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# Diagnosed hypertension in Canada: incidence, prevalence and associated mortality

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## ABSTRACT

**Background:** Hypertension is a leading risk factor for cardiovascular diseases. Our objectives were to examine the prevalence and incidence of diagnosed hypertension in Canada and compare mortality among people with and without diagnosed hypertension.

**Methods:** We obtained data from linked health administrative databases from each province and territory for adults aged 20 years and older. We used a validated case definition to identify people with hypertension diagnosed between 1998/99 and 2007/08. We excluded pregnant women from the analysis.

**Results:** This retrospective population-based study included more than 26 million people. In 2007/08, about 6 million adults (23.0%) were living with diagnosed hypertension and about 418 000 had a new diagnosis. The age-standardized prevalence increased signifi-

cantly from 12.5% in 1998/99 to 19.6% in 2007/08, and the incidence decreased from 2.7 to 2.4 per 100. Among people aged 60 years and older, the prevalence was higher among women than among men, as was the incidence among people aged 75 years and older. The prevalence and incidence were highest in the Atlantic region. For all age groups, all-cause mortality was higher among adults with diagnosed hypertension than among those without diagnosed hypertension.

**Interpretation:** The overall prevalence of diagnosed hypertension in Canada from 1998 to 2008 was high and increasing, whereas the incidence declined during the same period. These findings highlight the need to continue monitoring the effectiveness of efforts for managing hypertension and to enhance public health programs aimed at preventing hypertension.

**Competing interests:** None declared. Susan Quach's contribution to the manuscript was made in her previous capacity at the Public Health Agency of Canada. No official support or endorsement by Public Health Ontario is intended, nor should be inferred.

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Globally, raised blood pressure is the leading risk factor for death, accounting for about 13% of all deaths,<sup>1,2</sup> and it is the strongest risk factor for lost years of healthy life.<sup>1</sup> Left untreated, hypertension can increase the risk of stroke, coronary artery disease, dementia, heart and kidney failure, and other chronic diseases.<sup>3–6</sup> Managing hypertension through lifestyle modification or the use of anti-hypertensive medications, or both, can help mitigate these outcomes.<sup>7</sup> Over the past decades in Canada, mortality associated with cardiovascular diseases has decreased,<sup>8</sup> partly because of increased awareness and diagnosis of hypertension and better control of blood pressure.<sup>9,10</sup> However, the prevalence of hypertension remains high, and currently there are no mechanisms to track new cases at the national level.

To date, information about hypertension in Canada has been mainly obtained by health surveys conducted at the provincial or national levels. Such surveys typically provide prevalence (not incidence) data and include limited data about

trends over time.<sup>11–15</sup> National health surveys in Canada are resource intensive, do not include information about people who live in remote areas or institutions, and may underestimate hypertension prevalence because of recall bias and non-response.<sup>16</sup> The use of administrative data that is population-based and routinely collected, such as physician claims and hospital discharge data, allows for a more comprehensive picture of this condition. Other important advantages of using administrative data include the readiness of the data to be analyzed, cost-efficiency, wide geographic coverage and the relatively complete capture of patient contact with the health care system (i.e., less prone to selection bias).

Several recent studies in Canada and the United States have established valid methods for using administrative data to identify cases of hypertension.<sup>16–23</sup> In a study conducted in Ontario involving women and men aged 20 years and older, Tu and colleagues found that the prevalence and incidence of diagnosed hypertension were 24.5% in 2005 and 3.2% in 2004, respectively.<sup>24</sup> We used the same

validated case definition to examine the prevalence and incidence of diagnosed hypertension in Canada from 1998/99 to 2007/08 by age and by province and territory. We also compared all-cause mortality by age and sex among those with and without diagnosed hypertension.

## Methods

### Study design

We performed a retrospective population-based cohort study involving Canadian adults aged 20 years and older from 1998/99 to 2007/08. There is usually a lag time of two to three years for jurisdictions to obtain data and to accrue evidence for the application of the case definition for diagnosed hypertension. Although data from the provinces and territories were collected beginning in 1995/96, we chose 1998/99 as the starting point to exclude records of patients who had received a diagnosis of hypertension before the study period. This allowed us to avoid overestimating the number of incident cases. We chose 2007/08 as the end point because it had the most recent data available at the start of the study.

### Data sources

The Canadian Chronic Disease Surveillance System is a collaborative network of provincial and territorial surveillance systems supported by the Public Health Agency of Canada. This network collects and reports surveillance information on diagnosed diabetes (formerly the National Diabetes Surveillance System)<sup>25</sup> and other chronic conditions, such as diagnosed hypertension.<sup>26</sup> The Canadian Chronic Disease Surveillance System collects aggregated data by use of a personal health insurance number from linked administra-

tive databases from each province and territory, namely the health insurance registry, physician billing and hospital discharge databases. All provinces and territories use a standardized set of SAS macros to process their data, which ensures comparability. Full-time members of the Canadian Forces and people in the Royal Canadian Mounted Police and federal correctional facilities are not included in these databases.

We obtained data on age, sex, place of residence and date of death from health insurance registries, except in Quebec. We used the census to obtain this information for the province of Quebec. We used the total number of people eligible for health insurance in a province or territory, or the insured population, as the denominator for determining incidence, prevalence and mortality.

The physician billing database includes all fee-for-service payments for services rendered and may include information about alternate payment structures using shadow-billing claims. Many provinces and territories also include nurse-practitioner claims. Each claim contains at least one diagnosis coded using the ninth revision of the International Classification of Diseases (ICD), except in the province of New Brunswick where no standard nomenclature is used. Instead, they searched for the term “hypertension” and its abbreviations and acronyms.

Demographic, administrative and clinical data for all patients discharged from a hospital were obtained through the Canadian Institute for Health Information’s Discharge Abstract Database for most provinces and territories and from the Med-Écho system for Quebec. Up to 16 diagnoses, including the most responsible diagnosis, are listed for each hospital discharge when ICD-9 is used and up to 26 diagnoses when ICD-10 is used.

**Table 1:** Age-standardized\* prevalence and incidence of diagnosed hypertension among adults aged 20 years and older in Canada from 1998/99 to 2007/08

Year	Prevalence, %			Incidence, per 100 per year		
	Women	Men	Total	Women	Men	Total
1998/99	13.2	11.7	12.5	2.9	2.5	2.7
1999/00	14.4	12.9	13.8	2.8	2.5	2.7
2000/01	15.6	14.1	14.9	2.9	2.7	2.8
2001/02	16.5	15.2	16.0	2.8	2.6	2.7
2002/03	17.4	16.2	16.8	2.8	2.6	2.7
2003/04	18.1	17.0	17.6	2.7	2.6	2.7
2004/05	18.7	17.7	18.2	2.6	2.6	2.6
2005/06	19.1	18.4	18.8	2.5	2.6	2.6
2006/07	19.5	18.9	19.3	2.4	2.6	2.5
2007/08	19.7	19.4	19.6	2.3	2.4	2.4

\*Age-standardized to the 1991 Canadian population.

## Hypertension case definition

We considered insured individuals aged 20 years and older to have diagnosed hypertension if they met the following criteria: either two or more physician claims for hypertension within two years, or one recording of hypertension in the hospital discharge abstract. We identified hypertension cases using the relevant ICD codes (ICD-9-CM: 401.x, 402.x, 403.x, 404.x or 405.x; ICD-10-CA: I10.x, I11.x, I12.x, I13.x or I15.x). Once the case definition was met, prevalent cases remained prevalent while the patients were alive and resided in the province or territory (as long as their health insurance number was valid). Cases were deemed incident in the first year in which they met the case definition, and cases could be considered incident only once. Before 2001, all provinces and territories used the ICD-9 or ICD-9-CM classification system for both hospital discharge and physician billing data. For discharge data, however, some jurisdictions began using the ICD-10-CA classification in 2001/02 and some began using it by 2006/07. Validation studies conducted in three Canadian provinces showed that the sensitivity of the case definition was 66%–72%, the specificity was 95%–97%, the positive predictive value was 77%–87% and the negative predictive value was 88%–93%.<sup>17–19,24</sup>

To exclude cases of gestational hypertension, we excluded women aged 20–54 years with suspected pregnancy-induced hypertension (defined as a diagnosis code for hypertension 120 days before or 180 days after any pregnancy-related visit). Specific diagnosis codes indicative of pregnancy or obstetric events are available in the National Diabetes Surveillance System methods documentation.<sup>27</sup>

## Statistical analysis

Statistical analyses were performed using SAS Enterprise Guide (version 4.1). We calculated prevalence by dividing the total number of people diagnosed with hypertension by the insured population (or by the census population for Quebec). We calculated projected prevalence counts for five years (2008/09 to 2012/13) based on conservative assumptions in which we presumed that age- and sex-specific hypertension incidence and mortality would remain constant for the duration of the five-year projection period. We then applied these rates to moderate growth population projections by province and territory and summed the values to give the projected number of prevalent hypertension cases. We calculated incidence by dividing the total number of people with newly diagnosed hypertension during the

selected fiscal year by the total number of people at risk for hypertension during the same year (total number of insured population minus the prevalent cases). We obtained mortality rate ratios by dividing all-cause mortality among people with diagnosed hypertension by that among people without diagnosed hypertension.

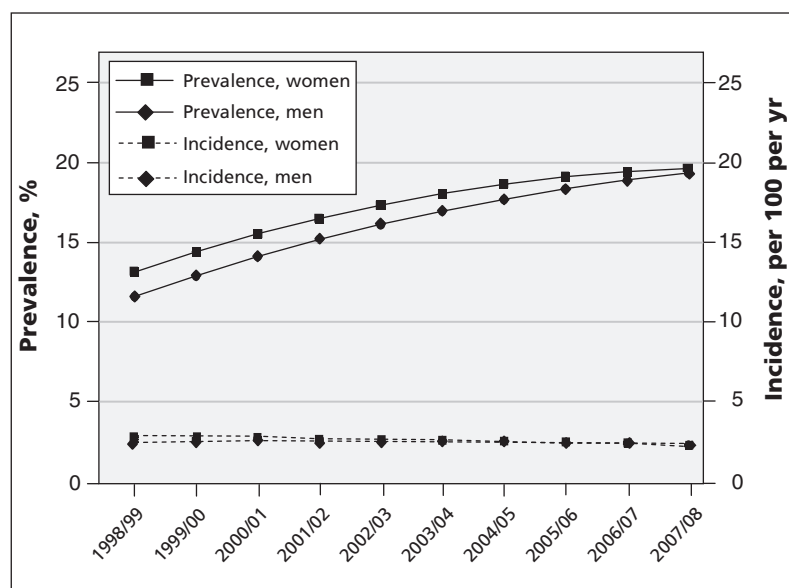
Where indicated, the incidence and prevalence were age-standardized to the 1991 Canadian population aged 20 years and older to allow a comparison of hypertension rates over the study period, and we calculated 95% confidence intervals (CIs). We conducted linear regression on the log of the rates to estimate the average annual per cent change. We evaluated statistical significance by testing the slope parameter for being different from zero. We used *t* tests to compare rates across jurisdictions and by sex.

## Results

In 2007/08, about 6 million (23.0%) Canadian adults had diagnosed hypertension. The crude prevalence was higher among women (24.3%, 95% CI 24.2%–24.3%) than among men (21.7%, 95% CI 21.7%–21.8%).

About 418 000 adults had newly diagnosed hypertension in 2007/08. The crude incidence per 100 was higher among men (2.1, 95% CI 2.1–2.1) than among women (1.9, 95% CI 1.9–2.0).

Overall, the age-standardized prevalence of diagnosed hypertension increased from 12.5% in 1998/99 to 19.6% in 2007/08, with an average annual change of 5% ( $p < 0.001$ ; Table 1, Figure 1). The average annual per cent change was not



**Figure 1: Prevalence and incidence of diagnosed hypertension among adults aged 20 years and older from 1998/99 to 2007/08 in Canada. The rates have been age-standardized to the 1991 Canadian population.**

significantly different between women and men ( $p = 0.06$ ). In contrast, the age-standardized incidence remained stable throughout the study period among men, with an average rate of 2.6%. There was a significant decrease in the average annual percent change of 2% among women ( $p < 0.001$ ; Figure 1, Table 1). If the 2007/08 age- and sex-specific incidence and mortality remain constant, we forecast that about 26.5% (7.4 million) of Canadian adults will be living with diagnosed hypertension by 2012/13 (Figure 2).

The prevalence of diagnosed hypertension increased with increasing age. The incidence also increased with age, up to age 80–84 (Figure 3). The prevalence was similar among women

and men under age 60. From the age 60 onwards, the prevalence was higher among women than among men. For example, among those aged 60–64 years, the prevalence was 43.6% (95% CI 43.5%–43.7%) among women and 43.0% (95% CI 42.9%–43.2%) among men. Similarly, the incidence was higher among women than among men for those aged 75 years or more. For example, the incidence per 100 was 8.6 (95% CI 8.5–8.8) among women aged 75–79 years, while it was 8.2 (95% CI 8.0–8.3) among men of a similar age (Table 2).

The age-standardized prevalence of diagnosed hypertension was higher in the Atlantic region (23.3%) than in the territories and western Canada (19.0%) ( $p < 0.001$ ; Figure 4, Table 3). A similar pattern was observed for incidence, with an age-standardized incidence per 100 of 3.3 in the Atlantic region and 2.5 in the territories and western Canada combined ( $p < 0.001$ ; Figure 4).

All-cause mortality increased with increasing age and was consistently higher among people of all ages with hypertension (2.2–120.4 per 1000) than among those without hypertension (0.5–105.1 per 1000) ( $p < 0.05$ ; Figure 5, Table 4). Mortality was two to four times higher among adults aged 20–49 years with hypertension than among those without hypertension ( $p < 0.05$ ). In contrast, mortality was 1.1–1.8 times higher among adults aged 50 years and older with hypertension than among those without hypertension ( $p < 0.05$ ).

## Interpretation

In this population-based study involving more than 26 million adults in Canada, we found that the age-standardized prevalence increased significantly from 12.5% in 1998/99 to 19.6% in 2007/08. The incidence per 100 during the same period decreased from 2.7 to 2.4.

Overall, the crude prevalence of diagnosed hypertension (23.0%) reported in 2007/08 was higher than that reported in the 2007 Canadian Community Health Survey (19.2%).<sup>28</sup> Self-reported hypertension in the latter survey may have been lower because about 5% of people who report the use of medication for hypertension do not report having hypertension, possibly because they think that they do not have the condition or that their hypertension has been “cured” when their blood pressure is controlled by medication or lifestyle modification.<sup>29</sup> Similarly, the crude prevalence observed in our study is higher than the prevalence based on direct blood pressure measurements among people aged 20–79 years in the Canadian Health Measures Survey (19.4%).<sup>11</sup> The prevalence of hypertension may also have been lower in those

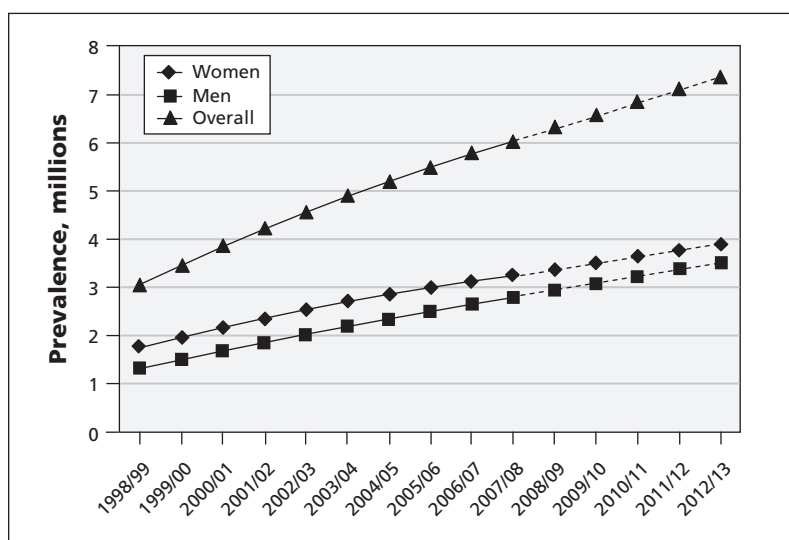


Figure 2: Observed and projected number of prevalent cases of hypertension among adults aged 20 years and older, by sex. Observed: 1998/99 to 2007/08; projected: 2008/09 to 2012/13.

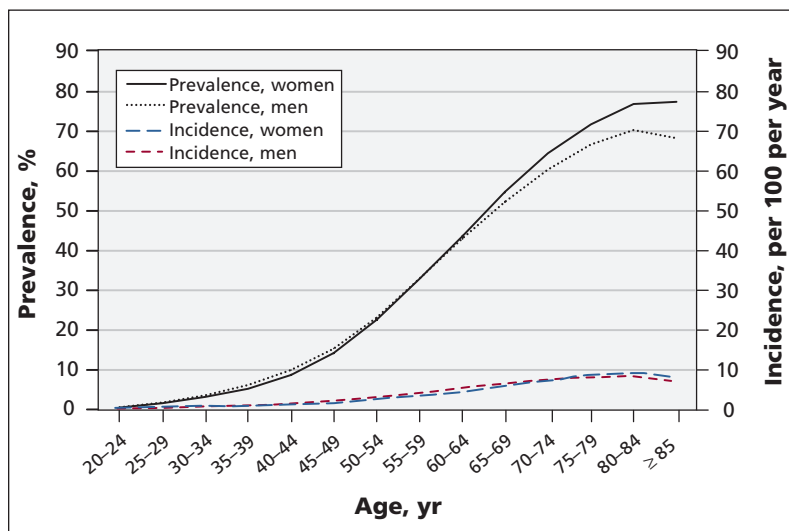


Figure 3: Age-specific prevalence and incidence of diagnosed hypertension among adults aged 20 years and older in 2007/08, by sex.

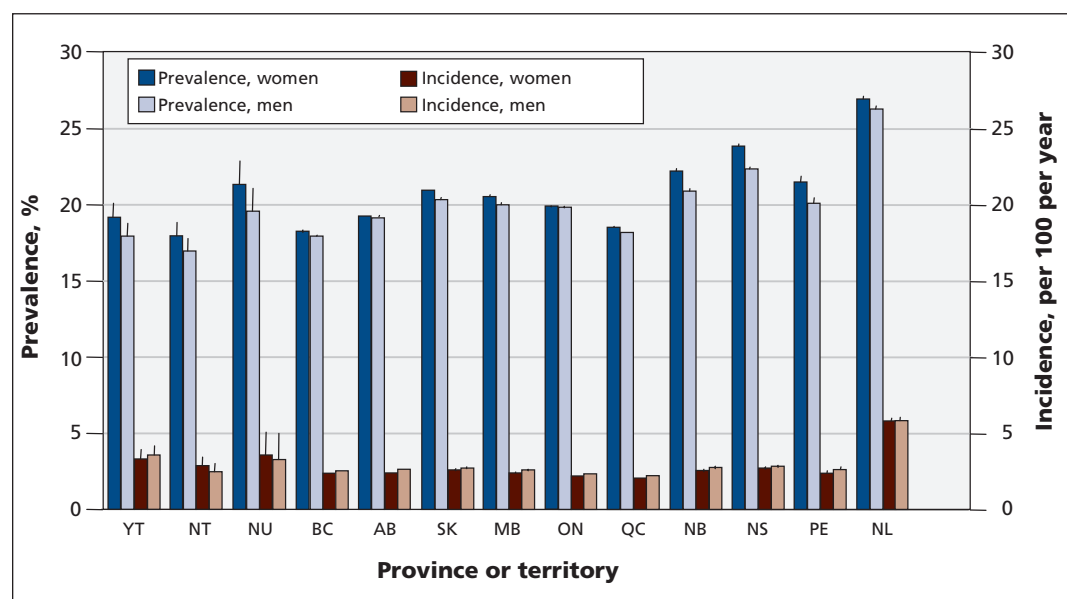
two surveys because they sampled only the household population, whereas our data were for all Canadian adults (with the previously noted exceptions) who have used the health care system.

The increase in the number of people with diagnosed hypertension is similar to that observed in studies conducted in Ontario and Manitoba using the same validated case definition.<sup>18,24</sup> However, the population prevalence of hypertension estimated from health measure surveys was stable between 1992 and 2009, varying only between 19.7% and 21.6%.<sup>30</sup> The increase observed in our study may be

partly because more people are being screened and diagnosed by physicians, and thus more people are aware of their condition.<sup>11,13,30,31</sup> The proportion of Canadians with hypertension who are aware of their condition increased from 56.9% in 1992 to 82.5% in 2009. Another likely contributor to this rise is the decline in mortality among people with hypertension and other cardiovascular diseases.<sup>8,9,32</sup> A recent systematic review using health examination survey data from 199 countries and territories found that, globally, systolic blood pressure decreased by 1 mm Hg per decade for men and

**Table 2:** Age-specific prevalence and incidence of diagnosed hypertension in 2007/08

Age, yr	Prevalence, %			Incidence, per 100 per year		
	Women	Men	Total	Women	Men	Total
20–24	0.5	0.6	0.5	0.2	0.2	0.2
25–29	1.6	1.7	1.6	0.3	0.3	0.3
30–34	3.2	3.6	3.4	0.4	0.6	0.5
35–39	5.2	6.2	5.7	0.7	0.9	0.8
40–44	8.7	9.9	9.3	1.2	1.4	1.3
45–49	14.2	15.4	14.8	1.9	2.1	2.0
50–54	22.6	23.1	22.8	2.7	3.0	2.8
55–59	32.8	32.9	32.9	3.4	4.0	3.7
60–64	43.6	43.0	43.3	4.6	5.2	4.9
65–69	54.8	52.3	53.6	6.1	6.4	6.3
70–74	64.5	60.4	62.6	7.5	7.4	7.4
75–79	71.8	66.7	69.5	8.6	8.2	8.4
80–84	77.0	70.3	74.3	9.2	8.4	8.8
≥ 85	77.5	68.3	74.6	7.6	6.9	7.3



**Figure 4:** Prevalence and incidence of diagnosed hypertension among people aged 20 years and older in 2007/08, by sex and province or territory. Rates are age-standardized to the 1991 Canadian population. Error bars indicate 95% confidence intervals.



women between 1980 and 2008.<sup>33</sup> Country- and region-specific data, however, showed complex patterns, with some modest to large decreases in systolic blood pressure in many areas but with some steady trends in others and possible increases in certain regions. These results may differ from the overall pattern in our study because those studies relied on direct blood pressure measurements, thus identifying individuals with hypertension who may not have been aware of their condition, while we relied on diagnosed hypertension.

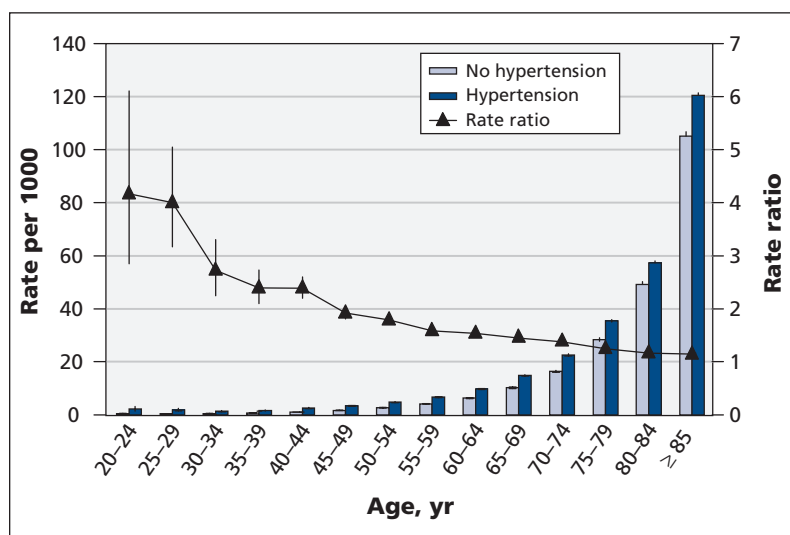
The modest decrease we observed in the incidence of diagnosed hypertension may be because

of the variation in trends in cardiovascular risk factors over the past decades in Canada. Although obesity rates have increased,<sup>34</sup> leisure time, physical inactivity and smoking rates have decreased.<sup>35-37</sup> Nonetheless, evidence from this study indicates that increased preventive measures are warranted to see a continued decrease in incident cases in the short term and a decrease in prevalence in the longer term.

In this study, prevalence increased with increasing age, whereas incidence increased up to age 80–84 years. The age-specific prevalence and incidence indicate that elderly women have higher rates of diagnosed hypertension than elderly men. This may be explained by the fact that women are, in general, more aware of hypertension than men, as shown in other studies.<sup>31,38-41</sup>

We found important regional variations, with higher prevalence and incidence observed in the Atlantic region than in the territories and western Canada. This pattern is consistent with the east-to-west gradients reported in other Canadian studies of risk factors, namely obesity and diabetes.<sup>42,43</sup> In addition, this pattern follows the east-to-west gradient of cardiovascular health outcomes, such as heart disease, for which hypertension is a leading risk factor.<sup>44</sup>

All-cause mortality was higher among people with hypertension than among those without hypertension, with rate ratios ranging between 1.9 and 4.2 among younger people. This may indicate that people with diagnosed hypertension, especially younger adults, are less healthy than those without diagnosed hypertension and thus experience worse



**Figure 5:** All-cause annual mortality and rate ratios in 2007/08 among adults aged 20 years and older with and without diagnosed hypertension, by age. Error bars indicate 95% confidence intervals.

**Table 3:** Age-standardized\* prevalence and incidence of diagnosed hypertension among adults aged 20 years and older in 2007/08, by province or territory.

Province or territory	Prevalence, %			Incidence, per 100 per year		
	Women	Men	Total	Women	Men	Total
British Columbia	18.3	17.9	18.1	2.4	2.5	2.4
Alberta	19.3	19.1	19.3	2.4	2.6	2.5
Saskatchewan	21.0	20.4	20.7	2.6	2.7	2.7
Manitoba	20.5	20.0	20.3	2.4	2.6	2.5
Ontario	19.9	19.9	19.9	2.2	2.3	2.3
Quebec	18.5	18.2	18.5	2.1	2.2	2.2
New Brunswick	22.2	20.9	21.6	2.6	2.7	2.7
Nova Scotia	23.9	22.3	23.2	2.7	2.8	2.8
Prince Edward Island	21.5	20.1	20.9	2.4	2.6	2.5
Newfoundland and Labrador	27.0	26.3	26.6	5.8	5.9	5.8
Yukon Territory	19.2	17.9	18.5	3.3	3.6	3.5
Northwest Territories	18.0	17.0	17.5	2.9	2.5	2.7
Nunavut	21.4	19.6	20.4	3.5	3.3	3.5

\*Age-standardized to the 1991 Canadian population.

health outcomes. However, because we did not investigate cause of death, we cannot attribute mortality specifically to cardiovascular disease. In addition, the confidence intervals for the rate ratios in the younger groups are wide (Figure 5), and the results need to be interpreted with caution.

### Limitations

The findings of this study should be considered in light of the following limitations. First, only people who were in contact with the health care system and who received a diagnosis of hypertension were included in this study. About 17% of Canadian adults with measured hypertension are unaware of their condition.<sup>11</sup> Thus, our estimates of prevalence and incidence are likely underestimated.<sup>11</sup> This probably did not have a large impact on our results, however, because a large proportion of Canadians (almost 80%) responding to the 2001 Canadian Community Health Survey reported that they had at least one contact with a general practitioner in the past 12 months.<sup>45</sup> As well, population denominators derived from administrative data have been shown to be comparable to those calculated using the Canadian census, with a difference of less than 1%.<sup>46</sup>

Second, the use of health administrative data to estimate diagnosed hypertension can result in the misclassification of hypertension cases and non-cases. Thus, balancing false-negatives and false-positives is required. Validation studies have indicated that the case criteria used by the Canadian

Chronic Disease Surveillance System minimizes both false-negatives and false-positives.<sup>17–19,47</sup> However, the case definition we used to identify cases maximizes specificity (95%–97%) compared with sensitivity (66%–72%), which would thus underestimate the proportion of Canadians diagnosed with hypertension.<sup>18,19,24</sup>

Third, geographic differences cannot be explained with certainty. Provincial and territorial coding practices and the capture of billing information from salaried physicians may differ by jurisdiction. However, because the validity of the case definition was similar among Ontario, Manitoba, Alberta and British Columbia,<sup>17–19</sup> it is more likely that patterns of risk factors, rather than methodologic limitations, explain the variation.

### Conclusion

The number of people living with diagnosed hypertension has increased steadily from 1998/99 to 2007/8. In addition, almost half a million Canadians were newly diagnosed with hypertension in 2007/08 alone, and the incidence only slightly declined during the study period. Programs to improve the lifestyles of Canadians, such as the proposed initiative to reduce sodium consumption,<sup>48</sup> will be critical to decrease the incidence and prevalence of diagnosed hypertension in Canada. This study highlights the need to continue tracking diagnosed hypertension in Canada to provide timely surveillance information that can be used to enhance prevention and management programs for Canadians.

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**Table 4:** All-cause mortality and rate ratios among adults aged 20 years and older with and without diagnosed hypertension in Canada in 2007/08

Age, yr	All-cause mortality, per 1000 people		Rate ratio
	No hypertension	Hypertension	
20–24	0.5	2.2	4.2
25–29	0.5	2.0	4.0
30–34	0.5	1.5	2.7
35–39	0.7	1.8	2.4
40–44	1.1	2.6	2.4
45–49	1.8	3.5	1.9
50–54	2.7	4.9	1.8
55–59	4.2	6.7	1.6
60–64	6.4	9.8	1.5
65–69	10.3	14.9	1.5
70–74	16.5	22.7	1.4
75–79	28.5	35.5	1.2
80–84	49.2	57.4	1.2
≥ 85	105.1	120.4	1.1



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