly, year-age group interaction terms were included in sex-specific regression models to determine if trends in individuals younger than 50 years differed from trends in individuals in each of the other age groups. Statistical significance was assessed at $P < 0.05$.

All data were analyzed at the Institute for Clinical Evaluative Sciences in Toronto, Canada using SAS, version 9.3 (SAS Institute, Cary NC). This study was approved by the Research Ethics Board at Sunnybrook Health Sciences Centre.

Table 1. Age-standardized* rates for hospital admissions (per 100,000) attributed to atherosclerotic cardiovascular events in men and women aged 20-105 years, Ontario 1994-2014†

Sex; disease	Number of hospitalizations		Rate		Relative reduction, % (95% CI)	Average yearly decline, % (95% CI)
	1994	2014	1994	2014		
Men						
AMI	12,839	14,236	403.0	255.0	36.7 (35.1-38.3)	2.2 (2.1-2.3)
Unstable angina	11,966	3582	372.1	63.9	82.8 (82.2-83.5)	8.1 (7.9-8.3)
Stroke	7392	7476	239.0	131.3	45.1 (43.3-46.8)	2.9 (2.8-3.1)
TIA	1849	1185	60.0	20.7	65.5 (62.7-67.8)	5.0 (4.5-5.3)
PAD	1699	1317	52.7	22.7	56.9 (53.4-60.1)	3.7 (3.2-4.1)
CHF	12,089	11,936	395.2	204.0	48.4 (47.1-49.7)	3.2 (3.1-3.3)
Total	47,834	39,732	1521.9	697.6	54.2 (53.5-54.7)	3.8 (3.7-3.8)
Women						
AMI	7426	7588	209.4	127.8	39.0 (37.0-41.0)	2.4 (2.2-2.5)
Unstable angina	9157	1957	255.1	33.4	86.9 (86.3-87.6)	9.3 (9.0-9.5)
Stroke	7768	7112	222.6	120.4	45.9 (44.0-47.6)	3.0 (2.8-3.1)
TIA	1881	1172	54.0	19.9	63.1 (60.2-65.8)	4.7 (4.3-5.0)
PAD	986	814	27.6	13.6	50.7 (45.8-55.1)	3.2 (2.6-3.6)
CHF	12,014	11,800	350.0	196.5	43.9 (42.4-45.4)	2.8 (2.7-2.9)
Total	39,232	30,443	1118.5	511.6	54.3 (53.6-54.9)	3.8 (3.7-3.9)

Ontario population aged 20+ years: 1994 = 7,915,584; 2014 = 10,615,647. Total is composed of hospitalizations resulting from AMI, unstable angina, stroke, TIA, PAD and CHF.

AMI, acute myocardial infarction; CHF, congestive heart failure; CI, confidence interval; PAD, peripheral arterial disease; TIA, transient ischemic attack.

* Rates are standardized to the 2006 Ontario census population.

† Trends across years examined using Kendall tau-b correlation coefficient with $P < 0.0001$ for all outcomes.

Results

Hospitalization rates

Temporal trends in the rates of hospitalizations for the 6 ASCVD conditions are shown in Table 1 and Figure 1. Overall, an age-standardized relative reduction in hospitalizations of 54.2% (95% CI, 53.5%-54.7%) and 54.3% (95% CI, 53.6%-54.9%) was observed in men and women, respectively, between 1994 and 2014. Although significant declines ($P < 0.0001$) in hospitalization rates for all conditions were observed, the greatest rates of decline were for hospitalizations resulting from unstable angina, with average yearly declines of 8.1% (95% CI, 7.9%-8.3%) in men and 9.3% (95% CI, 9.0-9.5%) in women, much of which began in 2000 (Fig. 1). Hospitalization rates for TIA showed the second fastest declines, with yearly averages of 5.0% (95% CI, 4.5%-5.3%) in men and 4.7% (95% CI, 4.3%-5.0%) in women. AMI was the most frequent cause of hospitalization

in men, whereas CHF was the most frequent cause in women (Table 1). Although rates of all ASCVD conditions declined, the absolute number of hospitalizations increased for some conditions, owing in part to the increase in the Ontario adult population, which grew 34% from 7.9 million in 1994 to 10.6 million in 2014.

By sex, trends in age-standardized rates were significantly different except for hospitalizations attributed to CHF, stroke, and TIA, with less pronounced absolute declines observed in women (Supplemental Table S2).

Mortality trends

Mortality rates for circulatory diseases, including cardiovascular causes, declined 52.7% (95% CI, 51.6%-53.8%) in men and 52.8% (95% CI, 51.7%-53.9%) in women between 1994 and 2012 (Table 2; Supplemental Fig. S1). The rates of decline in deaths from IHD and CBVD were also similar for

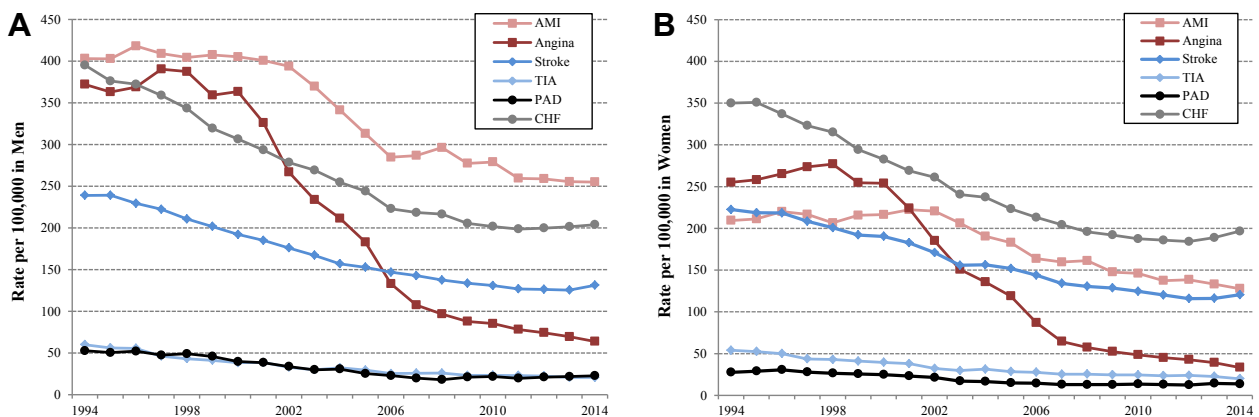


Figure 1. Age-standardized hospitalization rates (per 100,000) in (A) men and (B) women. Rates standardized to the 2006 Ontario census population. AMI, acute myocardial infarction; CHF, congestive heart failure; PAD, peripheral arterial disease; TIA, transient ischemic attack.

Table 2. Age-standardized* mortality rates for atherosclerotic cardiovascular disease and noncardiovascular-related disease (per 100,000) in men and women aged 20-105 years, Ontario 1994-2012†

Sex; cause of death	Number of deaths		Rate		Relative reduction, % (95% CI)	Average yearly decline, % (95% CI)
	1994	2012	1994	2012		
Men						
CBVD	2366	2022	81.6	37.0	54.7 (51.9-57.5)	4.2 (3.8-4.5)
IHD	9234	7323	306.1	134.3	56.1 (54.8-57.5)	4.4 (4.3-4.6)
Circulatory	14,358	12,432	480.7	227.4	52.7 (51.6-53.8)	4.1 (3.9-4.2)
Noncirculatory	23,853	32,124	762.4	596.7	21.7 (20.4-23.1)	1.3 (1.3-1.4)
Women						
CBVD	3480	2841	105.1	49.3	53.1 (50.6-55.5)	4.0 (3.7-4.3)
IHD	7870	5702	235.7	98.5	58.2 (56.7-59.7)	4.7 (4.5-4.9)
Circulatory	14,748	12,076	442.9	208.9	52.8 (51.7-53.9)	4.1 (3.9-4.2)
Noncirculatory	21,382	32,100	615.3	565.1	8.2 (6.6-9.9)	0.5 (0.4-0.6)

Ontario population aged 20+ years: 1994 = 7,915,584; 2012 = 10,323,459. Noncirculatory deaths include those missing information regarding cause of death.

CBVD, cerebrovascular disease; CI, confidence intervals; IHD, ischemic heart disease.

* Rates are standardized to the 2006 Ontario census population.

† Trends across years examined using Kendall tau-b correlation coefficient with $P < 0.05$ for all outcomes.

both sexes, with a steady decline of approximately 4% annually. In contrast, smaller relative reductions were observed in mortality rates attributable to noncardiovascular causes, which declined only 21.7% (95% CI, 20.4%-23.1%) in men and 8.2% (95% CI, 6.6%-9.9%) in women over this same period. The tests for trends were statistically significant for all mortality outcomes examined.

Across the study period, greater absolute declines in mortality were observed for men, with the exception of death from CBVD, with trends found to differ significantly across sex (Supplemental Table S2).

Revascularization procedures

Procedure rates are shown in Figure 2 and Supplemental Table S3. A significant increase in PCI procedure volume and rate ($P < 0.0001$) was observed during the study period, with the greatest increases occurring between 1994 and 2006 and rates remaining relatively stable thereafter (Fig. 2). In contrast, although rates of CABG increased slightly between 1994 and the late 1990s, an average yearly decline of 1% was observed in men and women, resulting from a steady decline in the 2000s. Trends in age-standardized rates were significantly different across sex for both PCI and CABG (Supplemental Table S2).

Age-specific trends

Age-specific rates for major ASCVD events are presented in Table 3. Across the study period, the greatest observed declines in hospitalization rates for AMI and CHF were among those aged 50-64 years and those aged 65-74 years; for stroke, these declines were among those aged 65-74 years and those aged 75+ years. When average yearly declines in rates were observed among those younger than 50 years of age, they were statistically significant ($P < 0.05$) but modest at $< 2\%$ (Table 3). For CHF and AMI in women and stroke in men, small increases in hospitalization rates were observed in this age group, although the trends did not approach significance in the latter 2 cases ($P = 0.7171$ and $P = 0.2047$, respectively). Age-specific trends were significantly different in patients 20-49 years of age vs patients in each of the other age groups ($P < 0.001$).

Composite measure

Significant declines in the age-standardized composite rates of hospitalization for 1 of the 6 ASCVD conditions or deaths resulting from circulatory diseases was observed from 1994-2012 (Supplemental Fig. S2; $P < 0.0001$). Declines in relative rates were comparable for both sexes, with a 49.2% decrease

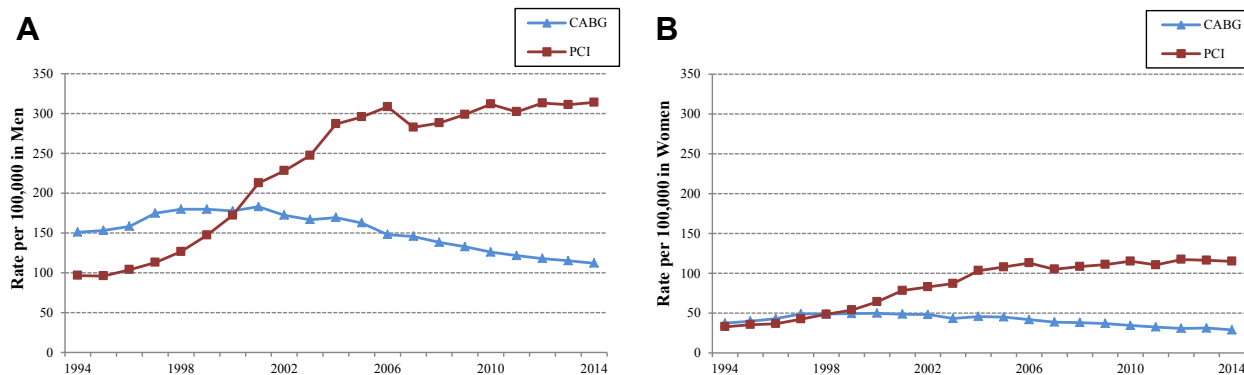


Figure 2. Age-standardized rate for cardiovascular revascularization procedures (per 100,000) in (A) men and (B) women. Rates standardized to the 2006 Ontario census population. CABG, coronary artery bypass grafting; PCI, percutaneous coronary intervention.

Table 3. Age- and sex-specific rates of major atherosclerotic cardiovascular events (per 100,000) in Ontarians aged 20-105 years, 1994-2012*

Sex; age (years)	Composite measure				AMI hospitalization				Stroke hospitalization				CHF hospitalization			
	n (rate)		Average yearly change (relative change) (%)		n (rate)		Average yearly change (relative change) (%)		n (rate)		Average yearly change (relative change) (%)		n (rate)		Average yearly change (relative change) (%)	
	1994	2012	1994	2012	1994	2012	1994	2012	1994	2012	1994	2012	1994	2012	1994	2012
Men																
20-49	4158 (162.7)	3097 (111.4)	-2.0 (-31.5)	1850 (72.4)	1701 (61.2)	-0.8 (-15.5)	451 (17.7)	487 (17.5)	381 (14.9)	324 (11.7)	0.4 (-1.1)	381 (14.9)	324 (11.7)	381 (14.9)	324 (11.7)	-0.9 (-21.5)
50-64	11,841 (1588.7)	10,802 (802.3)	-3.7 (-49.5)	4273 (573.3)	4886 (362.9)	-2.4 (-36.7)	1426 (191.3)	1719 (127.7)	2026 (271.8)	1555 (115.5)	-2.1 (-33.2)	2026 (271.8)	1555 (115.5)	2026 (271.8)	1555 (115.5)	-4.6 (-57.5)
65-74	14,370 (4023.9)	9277 (1820.7)	-4.3 (-54.8)	3658 (1024.3)	3056 (599.8)	-2.8 (-41.4)	2338 (654.7)	1627 (319.3)	3938 (1102.7)	2433 (477.5)	-3.9 (-51.2)	3938 (1102.7)	2433 (477.5)	3938 (1102.7)	2433 (477.5)	-4.5 (-56.7)
75+	17,340 (9166.7)	18,458 (5043.4)	-3.2 (-45.0)	3058 (1616.6)	4033 (1102.0)	-2.0 (-31.8)	3177 (1679.5)	2874 (785.3)	5744 (3036.5)	6486 (1772.2)	-4.1 (-53.2)	5744 (3036.5)	6486 (1772.2)	5744 (3036.5)	6486 (1772.2)	-2.9 (-41.6)
Overall†	47,709 (1533.4)	41,634 (778.3)	-3.7 (-49.2)	12,839 (403.0)	13,676 (255.0)	-2.2 (-36.7)	7392 (239.0)	6707 (131.3)	12,089 (395.2)	10,798 (199.8)	-2.9 (-45.1)	12,089 (395.2)	10,798 (199.8)	12,089 (395.2)	10,798 (199.8)	-3.7 (-49.4)
Women																
20-49	1543 (60.3)	1236 (43.6)	-1.7 (-27.7)	356 (13.9)	448 (15.8)	1.2 (13.7)	403 (15.8)	361 (12.7)	184 (7.2)	187 (6.6)	-0.8 (-19.6)	184 (7.2)	187 (6.6)	184 (7.2)	187 (6.6)	1.0 (-8.3)
50-64	5451 (717.7)	4475 (322.4)	-4.3 (-55.1)	1433 (188.7)	1609 (115.9)	-2.5 (-38.6)	910 (119.8)	1001 (72.1)	1187 (156.3)	838 (60.4)	-2.7 (-39.8)	1187 (156.3)	838 (60.4)	1187 (156.3)	838 (60.4)	-5.0 (-61.4)
65-74	10,027 (2337.8)	5441 (963.3)	-4.8 (-58.8)	2204 (513.9)	1532 (271.2)	-3.3 (-47.2)	1943 (453.0)	1205 (213.3)	2849 (664.3)	1633 (289.1)	-4.0 (-52.9)	2849 (664.3)	1633 (289.1)	2849 (664.3)	1633 (289.1)	-4.5 (-56.0)
75+	24,174 (7491.9)	22,539 (4236.6)	-3.1 (-43.5)	3433 (1063.9)	4153 (780.6)	-1.6 (-26.6)	4512 (1398.3)	3894 (731.9)	7794 (2415.5)	7713 (1449.8)	-3.5 (-47.7)	7794 (2415.5)	7713 (1449.8)	7794 (2415.5)	7713 (1449.8)	-2.8 (-40.0)
Overall†	41,195 (1191.2)	33,691 (596.2)	-3.7 (-49.9)	7426 (209.4)	7742 (127.8)	-2.4 (-39.0)	7768 (222.6)	6461 (120.4)	12,014 (350.0)	10,371 (184.1)	-3.0 (-45.9)	12,014 (350.0)	10,371 (184.1)	12,014 (350.0)	10,371 (184.1)	-3.5 (-47.4)

Ontario population aged 20+ years: 1994 = 7,915,584; 2012 = 10,323,459. Composite measure composed of 1 of either of the following: hospitalization resulting from acute myocardial infarction, stroke, peripheral arterial disease, congestive heart failure, unstable angina or transient ischemic attack, or death from circulatory diseases.

AMI, acute myocardial infarction; CHF, congestive heart failure.

* Trends across years examined using Kendall tau-b correlation coefficient with $P < 0.05$ for all subgroups except AMI hospitalizations in women ($P = 0.717$) and stroke hospitalizations in men ($P = 0.2047$) aged 20-49 years.

† Rates standardized to the 2006 Ontario census population.

from 1533.4 per 100,000 in 1994 to 778.3 per 100,000 in 2012 observed in men and a 49.9% decrease from 1191.2 per 100,000 in 1994 to 596.2 per 100,000 in 2012 in women (Table 3). Consistent with some individual ASCVD outcomes, average yearly declines during the study period were least pronounced in those aged 20-49 years and greatest in those aged 50-64 years and 65-74 years (Table 3).

Prevalence

Comparing 2001 and 2012, the self-reported prevalence of Ontarians living with heart disease or stroke, or both, declined nonsignificantly (P for trend = 0.19) from 7.7% to 7.1% for men and significantly (P for trend = 0.01) from 7.3% to 5.8% for women. The annual prevalence of self-reported heart disease decreased among both men and women as well as self-reports for stroke among women, with only the prevalence of heart disease in women being statistically significant (Table 4). A nonsignificant average yearly increase of 1.1% (95% CI, -4.7% to 9.4%) was observed in men for self-reported stroke. The absolute burden of self-reported heart disease and stroke increased because of population growth.

Discussion

As part of the CANHEART “big data” initiative, we studied contemporary temporal trends in hospitalizations and deaths from ASCVD conditions over a 20-year period in Ontario. Striking improvements were observed for most conditions, with an overall decline of approximately 50% in both hospitalizations and cardiovascular deaths, driven mostly by declines among those 50-74 years of age. Reductions in hospitalization rates were most notable for unstable angina and TIAs, which declined by > 80% and 60%, respectively. Declines in ASCVD hospitalization and death rates were accompanied by a slight decrease in the self-reported prevalence of Ontarians living with heart disease or stroke, or both. In contrast, declines in rates of noncirculatory deaths were less pronounced. Although our overall results are encouraging, there are inequalities in CVD declines, with improvements least evident, and in some cases nonexistent, among Ontarians younger than 50 years of age, which remains an area of ongoing concern.

Our findings of decreasing hospitalization and death rates from ASCVD are consistent with a number of previous studies conducted in Canada, the United States, and Western European countries, although most of these studies were over a shorter time frame and did not include all 6 ASCVD conditions examined in this study.^{1,9-11} In Western Europe, 10-year reductions in mortality from CVD and stroke were in excess of 30% and comparable to those observed in the present study.⁹ In the United States, annual rates of decline of 3.79% for all CVD mortality and 3.69% for heart disease mortality from 2000-2011 have been reported,¹⁰ similar to the average annual declines in deaths resulting from circulatory disease of 4.1% that we observed. In another study in the United States, a 43% relative increase in stroke among those 25-44 years of age and a 4.7% increase among those 45-69 years of age from 2000-2010 was observed.¹¹ Our study also found hospitalization rates for stroke in men to be rising at a modest average annual rate in the youngest age group of patients 20-49 years of age.

Table 4. Age-standardized* self-reported prevalence of heart disease and stroke (%) among men and women aged 20-102, Ontario 2001-2012†

Sex; outcomes	Number of events		Rate		Average yearly change, % (95% CI)	P for trend
	2001	2011-2012	2001	2011-2012		
Men						
Heart disease	258,069	327,231	7.0	6.4	-1.4 (-3.8 to 1.6)	0.09
Stroke	49,997	72,215	1.4	1.4	1.1 (-4.7 to 9.4)	0.85
Composite	285,284	367,188	7.7	7.1	-1.3 (-3.4 to 1.5)	0.19
Women						
Heart disease	257,283	246,242	6.5	4.8	-5.4 (-7.8 to -2.2)	0.01
Stroke	61,224	82,155	1.6	1.5	-0.3 (-6.2 to 7.2)	0.85
Composite	288,558	299,941	7.3	5.8	-4.3 (-6.7 to -1.6)	0.01

Estimates weighted using Statistics Canada survey weights. The composite measure is composed of self-reporting at least 1 of the following: having heart disease or experiencing the effects of a stroke.

CI, confidence interval.

* Rates standardized to the 2006 Ontario census population.

† Trends in prevalence rates across Canadian Community Health Survey cycles examined using Kendall tau-b correlation coefficient and associated P value.

Although a detailed analysis examining potential contributing factors to our findings is outside the scope of this article, studies conducted in Ontario and similar jurisdictions suggest that the reasons likely include a combination of declines in smoking rates, improved control of high blood pressure, and higher use of statin drugs and other lipid-lowering therapies.^{12,13} Advances in treatments over the past 2 decades for conditions such as acute coronary syndromes, cerebrovascular events, and CHF are also likely to be contributory. Despite our positive findings, obesity and diabetes rates in Ontario and elsewhere among younger individuals are rising,^{3,14} which may partially offset advances in ASCVD prevention and treatment, resulting in the significantly slower declines observed in this group. The lack of progress observed in event rates among Ontarians 20-49 years of age are particularly noteworthy because event rates in this group will become increasingly important as they age. The potential reasons for our findings that trends differed across men and women for some outcomes should be explored in future studies.

The population-based nature of the databases used in this study and the scope of outcomes examined enabled us to conduct a comprehensive examination of cardiovascular population health and disease burden in Ontario. However, we recognize some important limitations. First, our analyses relied primarily on ICD-9 and ICD-10 codes reported in administrative databases. Although most codes used in our study have been previously validated using chart reviews, clinical registries, and other data sources,¹⁵⁻²⁰ reporting may be subject to miscoding. Our findings are also a reflection of trends in Ontario, Canada's largest province, and may not be generalizable to other provinces in Canada. Among Canadian provinces, where an "east to west" gradient has been observed in CVD death rates and self-reported heart disease, Ontario has historically ranked in the middle.^{21,22} Due to limitations of the questions posed in the CCHS, except for stroke, only prevalence rates of heart disease overall could be determined. Since prevalence estimates in this study were from self-reported data, response bias may have influenced the results.

Conclusions

Our findings that the overall burden of most ASCVD conditions is on the decline in Ontario suggests that advancements in screening, prevention, and treatment of

ASCVD appear to have had an important public health and health systems impact over the past 2 decades. These results are encouraging but should not be grounds for complacency, because ASCVD remains among the leading causes of death in Canada,²³ and 90% of Canadians have suboptimal "cardiovascular health," with at least 1 cardiovascular risk factor.² Furthermore, in light of our finding that the declines in rates for younger Ontarians were modest, and in certain sex/age groups higher in more recent years than they were in 1994, the need for continued investment in improving ASCVD outcomes is important to ensure the progress made thus far continues.

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Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Cardiology* at www.onlinecjc.ca and at <http://dx.doi.org/10.1016/j.cjca.2016.11.009>.