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RESEARCH

Changes in the rates of awareness, treatment and control of hypertension in Canada over the past two decades

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Abstract

Background: Analyses of medication databases indicate marked increases in prescribing of antihypertensive drugs in Canada over the past decade. This study was done to examine the trends in the prevalence of hypertension and in control rates in Canada between 1992 and 2009.

Methods: Three population-based surveys, the 1986–1992 Canadian Heart Health Surveys, the 2006 Ontario Survey on the Prevalence and Control of Hypertension and the 2007–2009 Canadian Health Measures Survey, collected self-reported health information from, and measured blood pressure among, community-dwelling adults.

Results: The population prevalence of hypertension was stable between 1992 and 2009 at 19.7%–21.6%. Hypertension control improved from 13.2% (95% confidence interval [CI] 10.7%–15.7%) in 1992 to 64.6% (95% CI 60.0%–69.2%) in 2009, reflecting improvements in awareness (from 56.9% [95% CI 53.1%–60.5%] in 1992 to 82.5% [95% CI 78.5%–86.0%] in

2009) and treatment (from 34.6% [95% CI 29.2%–40.0%] in 1992 to 79.0% [95% CI 71.3%–86.7%] in 2009) among people with hypertension. The size of improvements in awareness, treatment and control were similar among people who had or did not have cardiovascular comorbidities Although systolic blood pressures among patients with untreated hypertension were similar between 1992 and 2009 (ranging from 146 [95% CI 145–147] mm Hg to 148 [95% CI 144–151] mm Hg), people who did not have hypertension and patients with hypertension that was being treated showed substantially lower systolic pressures in 2009 than in 1992 (113 [95% CI 112–114] v. 117 [95% CI 117–117] mm Hg and 128 [95% CI 126–130] v. 145 [95% CI 143–147] mm Hg).

Interpretation: The prevalence of hypertension has remained stable among community-dwelling adults in Canada over the past two decades, but the rates for treatment and control of hypertension have improved markedly during this time.

Elevated blood pressure is the most important modifiable risk factor for vascular disease and mortality in developed nations.[1] There is a strong log-linear relationship between blood pressure levels and vascular outcomes,[2] and there is robust evidence from randomized trials showing that reducing blood pressure can prevent cardiovascular events (particularly stroke).[3] Although audits throughout the 1990s consistently showed suboptimal control of blood pressure in clinical practice,[4] recent analyses of multiple Canadian datasets have suggested marked improvements in the prescribing rates for antihypertensive medications over the past decade, with attendant decreases in hypertension-related cardiovascular events.[5,6]

A recent population-based direct measures survey from Ontario suggested that control of

hypertension had improved nearly fivefold in Ontario between 1992 and 2006.[7] Given the size of this apparent change and its inconsistency with the results of surveys from other countries,[8–10] questions arose as to whether the changes seen in Ontario were representative of the management of hypertension nationwide.

The purpose of our study was to review the key findings from the last two national surveys conducted in Canada in which blood pressure was directly measured among community-dwelling adults — the 1986–1992 Canadian Heart Health Surveys (CHHS)[11] and the 2007–2009 Canadian Health Measures Survey (CHMS)[12] — and to place these results in context with the results from the 2006 Ontario Survey on the Prevalence and Control of Hypertension (ON-BP).[7]

Although the results of the automated blood pressure measurements from the CHMS have been previously published for the entire cohort,[12] the blood pressures reported in this manuscript have been adjusted to account for differences in the measurement techniques used between surveys. We also had access to additional information from all three surveys that allowed us to stratify our analyses by comorbidity status.

Methods

The methods used in the CHHS, ON-BP and CHMS have been described in full elsewhere.[7,11,12] Each of the surveys targeted a sample of participants across geographic regions but excluded people living in long-term care facilities. Participants in all three surveys were asked health-related questions in person and had their blood pressures measured.

In the CHHS, blood pressure was measured using a mercury sphygmomanometer and the average of four readings was recorded. In the CHMS and ON-BP surveys, blood pressure was measured using an electronic oscillometric monitor (BpTRU Medical Devices Ltd., Coquitlam, British Columbia) and the average of five readings was recorded.[7,12] For the purposes of our analyses, measurements from the ON-BP and CHMS surveys were converted to the expected manual sphygmomanometer readings using previously validated linear regression equations:[13] adjusted SBP = 11.4 + (0.93 × SBP_{BpTRU}); and adjusted DBP = 15.6 + (0.83 × DBP_{BpTRU}, where DBP is diastolic blood pressure, DBP_{BpTRU} is the diastolic blood pressure measured using the BpTRU monitor, SBP is systolic blood pressure, and SBP_{BpTRU} is the systolic blood pressure measured using the BpTRU monitor.

We limited our analyses in all three surveys to participants aged 20 years or older and excluded any women who were pregnant. In all three surveys, hypertension was defined as a mean systolic blood pressure greater than 140 mm Hg, a mean diastolic blood pressure greater than 90 mm Hg or self-reported daily use of blood pressure medication during the previous month. In a sensitivity analysis, a person with self-reported diabetes was defined as having hypertension if his or her mean systolic blood pressure was greater than 130 mm Hg or if his or her diastolic blood pressure was greater than 80 mm Hg. Participants who self-reported a diagnosis of hypertension but who were not receiving treatment and had normal blood pressures were not defined as having hypertension (51 participants from the CHMS). We defined participants with hypertension as having "con-trolled" blood pressure if their systolic blood pressure was less than 140 mm Hg and their diastolic blood pressure was less than 90 mm Hg; participants were defined as having "uncontrolled" blood pressure if either of these limits were exceeded. In a sensitivity analysis, people with self-reported diabetes were defined as having "uncontrolled" blood pressure if their systolic blood pressure was greater than 130 mm Hg and their diastolic blood pressure was greater than 80 mm Hg.

Survey weights generated by Statistics Canada were applied to the data from each of the three surveys. The weighted CHMS data were analyzed with SAS and SUDAAN software, using 11 denominator degrees of freedom in the SUDAAN procedure statements (SAS version 9.1, SAS Institute Inc., Cary, North Carolina). Mean values of systolic and diastolic blood pressures and estimates of hypertension and hypertension control were calculated. To account for the complex design of the CHMS, variance was estimated using bootstrap weights.[14]

Results

The household response rates for the three surveys were comparable (76.8% for the CHHS, 65.6% for the ON-BP and 69.6% for the CHMS), and similar proportions of household participants had their blood pressures measured in each survey (85.2% for the CHHS, 85.3% for the ON-BP and 83.6% for the CHMS). All three surveys enrolled demographically similar populations: 50.9% of the participants in the CHHS and ON-BP and 53.1% of the participants in the CHMS were women. The age ranges included in our analyses were 20–79 years for the ON-BP (mean 45 years), 20–79 years in the CHMS (mean 46 years) and 20–74 years for the CHHS (mean 41 years).

The population prevalence of hypertension estimated from each survey was stable: 21.6% of the adult population in 1992 (25.5% of men and 17.8% of women), 21.3% of the adult population in 2006 (23.8% of men and 19.0% of women), and 19.7% of the adult population in 2009 (19.9% of men and 19.4% of women). When people who reported having diabetes and had a systolic blood pressure of 130–140 mm Hg or a diastolic blood pressure of 80–90 mm Hg were included in the number of people with hypertension, prevalence rates increased by 0.5% in 1992 (CHHS), 1.3% in 2006 (ON-BP) and 0.7% in 2009 (CHMS).

Average systolic blood pressures were similar in the sample populations from the ON-BP and the CHMS; these averages were substantially lower than the averages seen in the CHHS among all subgroups (Table 1). Although the

values for systolic and diastolic blood pressures among people with untreated hypertension (an amalgam of those who were unaware of their condition and those who were aware but were not taking any antihypertensive medications) were similar in all three surveys, people who were receiving treatment for hypertension and participants who did not have hypertension had substantially lower systolic blood pressures in 2006 and 2009 compared with 1992 (Table 1).

The proportion of Canadians with hypertension who were aware of their condition and who were either not receiving treatment or receiving treatment that was not controlling their blood pressure dropped between 1992 and 2009 (Figure 1, Table 2). A much sharper decline in the proportion of people with hypertension who were unaware of their condition (from 43.2% to 17.4%, $p < 0.001$) was observed over this timeframe. The proportion of Canadians with hypertension whose blood pressure was under control and below 140/90 mm Hg increased from 13.2% in 1992 to 64.6% in 2009 ($p < 0.001$, Figure 1, Table 2). When controlled blood pressure for patients with diabetes was defined as 130/80 mm Hg or lower, then overall control rates increased from 12.1% in 1992 to 58.9% in 2009.

Among people who were receiving treatment but whose blood pressure was not under control, most had systolic blood pressures higher than 140 mm Hg. In 2009, the proportion of these people was 81.8%, compared with 80.2% in 2006 and 90.6% in 1992; 40.9% of the participants to the CHMS had diastolic blood pressures exceeding 90 mm Hg, compared with 32.4% of ON-BP participants and 52.7% of CHHS participants.

The prevalence of hypertension in people with comorbidities was relatively stable among all three surveys, with similar reductions over time in the proportions who were unaware of their condition or who were aware of their condition but not seeking treatment (Table 2). Of note, people with hypertension who had previously had a myocardial infarction or stroke were more likely to have controlled blood pressure than people with hypertension who had not previously had one of these events. This was true for both the 1992 and the 2009 data (1992 odds ratio [OR] 2.1 [95% CI 1.2–3.6] and 2009 OR 3.0 [95% CI 1.8–5.0]). Although there were strong trends toward better control of blood pressure (defined as lower than 140/90 mm Hg) in participants with hypertension who also reported having diabetes (1992 OR 1.6 [95% CI 0.9–2.8] and 2009 OR 2.0 [95% CI 0.9–4.5]) or dyslipidemia (1992 OR 1.6 [95% CI 0.9–2.5] and OR 1.5 [95% CI 0.9–2.4]) when compared with participants who did not report these conditions, these trends did not achieve statistical significance in either the 1992 or the 2009 data.

Discussion

The management of hypertension among community-dwelling Canadian adults appears to

Table 1: Mean blood pressure values from three population-based surveys conducted between 1992 and 2009 in Canada

Characteristic	Mean blood pressure, mm Hg (95% CI)		
	CHHS (1986–1992) n = 22 314	ON-BP (2006) n = 2 551	CHMS (2007–2009) n = 3 487
Systolic			
Sex			
Male	128 (128–128)	118 (117–113)	118 (117–120)
Female	120 (120–121)	114 (113–116)	115 (114–116)
Age groupings, yr			
Male, 20–39	123 (123–123)	115 (113–116)	114 (112–115)
Female, 20–39	111 (111–112)	108 (106–110)	106 (104–108)
Male, 40–59	129 (128–130)	119 (117–122)	120 (118–122)
Female, 40–59	123 (123–124)	116 (114–118)	115 (113–117)
Male, 60–79*	140 (140–141)	123 (121–126)	125 (124–127)
Female, 60–79*	140 (139–141)	122 (117–128)	129 (128–131)
People with no hypertension	117 (117–117)	113 (112–114)	113 (112–114)
People with untreated hypertension	146 (145–147)	148 (144–151)	148 (144–151)
People with treated hypertension	145 (143–147)	124 (122–126)	128 (126–130)
Diastolic			
Sex			
Male	79 (79–80)	75 (73–76)	77 (77–78)
Female	74 (74–74)	72 (71–73)	74 (73–75)
Age groupings, yr			
Male, 20–39	78 (77–78)	72 (70–73)	75 (74–76)
Female, 20–39	71 (71–71)	71 (60–69)	72 (70–73)
Male, 40–59	83 (82–83)	77 (76–78)	80 (79–81)
Female, 40–59	78 (78–79)	74 (73–75)	75 (74–76)
Male, 60–79*	81 (81–81)	76 (74–78)	77 (76–78)
Female, 60–79*	79 (78–79)	71 (69–73)	75 (74–76)
People with no hypertension	74 (74–74)	72 (71–73)	75 (74–75)
People with untreated hypertension	89 (89–90)	87 (85–90)	89 (87–90)
People with treated hypertension	85 (84–86)	76 (75–77)	77 (76–79)

Note: BP = blood pressure, CI = confidence interval, CHHS = Canadian Heart Health Survey, CHMS = Canadian Health Measures Survey, ON-BP = Ontario Survey on the Prevalence and Control of Hypertension.
*The upper age limit in the CHHS was 74 years.

have improved over the past two decades. Notably, the rates of awareness, treatment and control documented in the ON-BP and the CHMS are higher than those recently reported from physical measures surveys done in the United States[10] and elsewhere during the same periods.[8,9] These improvements are consistent with data[15] that showed marked increases in the use of antihypertensive drugs in Canada since the late 1990s (prescribing patterns that were not seen to the same extent in the US).[16] Although these prescribing changes happened at the same time as the initiation of the Canadian Hypertension Education Program,[5,17] it is not possible to say whether the program was directly responsible for the improvements in the control of hypertension.

Contrary to analyses of physician billing databases,[18] we did not find a substantial change in the prevalence of hypertension among community-dwelling adult Canadians between 1992 and 2009. A recent report using data from the US National Health and Nutrition Examination Survey (NHANES) also reported a stable prevalence of hypertension between 1999 and 2008.[10] Physical measures surveys such as the CHMS and the NHANES focus on community-dwelling adults, whereas analyses of administrative databases capture all individuals, including patients living in long-term care facilities. It is therefore not surprising that estimates of the prevalance of hypertension are higher in analyses of

administrative data. However, we believe that our findings suggest that at least some of the apparent increase in the incidence and prevalence of hypertension that are seen in analyses of administrative data may represent greater awareness of hypertension rather than an actual change in the underlying epidemiology. The marked decrease in the proportion of Canadians with hypertension who were unaware of their condition that we saw between 1992 and 2009 is entirely consistent with the trends seen over the past decade in the National Population Health Surveys and the Canadian Community Health Surveys.[17]

We found that people with treated hypertension and participants without hypertension had substantially lower systolic blood pressures in 2009 than in 1992. This result suggests that not all of the benefits we have observed in Canada are related to the use of antihypertensive medications. Indeed, we found that people without hypertension showed a 4-mm Hg drop in average systolic blood pressure between 1992 and 2009, which suggests a shift in the underlying population distribution of blood pressure. This is surprising, given the increasing rates of obesity and diabetes in the Canadian population over the past two decades and data from the NHANES that showed a 1.5-mm Hg increase in systolic blood pressure among Americans without hypertension over the same period.[10] It is possible that increases in physical activity and improvements in diet (www.statcan.gc.ca/pub/21-020-×/21-020-×2009001-eng.htm [accessed 2010 Sept. 3]) may have led to this change, but further study is needed.[19]

Most of the participants with blood pressure that was being treated but was not controlled were classified as such on the basis of their systolic blood pressure. This is not surprising, since education efforts have traditionally placed more emphasis on diastolic blood pressure (indeed, explicit targets for systolic blood pressure did not appear in the Canadian national guidelines until 2001), and several surveys have shown that clinicians tend to accept higher systolic blood pressures than are recommended in the guidelines before prescribing or increasing antihypertensive medications, particularly among older patients.[20–22] However, it has been estimated that the optimal control of systolic blood pressure in people with hypertension could prevent almost half of all atherosclerotic cardiovascular events in North America.[23]

Finally, among people with hypertension, those who also had cardiovascular or cerebrovascular disease were more likely to have their blood pressure under control. This is encouraging, as it suggests that either Canadian physi-
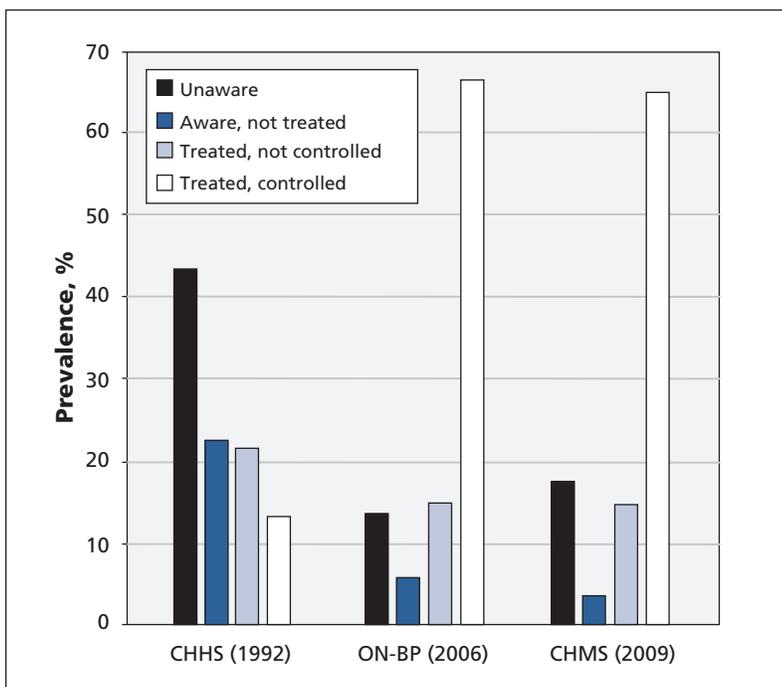
Figure 1: Rates of hypertension awareness, treatment and control among Canadians with hypertension from 1992 to 2009. CHHS = Canadian Heart Health Survey, ON-BP = Ontario Survey on the Prevalence and Control of Hypertension, CHMS = Canadian Health Measures Survey.

cians appropriately target more intensive therapy to patients at higher risk or that patients at higher risk are more compliant with their therapy. A similar result was seen in a chart audit of more than 10 000 patients from primary care practices in southwestern Ontario,[24] but such a result has not been seen in other countries.[25–27] This is important, as targeting therapy toward people with established disease or multiple cardiovascular risk factors will lead to greater absolute bene-

fits than treatment strategies targeting only single risk factors.[28]

Limitations

Although our analyses are based on nationally representative data, there are some limitations to our study. The proportion of people with hypertension who were aware of their condition is likely to be an overestimation because "regularly taking antihypertensive medication in the past

Table 2: Rates of awareness, treatment and control of hypertension among participants in three population-based health surveys, stratified by comorbidities, from 1992 to 2009			
	CHHS (1986–1992) N = 22 314	ON-BP (2006) N = 2 551	CHMS (2007–2009) N = 3 487
Subgroups	% (95% CI)*	% (95% CI)*	% (95% CI)*
Overall, no.†	5 127	651	890
Unaware	43.2 (39.5–46.9)	13.5 (8.9–18.0)	17.4 (14.0–21.5)
Aware, not treated	22.3 (19.4–25.2)	5.7 (2.7–8.8)	3.5 (2.2–5.4)
Treated, not controlled	21.4 (18.5–24.3)	14.8 (10.2–19.4)	14.4 (11.3–18.5)
Treated and controlled	13.2 (10.7–15.7)	66.0 (59.8–72.2)	64.6 (60.0–69.2)
No prior MI, stroke or dyslipidemia, no.	2 295	346	402
Unaware	52.3 (47.2–57.4)	21.8 (14.1–29.5)	25.6 (19.2–33.4)
Aware, not treated	21.2 (17.5–24.9)	10.5 (4.5–16.5)	4.3 (2.1–8.9)
Treated, not controlled	15.1 (11.8–18.5)	10.0 (5.9–14.1)	16.6 (11.9–22.7)
Treated and controlled	11.3 (7.9–14.7)	57.7 (49.8–65.6)	53.5 (47.4–59.4)
Prior MI or dyslipidemia, no.	2 832	305	488
Unaware	47.0 (42.6–51.5)	6.0 (1.9–10.1)	12.9 (9.9–16.8)
Aware, not treated	20.8 (17.6–24.0)	1.5 (0.0–3.3)	2.9 (1.9–4.4)
Treated, not controlled	18.8 (15.2–22.5)	19.1 (10.2–28.0)	19.9 (15.6–25.1)
Treated and controlled	13.3 (10.3–16.3)	73.4 (63.6–83.1)	64.3 (58.2–70.0)
Diabetes mellitus, no.	734	124	176
Unaware	43.3 (32.9–53.7)	3.7 (0.0–7.7)	16.6 (11.6–23.1)
Aware, not treated	21.5 (14.8–28.2)	0.0	1.1 (0.1–14.5)
Treated, not controlled	33.1 (24.2–41.7)	59.7 (44.0–75.3)	36.8 (30.6–43.5)
Treated and controlled	2.1 (0.4–3.9)	36.6 (21.6–51.7)	45.5 (38.9–52.3)
Prior MI or stroke, no.	606	77	111
Unaware	25.7 (16.6–34.7)	5.8 (0.0–12.9)	3.8 (1.3–10.4)
Aware, not treated	12.2 (6.9–17.5)	1.3 (0.0–3.9)	1.2 (0.3–4.7)
Treated, not controlled	40.1 (27.9–52.3)	18.7 (4.4–33.1)	15.8 (10.7–22.7)
Treated and controlled	22.1 (13.5–30.7)	74.2 (56.8–91.6)	79.3 (71.0–85.6)
Dyslipidemia, no.	2 562	277	435
Unaware	40.7 (35.2–46.2)	4.8 (1.5–8.2)	13.3 (10.1–17.4)
Aware, not treated	22.9 (18.5–27.4)	1.3 (0.0–3.2)	3.2 (2.0–4.9)
Treated, not controlled	20.4 (16.9–24.0)	19.7 (9.5–30.0)	20.2 (15.5–25.8)
Treated and controlled	15.9 (11.4–20.4)	74.2 (63.8–84.5)	63.4 (56.9–69.3)

Note: CHHS = Canadian Heart Health Survey, CHMS = Canadian Health Measures Survey, CV = cardiovascular, MI = myocardial infarction, ON-BP = Ontario Survey on the Prevalence and Control of Hypertension.
*Unless otherwise specified.
†The values for n provided for each comorbidity group are from the survey sample, but the percentages for awareness, treatment and control have been weighted to reflect the general population from which each survey sampled.

month" was part of the case definition. However, the measurement of blood pressure only once during these surveys will tend to underestimate control rates and overestimate prevalence compared with 24-hour ambulatory blood pressure monitoring.[29]

In addition, people with isolated office hypertension may have been misclassified as having uncontrolled hypertension, and people with masked hypertension may have been misclassified as having controlled hypertension. Regardless, the definitions for hypertension and hypertension control were identical among the three surveys (as well as in the NHANES).

One would expect the blood pressures recorded during the CHMS and ON-BP to be about 3 mm Hg lower than the blood pressures recorded during the CHHS. The blood pressures recorded in the CHMS and ON-BP were averages of at least five automated blood pressure readings using a BpTRU machine without an observer present, whereas blood pressure measurements in the CHHS were taken from four readings using manual mercury sphygmomanometers.[13] We took this discrepancy into account by adjusting all BpTRU measurements using regression equations to estimate the equivalent manual reading, thus allowing comparisons across surveys.[13] Although the regression equations we used for these adjustments have been previously independently validated,[13] and although the coefficients of correlation were high for both systolic (r^2 0.84) and diastolic (r^2 0.70) blood pressures, it should be noted that studies are ongoing to definitively establish the relation between BpTRU measurements and 24-hour ambulatory measurements.

If different cutoffs to define hypertension in surveillance studies are chosen in the future, then estimates of prevalence and control will need to be recalculated.[30]

Finally, as there is debate over the appropriate blood pressure targets for people with diabetes,[31] we used a definition of 140/90 mm Hg to define hypertension control for all people for our primary analysis, but we also reported prevalence and control rates if 130/80 mm Hg was used for people with diabetes.

Implications

In an earlier analysis of mortality data from countries with established market economies, we showed that those countries with the highest rates of control of hypertension and the lowest mean blood pressures had the lowest rates of death from stroke, myocardial infarction and heart failure.[32] In that context, the findings from the ON-BP and the CHMS are particularly encouraging and provide a potential explanation for the statistically significantly greater-than-expected reductions in cardiovascular mortality seen in Canada during the past decade.

A recent analysis of data from 5.4 million people from 199 countries documented that mean levels of systolic blood pressure in Canada were now among the lowest in the world.[33] However, despite marked improvements in rates for the control of hypertension over the past two decades, one-third of community-dwelling Canadian adults with hypertension still have blood pressures that are higher than the currently recommended targets, and cardiovascular disease remains the most common cause of premature death and disability in Canada. Continued efforts to optimize the management of hypertension are necessary to further reduce the burden of cardiovascular disease in Canada. Moreover, without continued vigilance and reinforcement after improvements in practice have been made, quality of care will deteriorate over time.[34]

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